National School Curriculum

SCIENCE
CURRICULUM FRAMEWORK

Classes PP-XII

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Department of School Education
Ministry of Education and Skills Development
Royal Government of Bhutan

“Your parents, relatives, and friends would be very proud of what you have achieved. At your age, to have completed your studies is your personal accomplishment. Your knowledge and capabilities are a great asset for the nation. I congratulate you for your achievements.

Finally, your capabilities and predisposition towards hard work will invariably shape the future of Bhutan. You must work with integrity, you must keep learning, keep working hard, and you must have the audacity to dream big.”

- His Majesty Jigme Khesar Namgyel Wangchuck

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FOREWARD

COVID-19 has caused unforgiving disruptions in the public education all over the world, and brought about threats of fragmentation in the society due to disparities in accessibility and connectivity in many systems. In Bhutan too, continuity of education and learning has been severely affected as a result of sporadic nationwide school closures, restrictions, and health protocols. The disruptions exposed the limitation of the existing ideologies and practices in education. This has deprived children living in poverty worldwide, who rely on the physical settings of their schools for educational materials and guidance, of the learning and other essential educational services. Cognizant of the global trend to embrace the competency-based learning as education for the 21st century, the current priority of the Government is to transform the knowledge and textbook based learning to competency-based learning through open source and experiential learning.

In the new normal education, human interaction and well-being is a priority. Technology, particularly digital technology that enables communication, collaboration and learning across distance, is a formidable tool though not a panacea but a source of innovation and expanded potentials. As we embrace this exceptional opportunity to transform the education, it is imperative to reimagine the organization of our educational institutions and learning environments. In the post COVID 19 era, we must prioritize the development of the whole person not just the acquisition of academic knowledge. Inspiration for the change can be drawn from the 1996 Delors report, *Learning the treasure within*. Its four pillars of learning as "learning to know", "learning to do", "learning to be", and "learning to live together" are the current global ethos of teaching and learning. Therefore, curricula must be increasingly perceived as an integrated, themes based and problems-based orientation that allows learners develop a strong base of knowledge about one's self and about the world, and find purpose of life and be better able to participate in social and political milieu.

The National School Curriculum is, not just a mere response to the pandemic, but also culmination of the curriculum reform work for the last four years by the erstwhile Royal Education Council. It is an attempt to transform education from the teaching of "what" to learning of "how" and "why" towards empowering learners with the transversal competencies and the 21s t century skills, and preparing them to be lifelong learners. In tandem with this initiative, we are optimistic that the paradigm shift in science education orients our education process in empowering young generation with the scientific mind-set and disposition, and skills towards nurturing nationally rooted and globally competent citizens.

With this curriculum material, we are optimistic that our learners and teachers are ushered through a life enriching experiential science education.

Tashi Delek

(Tashi Namgyal)
DIRECTOR

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1 Introduction

1.1 Background

Science is a human endeavour. It is an organised and systematic body of knowledge in any field of inquiry built through the lens of scientific process. Science basically consists of scientific content (ontology) and scientific process (epistemology). The scientific content ascribes the quantum of scientific knowledge explaining the natural and physical world, while the scientific process assists in understanding the nature of scientific knowledge; and how the scientific knowledge is constructed and accepted by the scientific community.

Bhutanese science education started with a curriculum borrowed from the neighbouring country. However, in 1986, the Royal Government of Bhutan (RGoB) replaced this curriculum by implementing a localised science curriculum founded on the principles of *New Approach to Primary Education* (NAPE). The localised primary science curriculum was implemented with the intent to promote the art of scientific inquiry through Bhutanese social, cultural, and environmental contexts. After more than a decade of implementation, the localised primary science curriculum became a hotspot of public scrutiny and debate. Bhutanese from various social strata argued that the localised primary science curriculum is not only shallow in content but also contains outdated learning activities. Therefore, the localised primary science curriculum was revised in 2001 mainly to add appropriate content to enhance quality learning (Royal Education Council [REC], 2012).

The K-12 science curriculum, however, was heavily criticised for being fragmented and lacking the sense of progression across different grades. Generally, the Bhutanese populace opined that the K-12 science curriculum is largely content-driven, and lacks attributes to prepare students for the world of work. Therefore, a large-scale movement of K-12 science curriculum reform was launched in 2008. To push the process of reforms, the Ministry of Education (MoE) commissioned to conduct a needs assessment of the science curriculum in 2007.

As a follow-up to the findings from the needs assessment, the K-12 science curriculum was reformed and implemented in phases. The reformed K-12 science curriculum from fourth to sixth-grade was implemented in 2013, while the reformed science curriculum from 10th and 12th-grade was implemented in 2017. At the core of the reformed K-12 science curriculum, the aim was to provide a clear statement of what learners are expected to achieve as a result of science education. It aspired to provide learning experiences organised with better coordination, consistency, coherence, and progression. Moreover, it envisioned to provide learning experiences that are more enriching, challenging, and relevant to learners' developmental appropriateness (REC, 2012).

In the early 2000s, the world witnessed increased connectivity with the advancement in digital technologies amongst the global villages. The world also confronted a plethora of ballooning real-world challenges. Cognizant of the changing priority of science education, the National Science Foundation (NSF) in the USA called for a 21st century integrative approach to science, technology, engineering, and mathematics (STEM). As a follow-up, the National Research Council (NRC) in its *K-12 Framework for Science Education* and *Next Generation Science Standards* raised the stake to connect scientific content and scientific process to form science standards and make the standards of engineering design at par with science standards (NRC, 2012, 2013). Thus, across most parts of the global education system, content and instructional practices of different science disciplines are mostly taught in conjunction with other STEM disciplines in real-life authentic contexts to address contemporary social, economic, environmental and inequity issues.

Considering the changing dynamics of science education from traditional silo-based approach to integrative STEM education, the Royal Education Council (REC) initiated Bhutanese science curriculum reform towards the fall of 2019. To strengthen the content and practice of 21st century skills, the Bhutanese K-12 science curriculum was reformed from the point of science, technology, engineering, and mathematics (STEM) educational approach. The reformed K-12 science curriculum highlights paradigm shift from:

1. teaching many isolated facts towards teaching fundamental or disciplinary core ideas in science (Biology, Physical Processes, and everyday materials).
2. teaching disciplinary core ideas and scientific processes together towards the construction and generation of scientific knowledge and ideas to inform their action.
3. raising the standards of engineering design process/design challenge at par with the science standards.
4. infusing technological design where appropriate to augment science standards and engineering design (National Research Council [NRC], 2014).
5. transforming knowledge-based teaching to competency-based learning through active engagement of learners.

Therefore, the reformed K-12 science curriculum aspires to augment the spirit of STEM education in Bhutan. While the disciplinary core ideas in science and scientific inquiry are expected to explain the natural and physical world, the engineering and technological design is expected to situate learning in the authentic Bhutanese and global contexts, connect to real-world situations, and foster deeper understanding of local or global challenges (NRC, 2013, 2014). The hallmark of the STEM education in our context is to foster scientifically elite professionals and technicians to contribute in national developmental activities, and scientifically literate citizens who can reap every opportunity that any development in the field of science can offer in raising their living standard and lifestyle.

1. 2 Rationale

Universally, science education is underpinned as ends and means to achieve scientific literacy. Although not a universal panacea, science education aims to make citizens scientifically literate who can make informed decisions, evaluate policy matters, and make informed judgment on the scientific pieces of evidence. According to NRC (2007), science education aspires to help students:

1. know, use, and interpret scientific explanations of the natural world;
2. generate and evaluate scientific evidence and explanations;
3. understand the nature and development of scientific knowledge;
4. stimulate sensitivity, innovation, creativity in the field of STEM, and transfer the learnt knowledge and skills in diverse situation; and
5. participate productively in scientific practices and discourse.

As Bhutanese education is inspired by the goal of producing nationally rooted and globally competent citizens, the K-12 science curriculum aspires to augment the quality of scientific literacy underpinned by the global scientific trend enriched by the principles of Gross National Happiness (REC, 2018). At the national level, K-12 science curriculum strives to produce Bhutanese citizens who can make judicious decisions, assess, and evaluate the Bhutanese national policy, and take part effectively in scientific and legal proceedings at varying platforms.
Concurrently, K-12 science curriculum is also aimed at producing quality science professionals, doctors, engineers, environmentalists, chemists, etc. From a classroom teaching point of view, Bhutanese K-12 science curriculum invests in pursuit of augmenting scientific competencies. Therefore, at the end of the K-12 science education, Bhutanese students are expected to use and apply scientific knowledge and skills to explain physical and natural phenomena, design and conduct scientific inquiry; and analyse, interpret, and relate the scientific data to appropriate context.

Moreover, as the philosophical foundations of K-12 science curriculum shifts from silo-based approach to integrative STEM education, the K-12 science curriculum aspires to produce but not limited to (a) promote STEM literacy, (b) enhance STEM innovators and professionals, (c) build future STEM workforce readiness, (d) articulate connections amongst STEM subjects, (e) develop 21st century competencies, and (f) foster interest and engagement in doing science. Development of such capabilities and competencies entail active engagement in the scientific methods and processes towards empowering students as scientifically literate and elite citizens.

2 Goals

The perennial goals of Bhutanese science education revolve around the premise of educating youths with both scientific knowledge and scientific process. However, as the national priority shifts from the culture of silo-based science towards the foundations of STEM, the eventual aspirations of Bhutanese science education today stand more from the tone of STEM-based approach. At the national level, the STEM-based science education aspires to produce individuals with STEM literacy capable of understanding and evaluating information, have a voice in science funding decisions, evaluating policy matters, and weighing scientific evidence provided in legal proceedings. Further, it purports to produce skilled and motivated future scientists, doctors, engineers, and STEM-based workforce or professionals.

The Bhutanese science curriculum is one of the channels in achieving national aspirations of science education. It strives to provide bastions in nurturing the spirit of both scientific practices (disciplinary core ideas and scientific inquiry) and engineering design. To realise such captivating curricular goals, the Bhutanese science curriculum desires to provide learning experiences in epitomizing the development of the following:

2.1 Understand the characteristics of science, nature of science (NOS), and nature of scientific knowledge (NOSK*)*.

The science education at its end must help learners to understand the characteristics of science or NOS. Thus, the science curriculum must help learners to understand that scientific knowledge is: tentative and revisionary (subject to change); empirically-based (based on and/or derived from observations of the natural world); subjective (theory-laden); necessarily involves human inference, imagination, and creativity (involves the invention of explanations); and is socially and culturally embedded.

2.2 Acquire core or fundamental scientific knowledge and understanding of the natural sciences at a level appropriate to their developmental stage.

Science uses distinctive ways of valuing, thinking, and working to understand the natural world around us. This is not the kind of knowledge that the learners can learn just by experience and, therefore, the science curriculum must provide all the learners with the opportunity to gain essential knowledge and understanding the dynamics of the physical environment and about the learners themselves.

2.3 Develop and apply the skills of scientific inquiry in understanding how scientists work; and how scientific knowledge is constructed, and accepted by the scientific community.

The charm of science lies at the heart of scientific inquiry. It revolves around the culture of sparking curiosity and quest to bring forth scientific claims with logical reasons. Therefore, science curriculum must inherently provide avenues to learners to experience and engage in the ethos of scientific practices and scientific habits of mind. To raise the spirit of STEM education through the slogan of "doing science", science curriculum must dwell on the following principles of scientific inquiry:

- Pose significant questions that can be investigated empirically
- Link research to relevant theory
- Develop method that permit the investigation of the question
- Provide coherent and explicit chain of reasoning
- Replicate and generalise across studies, and
- Disclose research to encourage professional scrutiny and critique (NRC, 2002)

2.4 Develop and apply the skills of problem-solving through design-based learning, engineering design process, or engineering challenge.

The footprint of engineering design process or engineering practices is foundational at the centre of STEM education. It is undoubtedly the universal approach to solve real word problems, as much as what engineers and scientists practice. Engineering design situates learning in authentic contexts or complex situations, and brings several STEM disciplines together to solve real-world issues. Fundamental to doing science is to empower learners to generate new knowledge and create alternative ideas and construct scientific artefacts in solving problems in the community. Therefore, science curriculum must provide learners a wide range of opportunities to practice engineering design process as:

- define and delimit real-world situations or problems by clearly stating the problem to be solved in terms of criteria for success and given constraints or limits,
- design solutions by initially generating possible solutions, then evaluating the promising ones to determine which best meet the problem criteria and constraints; and
- optimise the solution by systematically testing and refining solutions, and improving the final design by trading less important features for those considered more important (English & Kings, 2015)

2.5. Use, develop, and apply the skills of information, communication, and technology (ICT) in augmenting the science and engineering practices.

As global dynamics shift from the agrarian-based society to technologically savvy 21st century, ICT has become the life and living of today's world, including education. As a body of knowledge, object, activity, and volition, ICT harbours a wide range of potentials in invigorating STEM learning. Therefore, science curriculum must provide learners an avenue to: explore digital resources, manipulate and handle physical ICT related tools, design and create solutions using relevant ICT tools (software or apps), and promote the environmental, socio-economical, and cultural values through ICT.

2.6 Make learners 'scientifically literate' and be able to participate in critical and informed debates on the key questions and issues that may affect their own lives, community, country, and the world at large.

In particular, science education should equip the learners with the scientific knowledge, skills, values and attitudes that help them to become active, informed and critical citizens who can contribute to debates about sensitive moral, ethical, social, economic and environmental issues. They will also be active and critical participants in wider debates about good governance and democracy whilst respecting and maintaining the country's traditions and cultural values.

2.7 Prepare learners for higher studies in STEM disciplines, and also to allow them to make a smooth transition into jobs that require an understanding of STEM.

As a society, Bhutan aspires educated generations of scientists, technologists, doctors and teachers with a scientific temperament so that they can develop newer and better ways to meet the needs of a rapidly changing society, and to solve life related problems. The school science curriculum provides the quantum of scientific knowledge and skills that cater to the needs of the learners aspiring to pursue higher studies in STEM disciplines. For those who do not pursue higher studies or training in STEM, this course should enable the learners to understand the fundamentals of scientific principles, and develop skills useful in their lives; particularly in relation to agriculture, livestock farming, forestry and other technological environments.

2.8 Develop a sense of health and well-being and how to live a healthy life.

The science curriculum should equip learners with the STEM literacy and knowledge of health and nutrition to be able to live a healthy life for themselves, their families, and their community. For example, knowledge of good nutrition is essential to maintaining good health and well-being. The understanding of how to prevent diseases helps learners understand how they can lead healthier and happier lives not just for themselves, but also for their family and their community.

2.9 Inculcate in learners a love of learning science and learning STEM in general, which they carry on throughout their lives.

For learners completing their science education in class X, the Science Curriculum is designed to give them a useful education in science so that they feel motivated to engage in debate, be active citizens and learn more about STEM related issues that affect their lives, the lives of their families and their community. The scientific methods and processes stimulate the art of learning and excel in scientific studies. For those going on to science related careers, the curriculum is challenging and encouraging and arouses interest in science and inspires learners to be scientists, foresters, environmentalists, nurses, and engineers; continue to develop their knowledge, understanding and skills in science or STEM in general throughout their lives.

3 Key competencies

Competency is more than just knowledge and skills. A competency is the capability of the learner to apply or use a set of related knowledge, skills, and abilities required to successfully perform "critical work functions" or tasks in a defined work setting. It implies the ability to analyse and synthesize information and experiences to create "working knowledge" that can be used in a real-world setting, or transfer learning from one subject to another. For example, the ability to communicate effectively is a competency that may draw on an individual's knowledge of language, practical IT skills and attitudes towards those with whom s/he is communicating. The key competencies identified in NSCF are:

3.1 Spirituality and Values

Spirituality and values of an individual is quintessential of the psychosocial wellbeing and to live in harmony with oneself, others and in the society. Despite the general perception that science and spirituality are contradictory, they are deeply connected. Science is about things, which can be measured and quantified, whereas the knowledge and understanding of spirituality lie in the realm of subjectivity and the belief system that cannot be measured. However, science is a discipline of rational, logical thinking, informed by empirical, measurable, and replicable tools and technologies that manifest in the understanding of the realities of life and of the world around. This understanding fosters the formation of personal disposition of love, compassion, generosity, sanctity of life and the sense of mutuality. For example, weapons of mass destruction are the product of science; however, their deployment is influenced by the values of spirituality and the preciousness of life.

Science and spirituality complement because, their ideologies serve as the precursor of deeper understanding of each other through interpretation and objective analysis. For instance, spirituality inspires visionary thinking and values, while science provides methods to probe deeper in the realities of life and the world. Therefore, science education provides learning experiences that engage learners in wide range of scientific methods and processes leading to generation of knowledge, so that learners realise how the world works, and of one's own action on others and the environment. Empowered by the scientific aptitude and the sense of realisation, learner develop as socially responsible and productive individual.

3.2 Language

Science as a discipline of study and the body of knowledge of understanding about living things and of how the world works is unique. In essence, all the discipline of studies in school education has unique nature and characteristics and the different ways of learning and communication. As such, languages are categorised as scientific, financial, political, and others. The ability of learner to understanding and acquisition of scientific information and interpretation of data are influenced by the level of scientific language competencies.

Besides the mastery of generic scientific methods and processes, the science curriculum aims the development of authentic scientific languages competencies and application in their studies. In so doing, learning experiences invite the use of different forms of writing and communicating, namely to report the scientific finding, debate on certain issues, deliberate on ideas, and communicate ideas to wide range of audience. To this effect, scientific words are presented in the sequential order of the four levels of language – naming, process, concept, and mathematical representation.

3.3 Transversal Competencies

Transversal competencies are portable or soft skills vital in all form of human activities, at work or in studies. These skills are critical thinking, creativity, collaboration, communication, including citizenship and cultural sensitivity. Science as a discipline of methodical studies mandates that the learner is engaged in the scientific processes of observation, investigation, and draw conclusion with analytical and critical thinking that commensurate the grounded theories and the realities of how science works.

Towards generating a grounded scientific ideas and knowledge, science is generally ventured through a collaborative endeavour based on the shared values and the common goals. Thus, the science curriculum envisages the development of these skills in the following perspectives:

3.3.1 Critical and Innovative Thinking

Critical thinking, innovative thinking, creativity, entrepreneurship, resourcefulness, application skills, reflective thinking, presentation skills, responsible decision making, communication, leadership, and organisational skills. For example, apply the knowledge of hydrocarbons and polymerization to design physical or computer models of any polymer that might have commercial values.

3.3.2 Interpersonal Skills

Team work, collaboration, initiative, sociability, collegiality, self-discipline, enthusiasm, perseverance, self-motivation, compassion, integrity, commitment, self-awareness, tolerance, openness. For example, design a device, which uses covalent or ionic materials to relate the bonding with the properties of materials.

3.3.3 Global Citizenship

Respect for diversity, intercultural understanding, ability to resolve conflicts, civic participation. For example, argue for and against the use of nuclear weapons in the world.

3.3. 4 Physical and Psychological Health

Respect for the environment, healthy lifestyle, physical fitness, empathy, self-respect. Example, evaluate use of electrochemical cell in an electric car in terms of energy efficiency, renewability, and environmental impact.

3.3.5 Enterprising and Industrious

The world has witnessed great scientific leaps and technological advances, which define the present and the future. The youth unemployment rate has consistently remained high in Bhutan without any benefits of technological development on employment opportunities. Therefore, there is an urgent need to promote in learners the value of being enterprising and industrious through STEM education to foster the aptitude and disposition of self – employed and successful entrepreneur.

The competency-based education, hallmark of the science for the current era, through the experiential learning and real time experiences is central to entrepreneurial and business ventures driven by learner's mastery of portable skills. Hence, the science curriculum envisages the engagement of learners in wide range of activities in facilitating the development of dignity of labour, integrity, analytical, workmanship as an enterprising individual.

3.4 Sustainable Living

Sustainable living is a lifestyle that aims to reduce one's environmental impact for sustainability of the Earth and for the person. It can mean not choosing to consume a product that is made using practices that do not promote sustainability, buying local or bicycling to work place.

With climate change becoming a more serious problem every day, it is important than ever for people to do their part by practicing sustainable living to reduce the pressure on Earth's natural resources and to combat climate change.
The following learning activities in science, for instance, promote sustainable living in learners.

- Apply the principles of green chemistry to design a Bhutanese house that can keep us warm in winter
- Design a prototype to produce biofuel from local organic waste that may solve energy problems in the locality.
-

3.5 Health, Safety and Wellbeing

3.5.1 Health and safety

The learning and teaching science involve handling of potentially hazardous substances and equipment. Therefore, it is the responsibility of the teacher and the school to ensure safety and health of all students undertaking the study. Teachers and students always practice appropriate safety precautions. It is the responsibility of schools to ensure that teachers and learners comply with necessary health and safety protocols. For example, "In class IX Chemistry, design an experiment to investigate the difference between saturated and unsaturated hydrocarbons. Follow the health and safety protocol while carrying out the investigation."

3.5.2 Well-being

Social-emotional learning is the process through which learners acquire and effectively apply the knowledge, skills, and attitudes, necessary to understand and manage emotions; set targets and achieve the goals; feel and show empathy for others; establish and maintain positive relationships, and experience making informed and responsible decisions. The social – emotional skills include self-awareness, self-management, relationship skills, social awareness, and responsible decision-making.

3.6 Digital Competence

Digital competence is the combination of knowledge, skills, and values in context to the use of technology to perform tasks, solve problems, communicate, manage information, collaborate, so as to create and augment learning in science, which is not feasible with knowledge-based teaching and learning.

The world is going through the fourth industrial revolution, digital technologies is fundamental towards embracing the new generation ways of living, learning, working, and relating with each other. Consequently, digital technologies are gradually drastically changing the landscape of the job. This means technologies rule the work force, and therefore, mandates that the present generation of youths are digital savvy and empowered with technical temper and zeal.

4 Scientific Knowledge and Understanding

In addition to general competencies developed as a result of offering science curriculum, learners are expected to develop the subject related competencies based on the scientific knowledge and understanding, skills and processes, and scientific values and attitudes of curiosity, integrity and problem solving.
Thus, students are expected to:

- understand phenomena, facts and patterns, principles, concepts, laws, theories, and models in science.
- learn the vocabulary, terminology and conventions used in science.
- acquire knowledge of techniques and skills specific to the study of science.
- develop an understanding of technological applications of science and of their social implications.

5 Scientific Skills and processes

The scientific processes and skills are fundamental to the development of foundational and mastery of scientific skills. This component of science education is critical in personalizing learning and stimulates learners to generate new knowledge and create ideas and innovate plethora of scientific artefacts and young scientists and researchers. Following are the attributes of scientific skills and processes:

5. 1 Scientific Thinking

Learners are expected to:

- identify characteristics of objects or natural phenomena.
- recognize patterns and changes in the natural world and use them to forecast trends.
- develop valid conclusions by examining evidence and applying logical reasoning.
- recognize the critical significance of models in elucidating natural events.
- recognize that models are updated as new or contradictory evidence is discovered.
- use logical reasoning and experimentation to test hypotheses and concepts.
- use experimental evidence to identify preconception or misconception.
- apply concepts to new contexts by integrating them into a knowledge framework.

5. 2 Scientific investigation

Learners are expected to:

- ask relevant questions.
- develop hypotheses regarding scientific phenomena and methods for testing them
- distinguish between dependent and independent variable in research experiment.
- device plans and processes for conducting investigations
- choose appropriate methodology and apparatus to conduct investigations.
- observe and report experimental observations correctly and honestly.
- organize and analyze data, as well as draw conclusions from observations and experiments.
- use appropriate graphical tools to illustrate experimental data and convey concepts.
- write reports on investigations, draw conclusions, and offer predictions for the future.
- assess experimental results and identify elements that influence their quality and consistency.
- make recommendations for additional research, if necessary.

5.3 Practical Work

Learners are expected to:

- device and execute experiments.
- choose the right equipment and materials for an experiment.
- carry out experiments in accordance with procedures.
- operate the instrument in a safe and proper manner.

- measure with the precision that the instruments allow.
- be aware of the limitations of the equipment they are using.
- analyse and evaluate data from observations and experiments.
- assess experimental procedures and make recommendations for improvements.

5.4 Problem Solving

Learners are expected to:

- define and analyse problems in the science field.
- use scientific knowledge and concepts to address difficulties
- make suggestions for problem-solving ideas or solutions.
- make recommendations for solutions and assess their viability.
- create effective techniques for dealing with any challenges that may occur.

5.5 Decision Making

Learners are expected to:

- make judgments based on the evidence and arguments presented.
- rely on scientific ideas to back up decisions.
- provide appropriate arguments for choosing amongst alternatives.

5. 6 Information Handling

Learners are expected to:

- use libraries, the media, the Internet, and multi-media software packages to find, retrieve, reorganize, analyse, and evaluate scientific material.
- use information technology to organize and present data, as well as to cultivate self-directed learning habits.
- be cautious of the authenticity and reliability of secondary sources of information.
- distinguish between fact, opinion, and value judgment when analysing scientific data.

5 .7 Communication

Students are expected to:

1. read and comprehend publications that contain scientific vocabulary, concepts, and principles.
2. employ acceptable terminology to express science-related information orally, in writing, or in other appropriate formats.
3. logically and vividly organize, convey, and communicate scientific ideas

5.8 Collaboration

Students are expected to:

1. take an active role in group discussions, sharing thoughts and making suggestions.
2. communicate, negotiate, and compromise with others in group work.
3. create common goals and define and agree on the roles and duties of participants in research work.
4. do assigned responsibilities in a responsible manner.
5. be receptive to team members' suggestions and constructive criticism.
6. maximize the team's potential, capitalize on each member's unique strengths.
7. show willingness to assist less capable team members while also seeking assistance from more capable team members.
8. use ways to collaborate effectively in project teams.

5. 9 Self-directed learning

Students are expected to:

1. improve the study abilities to make the learning more effective and efficient.
2. engage in science-related self-directed learning activities.

3. cultivate suitable learning habits, abilities, and positive attitudes, all of which are necessary for lifelong and independent learning.

6 Scientific Values and Attitudes

The concepts and ideas that impact one's decisions, judgments, behaviours, and actions on the route to individual, societal, and environmental well-being are referred to as values and attitudes. Two significant elements that influence the cognitive process and behaviour are values and attitudes. They are learnt and acquired, as well as enduring and change-resistant. Knowledge, skills, attitudes, and values are not conflicting ideas in competency-based education; they are developed in tandem.

Learners are expected to develop the following types of values and attitudes as part of the scientific curriculum in order to live in harmony and peace in society.

6.1 Themselves and others

Learners are expected to:

- develop and possess positive values and attitudes such as curiosity, honesty, respect for evidence, perseverance, and tolerance for uncertainty.
- cultivate the habit of self-reflection and critical thinking.
- be open to discussing and commenting on scientific topics.
- develop open-mindedness and the ability to exhibit tolerance and respect for others' thoughts and decisions, even when they differ from your own.
- be conscious of the importance of personal and social safety, and commit to safe practices in their daily lives.

6.2 Science and an environment around us

Learners are expected to:

- appreciate scientific accomplishments while acknowledging their limitations.
- accept the knowledge and theories of science as tentative.
- use science knowledge and expertise to make rational decisions or judgments about challenges in their daily life.
- be aware of the social, economic, environmental, and technological consequences of scientific breakthroughs.

6.3 Learning as a lifelong process

Learners are expected to:

- recognize the repercussions of evolutionary nature of scientific and recognize the importance of knowledge updating in the realm of research and technology.
- be exposed to new scientific, technological, and scientific advancements and acquire an interest in them.
- become aware that scientific knowledge is a human creation that is prone to change.
- recognize the value of lifelong learning in our knowledge-based culture that is rapidly evolving.

7 Guiding Principles

Guiding principles are set of assumptions, theories, ideologies, and educational principles that guide the development of curriculum materials and for teachers during the delivery of instructions. They are critical in defining the boundary of coverage of the curriculum, in terms of content extent, pedagogical approaches and strategies, learning experiences cognizant of individual differences in learning. The Science Curriculum

Framework is developed based on the broad guiding principles of National School Curriculum Framework and specific subject guiding principles as reflected below.

7.1 Developmental Appropriateness

The Science Curriculum Framework emphasises the importance of a developmentally appropriate curriculum based on the knowledge and skills about how children develop and learn. Although, no one theory of development is sufficient, the Science Curriculum was informed by:

i. Stage theory of development proposed by Jean Piaget. Therefore, during Key Stages 1 and 2, the Science Curriculum focuses on concrete everyday experiences for younger learners such as grouping and sorting. At Key Stage 1 in Strand 1, Life processeses, learners are asked to ‘group living things according to observable similarities and differences. For example, plants and animals as wild or domestic, and fruits and vegetables as edible or non-edible. At higher key stages, Key Stages 3 to 5, learners are introduced to more abstract ideas such as theories and models. For example, at Key Stage 4 in Strand 3, Materials and their Properties, learners are required to ‘explain, using particle theory, how the rates of reaction depend on the frequency and energy of collisions between particles, and apply this knowledge to explain why temperature, concentration and surface area affect the rates of chemical reactions.’

ii. Bloom’s taxonomy of cognitive domain to inform the writing of the key learning outcomes. For example, in the lower key stages there is more focus on learning outcomes which require learners to be able to recall and describe. At higher key stages the focus changes to learning outcomes where learners are required to explain, apply, synthesise, evaluate, and create.

iii. The outcomes of the consultation meetings. At all stages of development, key stakeholders’ views were sought to ensure that the Science Curriculum is developmentally appropriate and progressive for Bhutan’s learners, and that it fulfils the needs of the Bhutanese society.

7.2 Learners and Learning

Children learn from birth, and learning continues throughout their lives. This view is supported by the science education literature, which demonstrates that learners already bring an understanding of the natural world to the science classroom. As soon as learners start to interact with the environment, they start developing personal beliefs, concepts, and skills about the world around them. Using their past experiences, beliefs and myths, children develop ideas and theories to explain the natural phenomena which may not always be consistent with the conventional scientific ideas. For example, when learners come to their first science class, they have their own ideas of why people need food and water to live; why water flows downhill; and what happens if they touch hot objects. Therefore, children and scientists both have views about how and why things behave as they do and have meanings for words in science.

However, children’s views and meanings may be quite different from the scientists’ meanings. What needs to be remembered, from the point of view of science teaching, is that in terms of the child’s maturity, experiences and language, the child’s view may appear far more sensible and logical to him or her than the scientists’ viewpoint. They are amazingly tenacious and resistant to any change. In order to develop children’s ideas consistent with conventional science, the science education literature advocates that learning must take place through the active participation of learners. This is further discussed in the next two sections, 4.3 Teaching for Constructing Knowledge and 4.4 Effective Pedagogy, the principles through which effective teaching and learning can occur.

7.3 Teaching for Constructing Knowledge

As discussed in section 4.2, learners already bring considerable understanding about the natural world to the classroom, which may or may not be consistent with the conventional scientific understanding. These understandings are deeply held and are resistant to change. In response to these challenges, several constructivist approaches to science teaching are being proposed, which are summarised as:

- identification of the students' past experiences, ideas, and views before the teaching;
- provision of opportunities for the students to explore their ideas and test their strength in explaining phenomena, accounting for events, and making predictions;
- provision of stimuli for the students to develop, modify and, where necessary, change their ideas and views; and
- support the learner's attempts to rethink and reconstruct his or her ideas and views.

Therefore, as this document is developed into the taught curriculum, the designers must ensure that the teacher's role is to bring to the learning process ideas, explanations, activities that cause the learners to question their ideas in the process of 'cognitive disequilibrium' (Hodson, 1998, p.37). However, the cognitive disequilibrium is not enough to achieve conceptual change, as it is only when the ideas from science are perceived by learners to be more intelligible, plausible, and fruitful than their own ideas that conceptual change can begin to take place. 'Intelligible' means that the new science concepts are understood clearly by the learner; 'plausible' suggests that the new ideas are reasonable to the learner; and 'fruitful' suggests it has the capacity to provide something of value to the learner by solving problems, making valid and reliable predictions or provide new insights, and suggest new ideas for investigation and study (Hodson, 1998, p.39).

In summary, the learning activities designed from this Curriculum Framework should be able to offer opportunities for the learners to feel that the conventional scientific ideas are more intelligible, plausible, and fruitful than their own everyday understandings in the development of more complex understandings of the accepted scientific ideas.

7.4 Effective Pedagogy

Learning is a result of active interaction between a learner with teachers and the surrounding world to which they belong. This section discusses the key principles of effective pedagogy that curriculum developers and teachers need to adopt to help learners learn as social and personal enterprise.

i. Active hands-on learning

The teaching of a curriculum that seeks to achieve the goals and learning outcomes outlined later in this document, and to achieve constructivist teaching as described above, rests on the premise that science is an active process. Through role playing, games, simulations, talking, reading, writing, and experimentation, students continue to explore their own understanding and begin to gain an appreciation of the views and understanding of others.

Learning is therefore, something that learners do, not something that is done to them. 'Hands-on' activities are essential throughout a good science education, but they are not enough. Activities should also involve an approach that requires learners to think and be critical in a more inquiry-led approach. An 'investigative' or 'enquiry' approach encourages children to be more independent and self-reliant, to think of themselves as able to pose their own questions about the physical world and to find answers to them through their own efforts. In this way, it contributes to the general educational goals concerning the development of learners as virtuous individuals and their capacity for purposeful and independent action in the world. This kind of investigative-led learning is essential. The learners, when engaged in a range of investigative activities, such as asking questions, designing investigations, constructing explanations, and testing these explanations against current scientific knowledge and communicating their ideas to others in a wide range of ways learn to think and be critical both in the science classroom and in their daily lives as educated citizens. It is believed that learning is enhanced when the learners accept responsibility for their own learning. The teacher assumes the role more of a facilitator and less of a purveyor of facts, principles, and skills. Inevitably, such an approach demands the teachers to adequately plan and prepare the learning experiences to engage the learners through a more inquiry-led process. Furthermore, the teachers should constantly monitor the teaching-learning processes in their classrooms and use assessment to ensure that the different teaching strategies that they use in classrooms are helping the learners make progress in their learning. Therefore, assessment is considered in the next section.

ii. Assessment for learning

Assessment for learning is on-going and takes place in lessons and in between lessons and should be an integral part of the science teaching and learning process. The types of assessment should assess not only the learner's developing knowledge and skills, but also their ability to think critically, solve problems and apply their knowledge to new challenges and situations. The assessment must be based on whether the learners have achieved the outcomes stated in the Science Curriculum Framework at the appropriate level, with evidence gathered using a wide variety of appropriate assessment strategies and tools. At the same time, the assessment should guide teachers in the selection of appropriate teaching strategies as stimuli variation in improving the learners' learning.

iii. Classroom environment

A conducive learning environment is pivotal to the successful implementation of the new Science Curriculum. The key characteristic of exemplary science teachers is their ability to establish supportive classroom environments for their learners. Therefore, the teachers must show respect to the individual learner's views and needs; create a safe and secure environment; and provide the learners with the opportunity to actively participate in the teaching-learning process. It is crucial that the science teachers exhibit tolerance and respect for the diverse ideas, skills, and experiences of all learners. Research studies have proven that the learners enjoy learning science when they see how science relates to their lives. For this, it is imperative that the science teachers go beyond their classroom teaching routine to engage learners in other science activities. The science teachers together with the learners develop a science corner, a nature corner, a museum shelf, an aquarium, a weather station, and an eco-pond in and around the classroom. These are some of the essential learning facilities that the science class can develop to aid the science teaching-learning processes and the learners self-learning.

iv. Effective use of Information and Communication Technology (ICT)

The science teaching and learning process can also be enriched with the purposeful integration of ICT. This has the following benefits: ICT in science classes promotes cognitive acceleration in learners; enables a wider range of experience so that learners can relate science to their own and other real-world experiences; increases the learners self-learning management and facilitates data collection and presentation. Therefore, ICT can play a vital role in supporting the learning of science in areas such as measuring, exploring, investigating, analysing, and interpreting. In addition, simulations can be used when an activity is not possible in a science laboratory. The Internet can also be used by the learners to access information and undertake problem solving activities. While using ICT, the learners also develop their skills in a wide variety of ICT applications, which should serve them well in the future. The new Science Curriculum, therefore, encourages the integration of ICT as an integral part of the science teaching strategy as and when feasible.

v. Gender sensitive

It is important that teachers ensure equal participation of boys and girls in all aspects of the science learning process, consistently use non-sexist language, and avoid competitive approaches in curriculum design and teaching. Activities, materials, and resources must be developed by the curriculum designers that appeal both girls and boys, and be relevant to their lives.

7.5 Language Learning

Scientific terminology and the grammatical structure of scientific English is vital for learners to effectively comprehend and communicate their ideas and study findings to the class and the wider world.

i. ***Scientific terminology***

Wellington and Osborne (2001, p. 20) identified three levels of difficulty for scientific terms. At the lowest level of difficulty, are 'naming words' such as oesophagus, fibula, meniscus, and vertebra. Level 2 words are 'process words' which include words such as evaporation, distillation, condensation, photosynthesis, and evolution. Level 2 words also offer an additional challenge as some are processes which can be observed and demonstrated directly, such as distillation. However, other level 2 words, such as evolution 'belong to a higher level within this category' because they are not directly observable. The most challenging category, level 3 words are concept words such as energy, force, and work. Concept words denote ideas at gradually ascending levels of abstraction. The difficulty is magnified because these words cannot be understood in isolation. They are a part of a network of other words, all related together, often in a 'vertical structure', i.e., the understanding of one word (such as power) depends on the prior understandings of other words (such as work and energy). Without the prior understanding of the components of the concepts, the learners will not understand the concepts. Therefore, it is suggested that new technical terms be introduced in a systematic way and at an appropriate pace so that not too many terms are introduced in a lesson. The Science Curriculum has been designed to be developmentally appropriate and takes account of the Piagetian stages. Therefore, the teachers will have to be careful not to introduce too many new terms too quickly and to consider the level of difficulty of the scientific terminology that is being introduced.

ii. ***The grammar of scientific English***

The language of Scientific English must be direct, using commonly understood words. Wellington and Osborne give examples of classroom strategies that teachers can use to develop these areas, for example, writing frames and Directed Activities Related to Text (DARTs). Writing frames are templates to help the learners model certain grammatical ways of writing in Scientific English, such as writing an explanation for a practical activity. DARTs activities make learners read and engage actively with textbooks or reference books to develop both their reading and scientific writing skills. So, as the curriculum developers and the teachers develop the curriculum, they will need to consider the appropriate use of writing frames, and DARTS activities to facilitate the learning of scientific English.

7.6 Knowledge and Understanding

Every subject area of the school curriculum must contribute to the general education of the learners so that they are:

- skilled in the use of speech, symbol, and gesture to communicate their ideas;
- factually well informed;
- capable of innovating and appreciating objects of aesthetic significance;
- endowed with rich social, cultural, and environmental values;
- able to make informed decisions and to judge between right and wrong; and
- motivated to learn.

The aspiration of the Science Curriculum is to develop in learners the notion of a 'scientific temper' which is the spirit of enquiry, the courage to question objectivity, and to be divergent in independent thinking guided by the knowledge of scientific methods of enquiry and its use in solving problems. Therefore, the Science Curriculum has been developed not only to give the learners a strong foundation in science so that they are factually well informed but also to develop scientifically literate citizens, which is consistent with the idea of developing a scientific temper imperative to pave the path to go beyond the prescribed course of studies. A scientific literate citizen is seen as one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; understands key concepts and principles of science; is familiar with the natural world and recognises both its diversity and unity; and uses scientific knowledge and scientific ways of thinking for individual and social purposes. This then contributes in making effective learners who can make 'wise decisions and judge between right and wrong'. For example, in Strand 1, working scientifically, the earners progressively carry out more complex investigations, which require them to collect and use evidence to solve problems. In Strands 2, 3 and 4, the learners engage with ideas about the sustainable development e.g., sustainable use of timber and energy in order to understand the decisions that need to be made for humans to live in harmony with their environment, now and in the future, drawing on their scientific knowledge and understanding.

7.7 Culture and Values

The Science Curriculum outlines the importance of the practices of Buddhism and its profound influence on the learners' spiritual, cultural and traditional way of living. The programme of study in science is to be developed consistent with the above principle in the following ways:

i. ***Individual self-discipline***
The Science Curriculum contributes significantly to an individual's self-discipline. For example, in Strand 2 Life processeses, the Science Curriculum requires the learners to recognise the dangers of many types of drug abuse to the learners' individual wellbeing, so that they have the knowledge and understanding to act responsibly, and with self-discipline, to protect their own health and the health of their family and community. Strand 1, working scientifically, also develops the learner's skills in team work when they carry out investigations in groups. In doing so, learners will have to take individual responsibility for the success of the investigation, and develop qualities of honesty in communicating their results and explaining their conclusions.

ii. ***Individual relationship with nature***
The fundamental law of nature is that all forms of life regardless of religion, law, creed, or education survive by cooperation based on their interconnectedness and the precept of *Tha Dhamtsi Lay Jumdrey*. This philosophy extends reverence to all species of organisms, the values of environmental care and protection, and aversion to pollution of land, air, and water as important aspects of traditional values. The Science Curriculum ensures that the learners develop a deep understanding of their own relationship with nature. For example, in Strand 2, Life processeses at Key Stages 1, 2 and 3, the learners consider ways they can care for animals and plants and for the environment. By Key Stage 4, they learn about ideas of interdependence, adaptation, competition and predation and the impact of humans on the environment and how to live more sustainably in harmony with their environment. At Key Stage 5, they study the sustainable management of natural resources, such as forests and agriculture, and they look in detail at the harmful effects of pollution. In Strand 3, materials and their properties, learners at Key Stage 3 study the effects of pollution by considering the harmful effects of burning fossil fuels, such as global climate change. At Key Stages 4 and 5, the topic "green chemistry" looks at pollution, sustainable development, the chemistry of global climate change, biodegradable and non-biodegradable polymers and the chemistry of the damage to the ozone layer.

iii. ***Relationship with others in society***
Learners thrive better in classrooms where there are relationships of respect, trust and cooperation between teacher and the learner, and amongst learners themselves. In the classroom, there are issues of duty and obligation between the teacher and the learner, but also amongst the learners themselves. Issues of duty and obligation amongst the learners particularly, arise as they embark on scientific investigations in groups.

Each member of the group has a duty and obligation to contribute to the success of the task, to be enthusiastic, and to encourage and support others in the group who may find the task challenging so that all learn and benefit from the collaborative effort.

Therefore, the Science Curriculum ensures that the learners undertake investigative work in order to contribute to developing strong purposeful, caring, and constructive relationships in the classroom. The development of these qualities within the classroom will manifest in the learner's daily lives in the community, where they will have to solve problems that arise on a day-to-day basis.

7.8 Community Involvement

The Science Curriculum, to the maximum extent, is designed to offer teachers opportunities to involve the members of local community in the teaching and learning of science on the local knowledge and practices. In Strand 2, Life processeses, local farmers and foresters can contribute to the learners understanding of local sustainability issues. In Strand 3, materials and their properties, local businesses such as soap makers can contribute to an understanding of how chemical reactions are used in the community to make useful products that benefit human health. In Strand 4, Physical Processes, there are opportunities for those working in the community to talk with the learners or for the learners to visit these projects for first-hand information and observations. In addition, the Science Curriculum encourages field work by taking the learners out to project sites, nature reserves in the local community to explore scientific ideas and to become aware of the applications of science in the real-life situations.

7.9 Local Knowledge

Communities are storehouses of knowledge and practices about different aspects of Bhutan's environment, and traditional and cultural values passed down over generations. The constructivist paradigm also states that the child's community and local environment forms the context for more effective learning and constructing knowledge. Therefore, the Science Curriculum has been designed so that, at different key stages, the learners' own thoughts and immediate contexts are drawn upon to construct knowledge. For example, in Strand 2, Life Processes, the learners study animals and plants drawing on examples from their immediate environment. At higher levels, the learner's study ethno-biology and, as said previously, how plant products are used traditionally for food, shelter, medicine, clothing and in religious ceremonies to show the links between science and traditional practices. In Strand 3, materials and their properties, local knowledge of the production of soap and other important local products is drawn upon to study chemical reactions. In Strand 4, Physical Processes, local knowledge of how simple machines work is drawn upon in the force's topic and, in the energy topic, local knowledge is drawn upon to demonstrate how energy is conserved in the use of renewable energy resources.

7.10 Science and GNH

The development philosophy of Bhutan rests on the nine domains of Gross National Happiness. "A GNH inspired education system is expected to engender students who are genuine human beings, realising their full potential, caring for others, ecologically literate, contemplative as well as analytical in their understanding of the world, free of greed and without excessive desires; knowing, understanding of the world, and appreciating completely that they are not separate from the natural world and from others. In sum, they must manifest their humanity fully."
Lyonchoen Jigme Y Thinley (December 2009), GNH Workshop
The Science Curriculum has been designed underpinning the principles of Gross National Happiness as an approach to science teaching so that, learners imbibe the essence of harmonious living in the society and with the environment, and to engender students with full values of humanity and capability. Science is one of the learning

areas that enhances the understanding of the natural world; hence, it is a vital medium for disseminating the values and principles of GNH through its myriad conceptual and pedagogical tools.

8 Curriculum Structure and Organization

The school curriculum is the core tool for educating learners and transform them to knowledgeable, rational, and human beings, who are socially responsible and enterprising individual with potentials to contribute in nation building. It comprises of all the learning experiences that happen under the auspices of schools, which include aims and objectives, instruction, and assessment towards attaining the targeted learning outcomes and standards by learners. As informed by theories of child development and learning, the curriculum contents are structured under different areas of learning, and organized systematically for coherence and progression.

8.1 Strands

The science curriculum is offered through two ways as “Content strands” and “Process Strand”

8.1.1 Process strand

Working Scientifically: Science involves a distinctive way of looking and thinking about the world. In science, scientific inquiry is central to all investigation. Through the process of scientific enquiry, students develop answers to questions and improve explanations for phenomenon in the natural world. Scientific investigation like questioning and predicting, planning, and conducting investigations, processing and analysing data and information, problem-solving and communicating are included under this strand.

Working scientifically involves investigation processes, including understanding the types of questions that are the province of science; the design of experiments; reasoning and arguing with scientific evidence; and analysing and interpreting data. Science curriculum provides a platform for the learners to engage in scientific inquiry to develop their knowledge and concepts of scientific ideas. In science curriculum, activities should be designed for the learners where they can scientifically investigate the problem. The achievement of working scientifically will depend on the three other strands.

In order to fulfil this strand, science curriculum includes learning activities on life and living, materials and their properties and Physical Processes. The process strand or general or essential skills are not taught separately; rather it serves as the means of engaging learners through all lessons in the subject. For example, in science – students observe, measure, analyse and draw generalization (knowledge construction). To bring about the STEM education through this strand, Scientific Method and Engineering Process and Society and Technology are being emphasised.

8.1.2 Conceptual strand

1. **Life Processes:** Any attempt to unfold the mysticism of living things from the work of protein molecules, to the growth of organism, from a single cell to the majesty and intricacy of whole ecosystem is attributed as part of life and living. It deals with living organism and their organization, Life processes, and relationships to each other and their environment. Life and living have become one of the leading metaphors of scientific literacy given its dynamism in growth and expansion, profundity in discovery, and applications in everyday life.
2. **Materials and their Properties:** Through this strand, learners’ study about matter, its properties, how and why substances combine or separate to form other substances and how substances interact with energy. The basic knowledge in materials and their properties can help learners in earning a degree in chemistry where they can explore various areas of chemistry including biochemistry, organic, inorganic, physical, environmental, and experimental chemistry. Learners learn the basic laboratory courses that are useful to conduct research and laboratory work as they move to higher level. The study of materials and their properties is essential in science education as there is much to learn and discover. Some concepts in

materials and properties are essential to learn other sciences. Through materials and their properties, learners learn to appreciate the world and understand how to collect, organize, and interpret chemical data. Learners develop their skills to use equipment to analyse and can apply principles of chemistry to solve qualitative and quantitative problems.

3. **Physical Processes:** Under this strand, learners will understand and learn to apply key scientific concepts such as force and motion, energy, light and sound, electricity and magnetism, waves and the Earth and the universe. Learners will also consider key environmental issues such as energy use and conservation. The Physical Processes generates the knowledge that is applicable in solving the crisis in the field of climate change, energy, peace, societal development, and economic development. It enhances deeper understanding of how Physical Processes is correlated with the development of knowledge in Life Processes and materials and their properties. It also supplements in building the foundational knowledge and skills in the field of physical world and universe.
4. **Environmental Science:** Environmental Science is the study of environmental systems, the threads of life that every life form is linked with. It offers an integrated, quantitative, interdisciplinary, and students-centred approach. The multidisciplinary nature of the study integrating physical, chemical, biological, and social sciences, peppered with cultural and spiritual belief of human societies brings the holistic perspective, making it unique and interesting among the widely taught school courses. The study exposes students to fundamentals of physical, chemical, geological, biological, and social processes that interact to shape the environments of the planet that we inhabit. This helps students to connect various processes in the system together, which is extremely important in treating the challenges as a whole and not in isolation. Ultimately, the study of environmental science aims to empower students to make right choices for sustainable future with global perspectives, and transform them to be responsible and productive citizens in the 21st century world.

8.2 Key Stage

8.2.1 Key Stage 1(PP-III)

This period is best described as the "symbolic mastery". What is important at this key stage is the opportunity to explore and to work intensively with materials that nourish the human intelligence. During Key Stage 1 (Classes PP-III), the learners should be able to observe, explore on their own and ask questions about living things, materials and phenomena focused on their immediate environment and concrete everyday experiences. They begin to work together and ask questions to collect evidence to help them answer questions and to link this to simple scientific ideas. In the early years of this key stage, the learners will be developing their observation skills using their senses to gather and record information, identify patterns, and talk about their ideas. They communicate their ideas and observations orally, by drawing, or singing, for example.

In the later years of this key stage, they will begin to identify parts of a system and begin to understand the relationship between cause and effect, for example touching a fire will burn their hands or dirty water can cause diseases. They communicate their ideas and observations descriptively in different ways using simple scientific language, for example being able to use the correct names for different parts of their body. They will also be able to use drawings, charts, and tables for communication. The learners should know about the contributions of some key people in science using pictures and simple stories. The science components are integrated in language and mathematics in this key stage and is not taught as separate subject.

8.2.2 Key Stage 2 (IV-VI)

Science is taught as separate subject starting from this key stage. The children in this key stage develop a new quality of mind. They start to understand perspectives as their memory capacity increases. Therefore, children can make mental operations, think logically and are ready for a deeper understanding of different subject areas. During

Key Stage 2 (Classes IV-VI), the learners discover a wider range of living things, materials, and phenomena, though still predominantly focused on their immediate environment and concrete everyday experiences. They begin to make links between ideas and to explain things using simple models and theories and, therefore, begin to think in more abstract terms such as in Strand 3 being able to classify materials as solids, liquids, and gases or in Strand 4 being able to classify forces as contact or non-contact forces. They apply their knowledge and understanding of scientific ideas to familiar everyday occurrences, everyday things, and their personal health.

In the later part of this key stage, they begin to think about how humans have used scientific knowledge and skills for developments. The learners should also be able to appreciate that scientific and technological developments have both positive and negative effects. They use their learning in science for planning positive action for the welfare of themselves, others, and the environment in their own communities. They carry out more systematic investigations, working on their own and with others. For example, they might investigate the solubility of common substances such as salt, sugar, and flour. They also understand how to design a fair test to show the influence of variables in their investigations. For example, when investigating the effect of light on plant growth, they control variables such as the type of plant and the amount of water given.

They reflect on their learning and work and consider ways their investigations can be improved, modified, or adapted. They use a range of reference materials in answering questions and to consider scientific phenomena in greater depth. They talk about their work and its significance, and communicate ideas using a wider range of scientific language, simple diagrams and drawings, charts, and graphs. They understand that scientists are creative and that they work to try establish cause and effect in the natural world. They begin to understand the importance of testing ideas using evidence from observations and experiments.

8.2.3 Key Stage 3 (VI-VIII)

In the adolescent years, there are significant developments, mainly the movement towards abstract thinking, dealing logically with multifaceted situations and the development of meta-cognitive abilities. During Key Stage 3 (Classes VII-VIII), the learners build on their scientific knowledge and understanding and make simple connections between different areas in science. They use basic scientific ideas and models to explain phenomena and events, and to understand a range of familiar applications of science. They can also apply their basic scientific knowledge to improve their quality of life and for the welfare of others in the community. They think about the positive and negative effects of scientific and technological developments on the environment. For example, the learners, after knowing about global climate change can learn how to act locally to lessen the effects of global climate change, by planting trees and by not burning paper and plastics.

Learners do simple quantitative work, like calculating the resistance in a circuit using readings of current and voltage, carrying out investigations on their own and with others. They evaluate their work, in particular the strength of the evidence they and others have collected, and they find patterns that allow for predictions. They select and use a wide range of reference materials and begin to be aware that these sources of information can be biased which will influence the validity and reliability of the information in answering questions. They communicate clearly what they did, and they can also consider the significance of their work. They communicate their ideas clearly and precisely in a variety of ways including the use of ICT. They can recognise that modern day science has its origins in the contributions of scientists from many different cultures and from different societies from around the world. They can describe how different scientists have worked together both in the past and on the present-day scientific developments. They also know about the key role of experimental evidence and creative thought in developing and testing scientific ideas and theories by drawing on examples from past and present scientific discoveries.

8.2.4 Key Stage 4: (IX-X)

Science is bifurcated into disciplined based sciences starting from this key stage and taught as physics, chemistry, biology and environmental science. At this key stage, learners demonstrate significant developments in terms of logical and abstract thinking and can comprehend complex situations. For older children, education is for understanding, for mastering disciplines and for apprenticeship. During Key Stage 4 (Classes IX and X), the learners develop basic knowledge and understanding of the concepts of Chemistry, Biology and Physics and the fundamental skills needed for the use of these in new and changing situations. The learners discover a wider range of scientific ideas and consider them in greater depth, laying the foundations, if appropriate, for further study in science and apply these ideas in new contexts to solve problems. They explore how technological advances are related to the scientific ideas underpinning them. They consider the power and limitations of science in addressing social, industrial, ethical, and environmental issues, and how different groups in the community and beyond may have different views about the role of science. They make informed judgments on statements and debates that have a scientific basis and use their learning in science for planning positive action for the welfare of themselves, others in their community and the environment. When they carry out investigations, working either on their own or with others, they draw on increasingly diverse and complex sources of information which they select considering issues of the reliability and validity including the key scientific concepts introduced at this key stage to plan their investigation or inquiry.

They use a wide range of techniques to carry out their plans and investigations which will be quantitative in nature. They evaluate critically all the evidence collected to draw conclusions. In drawing these conclusions, they compare, contrast, synthesise, question, and critique the different sources of information. They communicate their ideas clearly and precisely in a variety of ways including the use of ICT. They see how scientists work together to develop new ideas, how new theories may, at first, give rise to disagreements in the scientific world and how social, cultural, and religious contexts may affect the extent to which different theories are accepted. They see the limitations of science and the questions it can and cannot answer. For example, science can answer questions like ‘Why is the sky blue?’ and ‘Why do we resemble our parents?’ However, it cannot currently answer more philosophical questions, for example, ‘Why are we here?’ and ‘what is the purpose of life?’

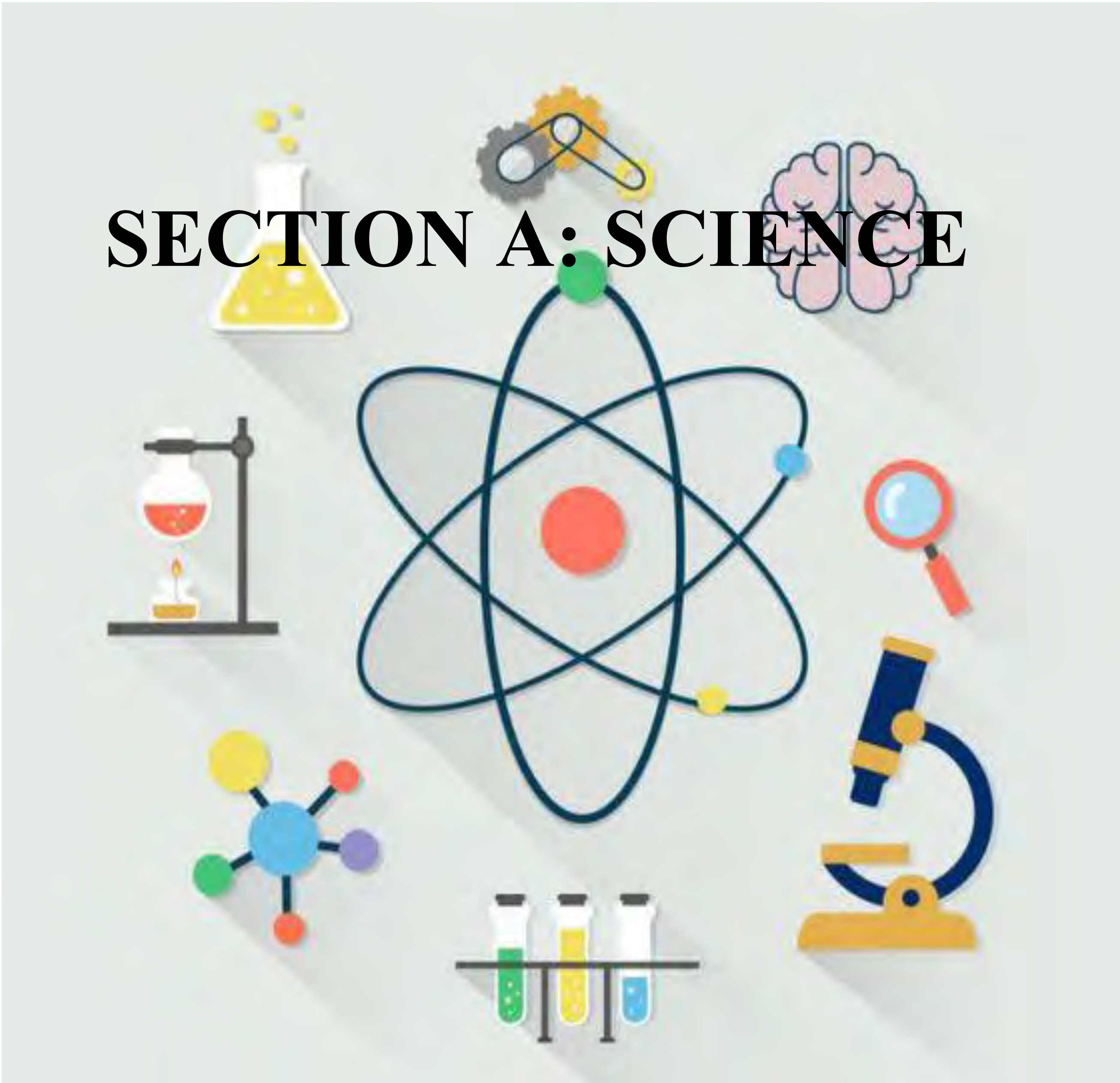
8.2.5 Key Stage 5 (XI-XII)

At this key stage, the learners have well developed meta cognitive abilities and an understanding of the natural world around them. Children with young and maturing minds are moving towards making critical and informed decisions about a career and becoming a productive member of society.

During Key Stage 5 (Classes XI - XII), learners develop essential knowledge and understanding of the concepts of Chemistry, Biology and Physics and the skills needed for the use of these in new and changing situations. They will be able to use theories, models, and ideas to develop and modify scientific explanations. They will be aware of how advances in information technology and instrumentation are used in Chemistry, Biology and Physics; and appreciate the contributions of Chemistry, Biology and Physics to society and the responsible and ethical use of scientific knowledge and evidence. The learners will be able to bring together knowledge of ways in which different areas of Chemistry, Biology and Physics relate to each other. In investigative work, they will be able to demonstrate a high level of responsibility in the management of a wide range of tasks in different contexts and in the management of their own learning. They will be able to plan and manage complex investigations where they will be able to clarify goals and approaches in relation to the information they need to access and collect. They will be able to show initiative, creativity, perseverance, and problem-solving skills in these investigations, and be able to compare and evaluate information and ideas from different sources, such as the Internet, and critically select and synthesise information to answer scientific questions and solve scientific problems. They will use ICT in imaginative and creative ways to communicate their scientific understanding. They appreciate the role of the scientific community in validating new knowledge and ensuring integrity and appreciate the ways in which society uses science to inform decision making.

8.3 Key Stage wise Competency based Standards

Learning standards are concise, written descriptions of what students are expected to know and be able to do at a specific key stage of their education. Learning standards describe educational outcomes —i.e., what students should have learned by the end of a course, grade level, or grade span, but they do not describe any particular teaching practice, curriculum, or assessment method. The competency-based standard which describes the ability to apply knowledge and skills in diverse situation serves as the bench marks for different key stages. Specific subject standards are mentioned for different content strands for different key stages.



9 SECTION A: SCIENCE

9.1 Key Stage 1 (PP-III)

1.1.1 Strand: Life Processes

Competency Based Standard

By the end of Key Stage 1 (Class III), the learner should be able to:

- use the knowledge of variations or characteristics to classify things into living and non-living, fruits and vegetables, domestic and wild animals with examples and state their significance.
- identify the human and animal body parts, state their functions, explain the life cycle of some common animals, and share their importance.
- identify the parts of plants and their functions and explain the role of flowers, fruits, and seeds in reproduction.
- explain the relationship between plants and animals based on habitat and food.

Class-wise Competency

Class PP

By the end of class PP, the learner should be able to:

1. **Classification and Variation**

- state the examples of things from the environment and sort them into living and non-living things based on their unique characteristics.

2. **Human and Animal**

- name the external parts of the human and animal body and state their importance.

3. **Green Plant**

- collect and name different parts of a plant and state their importance.

4. **Living Things and their Environment**

- name animals and recognise the places they live.

Table 1. *Learning objectives and process/essential skills for Life processes, class PP*

Learning objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential skills	
		Scientific Methods and Engineering	**Society and Technology**
i. Name some living and non-living things in the surrounding through observation. ii. Sort things into living and non-living things.	1. **Classification and Variation** 1.1 Living and non-living things *(Scope: name and sort examples of living and non-living).*	**Obtaining, Evaluating and Communicating Information** The learners observe, identify and sort things around them into living and non-living	**Serving human values and influence value formation** The learners examine the things around them to develop a caring attitude towards living things.

i. Recognise the external parts of the human and animal through observation.	**2. Human and Animal** 1 External parts of the body *(Scope: identify and name the external parts of human and animal)*	**Obtaining, Evaluating and Communicating Information** The learners observe and name the external parts of a human and animal.	**Serving human values and influence value formation** The learners study the human and animal around them to recognise their external parts.
i. Identify the external parts of a plant to name them.	**3. Green Plants** 3.1 Parts of a plant *(Scope: collect different parts of a plant [leaf, root, stem, and flower] to name them)*	**Obtaining, Evaluating and Communicating Information** The learners collect, observe and name different parts of a plant.	**Serving human values and influence value formation** The learners observe different plants around them to recognise the external parts.
ii. Name the habitat of some common animals through observation and information gathered from the internet.	4. **Living Things and their Environment** *(Scope: habitat for some common animals [e.g., stable, shed, kennel, nest, water, etc.]).*	**Obtaining, Evaluating and Communicating Information** The learners observe and name the habitat of some common animal	**Exploring Digital Resources** The learners use the internet to explore the habitat of common animals.

Class-wise Competency

Class I

By the end of class I, the learner should be able to:

1.Classification and Variation

- classify things into living and non-living based on observable features to enhance learners' ability to study the patterns in daily activities.

2.Human and Animal

- draw and label the external structures of human and animal to improve hand-eye coordination.

3.Green Plants

- observe the plants and then draw, colour, and label the different parts.

4.Living things and their Environment

- identify the relationship between plants and animals to be aware of their coexistence.

Table 2. *Learning objectives and process/essential skills for Life processes, class I*

Learning objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential skills	
		Scientific Methods and Engineering	Society and Technology
i. Observe things around them and classify into living and non-living based on their observable features to enhance learners' ability to study patterns in daily activities.	**1. Classification and Variation** 1.1. Living and non-living things *(Scope: classification of living and non-living things based on common observable features).*	**Asking questions and defining problems** The learners observe the observable features of the things around them to identify them.	**Serving human values and influence value formation** Explore different things around them and appreciate its presence.
Draw the external parts of human and animal and label it to improve hand-eye coordination.	**2. Human and Animal** 2.1 External parts of the body *(Scope: identify and draw the external parts of human and animal).*	**Obtaining, Evaluating and Communicating Information** The learners identify and draw the external parts of human and animal.	**Using physical tools** The learners study the external parts of human and animal around them using learning aids.
i. Draw, colour and label the different parts of a plant	**3. Green Plants** 3.1 Parts of a plant (*Scope: different parts of a plant [leaf, root, stem, and flower]*)	**Obtaining, Evaluating and Communicating Information** The learners observe, draw, colour, and label different parts of a plant.	**Exploring Digital Resources** The learner's study different parts of a plants by exploring digital resources.
i. Identify the relationship between plants and animals through observation to learn the	**4. Living Things and their Environment** 4.1 Plants and animals' relationship (*Scope: the relationship between plants*	**Obtaining, Evaluating and Communicating Information**	**Exploring Digital Resources**

importance of co-existence.	*and animals in terms of food and habitat).*	The learners observe and identify the relationship between plants and animals.	The learners use the internet to explore additional information on the relationship and importance of co-existence between plants and animals.

Class-wise Competency

Class II

By the end of class II, the learner should be able to:

1. **Classification and Variation**
- classify into wild and domestic animals to understand about animals that have direct use to humans.

2. **Human and Animal**
- recognise the functions of human and animal body parts to understand its significance.

3. **Green Plants**
- observe different parts of a plant to learn the functions of each part for survival.

4. **Living Things and their Environment**
- identify different types of food and habitat in the environment to care for animals and plants.

Table 3: *Learning objectives and process/essential skills for Life processes, Class II*

Learning Objectives (KSVA)	**Core Concepts (Chapters/Topics/Themes)**	**Process/Essential Skills**	
		Scientific methods and Engineering Practices	**Society and technology**
i.Classify animals into wild and domestic animals. ii.State the uses of domestic animals	1. **Classification and Variation** 1.1. wild and domestic animal *(Scope: classification of wild and domestic animals and the uses of domestic animals)*	**Obtaining, Evaluating and Communicating Information** The learners classify the animals around them and explore the uses of the domestic animals.	**Serving human values and influence value formation** The learners use the environment to study different animals.

i. State the functions of human and animal body parts through observation to understand its significance.	**2. Human and Animal** 2.1 Body parts *(Scope: functions of external body parts of human and animal).*	**Obtaining, Evaluating and Communicating Information** The learners observe human and animal body parts and state their functions.	**Serving human values and influence value formation** The learners study the body parts of humans and animals around them to understand its significance.
i. Observe different parts of a plant around them to learn the functions of each part for survival.	**3. Green Plants** 3.1 Parts of a plant (*Scope: different parts of a plant [leaf, root, stem and flower] and their functions)*	**Obtaining, Evaluating and Communicating Information** The learners observe and learn the functions of different parts of a plant.	**Serving human values and influence value formation** The learners observe different plants around them.
i. Identify different types of food and habitat of animals in the environment through observation to care for animals and plants.	**4. Living Things and their Environment** 4.1 Food and habitat (*Scope: identify different types of food and habitat).*	**Obtaining, Evaluating and Communicating Information** The learners observe and identify different types of food and habitat of animals in the environment.	**Exploring Digital Resources** The learners use the internet to explore additional information on different types of food and habitat in the environment and develop care for them.

Class-wise Competency

Class III

By the end of class III, the learner should be able to:

1. Classification and Variation

- classify fruits and vegetables and state their importance for a healthy life.

2. Human and Animal

- describe a life cycle of some common animals to appreciate diversity.

3. Green Plants

- examine the role of flowers, fruits, and seeds in reproduction to understand the significance of each part in the survival of flowering plants.

4. Living Things and their Environment

- identify the ways to protect food and habitat to promote a sense of belongingness.

Table 4. *Learning objectives and process/essential skills for the Life processes, Class III*

Learning Objectives (KSVA)	Core concepts	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and technology
i. Develop a model of different types of fruits and vegetables to study their importance for a healthy life.	**1. Classification and Variation** 1.1. Fruits and vegetables *(Scope: develop models of different types of fruits and vegetables using available materials, and study their importance).*	**Developing and using models** The learners develop a model of different types of fruits and vegetables to study their importance.	**Using physical tools** The learners use available materials to make models of different types of fruits and vegetables.
i. Describe a life cycle of some common animals to appreciate diversity.	**2. Human and Animal** **2.1 Life cycle** *(Scope: life cycle of some common animals, e.g.: life cycle of chicken, frog, butterfly, etc.).*	**Analysing and interpreting data** The learners study the life cycle of some common animals and make some inferences.	**Exploring digital resources** The learners compare their inferences and confirm the concept using a video from the internet.
i. Investigate the role of flowers, fruits, and seeds in reproduction to help learn the significance of each part in survival of flowering plants.	3. **Green Plants** 3.1 Flowers, fruits, and seeds (*Scope: function of flower, fruit, and seed)*	**Planning and carrying out investigations** The learners investigate the role of flowers, fruits, and seeds in reproduction.	**Exploring digital resources** The learners observe and study the role of flowers, fruits and seeds in reproduction using any ICT tool.

i. State ways to protect food and habitat through observation to promote a sense of belongingness.	**4. Living Things and their Environment** 4.1 Food and habitat *(Scope: different ways to protect food and habitat).*	**Obtaining, Evaluating and Communicating Information** The learners observe and record different ways to protect food and habitat in the environment.	**Promoting Socio-cultural, Economic, and Human Values** The learners use the internet to explore additional information on different types of food and habitat in the environment.

1.1.2 Strand: Materials and their Properties

Competency Based Standard

By the end of Key Stage 1 (Class III), the learner should be able to:

- name some materials, sort them into groups, state their uses and properties to use different types of materials for right purposes in their daily life.
- investigate objects which undergo changes due to Physical Processes such as heating, cooling, squashing, bending, twisting, stretching, etc. to adapt to the changes happening in nature.
- classify everyday materials as pure and mixtures to acquire the skills of sorting things and to know the properties of substances.

Class-wise Competency

Class PP

By the end of class PP, the learner should be able to:

1. Grouping Materials

- name some materials based on observation to acquire the skills of naming different things around them.

2. Materials and Change

- investigate different properties of materials to understand how materials behave in their natural state.

Table 5. *Learning objectives and process/essential skills for materials and their properties, class PP*

Learning Objectives (KSVA)	Core concepts	Process/Essential Skills	
		Scientific methods and Engineering Practices	**Society and technology**
i. Identify some materials based on observation of different things around them to acquire the skills of naming them.	**1. Grouping Materials** 1.1Name materials *(Scope: name some materials e.g., rocks, wood, sticks, plastic, etc.)*	**Obtaining, Evaluating and Communicating Information** The learners observe and name things around them through field visits	**Using Physical Tools** The learners observe things around them to name different things

i. Investigate different properties of materials around them through observation.	**2. Materials and Change** 2.1 Physical Processes *(Scope: properties of materials [colours, sizes, shapes, etc.]*	**Obtaining, Evaluating and Communicating Information** The learners investigate different properties of materials around them.	**Serving human values and influence value formation** The learners compare different types of materials around them.

Class-wise Competency

Class I

By the end of class I, the learner should be able to:

1. **Grouping Materials**

- explore the similarities and differences of objects in the surrounding to use different types of materials for the right purposes in their daily life.

2. **Materials and Change**

- name some Physical Processes that bring changes in objects based on observation to realize how changes happen around them.

Table 6. *Learning objectives and process/essential skills for materials and their properties, Class I*

Learning Objectives (KSVA)	**Core Concepts (Chapter/Topics/Themes)**	**Process/ Essential Skills**	
		Scientific methods and Engineering Practices	**Society and Technology**
i. Explore the similarities and differences of objects in the surrounding through observation.	**2. Grouping Materials** 1.1Materials and properties *(Scope: similarities and differences of objects in terms of hardness, colour, material composition, etc.).*	**Obtaining, Evaluating and Communicating Information** The learners observe and compare things around them.	**Using physical tools** The learners observe things around them to explore their similarities and differences
i. Investigate some Physical Processes that bring changes in the object.	**2. Materials and Change** 2.1 Physical Processes *(Scope: name some Physical Processes e.g., heating, cooling, twisting, etc.).*	**Planning and carrying out investigations** The learners investigate some Physical Processes	**Using physical tools** The learners observe Physical Processes occurring around them to realize

		that bring changes in the objects.	changes happening around them.

Class-wise Competency

Class II

By the end of class II, the learner should be able to:

1. Grouping Materials

- sort different objects into groups based on properties to acquire skills of sorting things in their daily life.

2. Materials and Change

- investigate the changes in materials due to physical forces to relate the implications of force on the materials in their daily life.

Table 7. *Learning objectives and process/essential skills for materials and their properties, Class II*

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Process/Essential Skills	
		Scientific methods and Engineering Practices	**Society and technology**
i. sort different objects around them into groups based on the properties.	**1. Grouping Materials** 1.1 Sorting materials *(Scope: sort materials around them based on hardness, shininess, roughness, transparency, ability to float and so on)*	**Obtaining, Evaluating and Communicating Information** The learners observe and sort things around them.	**Using physical tools** The learners explore and observe things around them.
i. investigate the changes in materials due to physical forces.	**2. Materials and Change** 2.1 Changes in materials *(Scope: changes in the material due to physical forces such as squashing, bending, twisting, and stretching)*	**Planning and carrying out investigations** The learners investigate changes in materials due to physical forces.	**Using physical tools** The learners observe changes in different materials around them.

Class-wise Competency

Class III

By the end of class III, the learner should be able to:

1. Grouping Materials

- investigate the uses of materials in the locality and its availability in nature for efficient and sustainable use.

2. Materials and Change

- investigate the change in materials when heated or cooled to adapt to the changes happening in nature.

3. Introduction to Mixtures

- classify everyday materials as pure and mixtures to acquire the skills of sorting things.

Table 8. *Learning objectives and process/essential skills for materials and their properties, Class III*

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Process/ Essential Skills	
		Scientific methods and Engineering Practices	Society and Technology
i. Identify the uses of materials in the locality and its availability in nature through field visit.	**2. Grouping Materials** 1.1 Materials and its use *(Scope: sort locally available materials, list some naturally found materials, and group different rocks and soil based on colour, texture, hardness and so on)*	**Planning and Carrying Out Investigations** The learners explore and identify uses of materials in their locality through field visit.	**Promoting Socio-cultural, Economic, and Human Values** The learners observe materials and their uses in the locality.
i. Investigate the change in materials when heated or cooled and compare with the videos from the internet.	**2. Materials and Change** 2.1 Changes in materials *(Scope: changes in water and candle wax due to heating and cooling).*	**Planning and Carrying Out Investigations** The learners investigate changes in materials due to heating and cooling.	**Exploring digital resources** The learners compare the observation made in the investigation with the videos from the internet.

i. Classify everyday materials as pure substance and mixture.	3. **Introduction to Mixture** 3.1 Pure substance and mixture (*Scope: classification of materials as pure substance [e.g., water, salt, sugar, etc.] and mixtures [e.g., tea, coffee, dirty water]*)	**Obtaining, Evaluating and Communicating Information** The learners observe and classify materials into pure substance and the mixture.	**Using physical tools** The learners collect different materials to classify them into pure substance and mixture

1.1.3 Strand: Physical Processes

Competency Based Standard

By the end of Key stage 1 (Class III), the learner should be able to:

- investigate the effect of push and pull on an object and rigid body to recognise the significance of force in doing work.
- identify the sources of electricity, explore home electrical appliances, and describe safety measures for personal safety and wellbeing.
- identify different sources of light and sound in the local community and explain its effects to make appropriate use of it.
- identify the heavenly bodies and explain the causes of day and night based on the availability of the sun to understand different timing.

Class-wise Competency

Class PP

By the end of class PP, the learner should be able to:

1. Forces and Motion

- identify push and pull as a force from day-to-day activities.

2. Electricity

- identify common electrical appliances at home to make safe and efficient use of it.

3. Light and Sound

- identify different sources of light at home and the local community to make appropriate use of it.

4. The Earth and Heavenly Bodies

- observe the heavenly bodies to learn their name.

Table 9: *Learning objectives and process/essential skills for Physical Processes, class PP*

		Process/ Essential Skills

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Scientific methods and Engineering Practices	Society and Technology
i. Identify, push, and pull as a force through an investigation.	**Forces and Motion** 1.1 Push and pull *(Scope: explore push and pull, e.g., pushing a chair, closing, and opening a door, pulling a desk, lifting a book, etc.).*	**Planning and Carrying Out Investigations** The learners use different things around them to investigate push and pull.	**Using physical tools** The learners explore to recognise push and pull in everyday activity.
i. Name common electrical appliances available at home through observation.	2. **Electricity** 2.1 Electrical appliances *(Scope: name common electrical appliances at home).*	**Obtaining, Evaluating and Communicating Information** The learners observe different electrical appliances at home and name it.	**Using physical tools** The learners observe different electrical appliances around them.
i. Identify different sources of light at home and their local community.	**3. Light and Sound** 3.1 Sources of light *(Scope: list some sources of light found at home and their local community).*	**Obtaining, Evaluating and Communicating Information** The learners identify and list different sources of light.	**Using physical tools** The learners observe different sources of light around them.
i. Name heavenly bodies through observation and drawing inferences from the internet.	**4. The Earth and Heavenly Bodies** 4.1 Heavenly bodies *(Scope: name some heavenly bodies such as the sun, the moon, and the stars).*	**Obtaining, Evaluating and Communicating Information** The learners observe heavenly bodies to name them.	**Using digital resources** The learners use the internet to explore more on heavenly bodies.

Class-wise Competency

Class I

By the end of class I, the learner should be able to:

1. Forces and Motion

- investigate everyday situations where force causes motion to use it effectively.

2. Electricity

- identify common electrical appliances and state their uses to make safe and efficient use of it.

3. Light and Sound

- identify different sources of sound around us to be aware of the connections to the activities in our daily life.

4. The Earth and Heavenly Bodies

- explain the cause of day and night based on availability of sunlight.

Table 10: *Learning objectives and process/essential skills for Physical Processes, class I*

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Investigate everyday situations where force causes motion.	1. **Forces and Motion** **1.1 Effect of force** *(Scope: explore where force causes motion).*	**Planning and Carrying Out Investigations** The learners investigate everyday situations where force causes motion.	**Using physical tools** The learners use different things around them.
i. Identify common electrical appliances at home and state their uses.	**2. Electricity** 2.1 Electrical appliances and use *(Scope: identify household electrical appliances and state their uses).*	**Obtaining, Evaluating and Communicating Information** The learners observe and identify different electrical appliances at home and state their uses.	**Using physical tools** The learners observe different electrical appliances around them.
i. Identify different sources of sound around them.	**3. Light and Sound** 3.1 Sources of sound *(Scope: list different sources of sound)*	**Obtaining, Evaluating and Communicating Information**	**Using physical tools** The learners observe different

		The learners identify different sources of sound and list them.	sources of sound around them.
i. Explain the cause of day and night based on availability of sunlight.	**4.The Earth and Heavenly Bodies** 4.1 Cause of day and night *(Scope: Cause of day and night based of availability of sunlight)*	**Developing and using models** The learners explore the cause of day and night	**Using physical tools** Learners use digital resource for further exploration

Class-wise Competency

Class II

By the end of class II, the learner should be able to:

1. Forces and Motion

- investigate the effects of pushes and pulls on rigid and non-rigid bodies for efficient use of force.

2. Electricity

- explore safety measures in using electrical appliances to recognise safety measures in daily life.

3. Light and sound

- explore the effect of light on the visibility of objects to realise the importance of light.

4. The Earth and Heavenly Bodies

- explore the uses of the sun's energy to appreciate its importance in daily life.

Table 11: *Learning objectives and process/essential skills for Physical Processes, class II*

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Investigate the effects of push and pull on a body.	**1. Forces and Motion** 1.1 Effect of force *(Scope: explore the effects of push and pull* *[e.g., change in position, making objects move or*	**Planning and Carrying Out Investigations** The learners investigate the effects of push and pull on a body by carrying out simple experiments.	**Using physical tools** The learners use different things around them.

	stop, change in shape, and change in direction].		
i. Explore safety measures while using electrical appliances using information from the internet.	**2. Electricity** 2.1 Electrical appliances and safety measures *(Scope: list safety measures while using electrical appliances at homes).*	**Obtaining, Evaluating and Communicating Information** The learners explore and list safety measures related to electrical appliances at home.	**Using digital resources** The learners explore the digital resources to study the safety measures while using the electrical appliances.
i. Examine the effect of light on the visibility of objects through an activity.	**3. Light and Sound** 3.1 Effect of light *(Scope: the effect of light on visibility of objects. E.g., day and night).*	**Obtaining, Evaluating and Communicating Information** The learners design an activity to study the effect of light.	**Using physical tools** The learners use materials around them to explore the effect of light and use the internet to explore more.
i. Explore the uses of sun energy in daily life.	**4.The Earth and Heavenly Bodies** 4.1 Sun energy *(Scope: Uses of sun energy such as drying clothes, source of light, source of heat, etc.).*	**Obtaining, Evaluating and Communicating Information** The learner explores the uses of sun energy.	**Exploring digital resources** The learners use the internet to explore the information.

Class-wise Competency

Class III

By the end of class III, the learner should be able to:

1. Forces and Motion

- investigate the effect of varying magnitude and direction of pushes and pulls on a body for efficient use of force in their everyday

2. Electricity

- explore different sources of electricity to recognize their uses in daily life.

3. Light and Sound

- investigate the effect of different objects on light to recognize their suitability for different purposes.

4. The Earth

- identify the features of day and night to relate to daily life patterns.

Table 11: *Learning objectives and process/essential skills for Physical Processes, class III*

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Process/Essential Skills	
		Scientific methods and Engineering Practices	**Society and Technology**
i. Investigate the effect of varying magnitude and direction of push and pull on a body through activity.	**1.Forces and motion** 1.1 Effect of force *(Scope: the effect of pushes and pulls of different magnitude and direction on a body).*	**Obtaining, Evaluating and Communicating Information** The learners design an activity to explore the effect of varying magnitude and direction of pushes and pulls on a body.	**Using physical tools** The learners use different things around them to learn t*he effect of pushes and pulls of different magnitude and direction on a body)*
i. Explore different sources of electricity through observation and using the internet.	**2. Electricity** 2.1 Source of Electricity *(Scope: explore different sources of electricity and list them).*	**Obtaining, Evaluating and Communicating Information** The learners explore different sources of electricity.	**Exploring digital resources** The learners use the internet to explore more on different sources of electricity.
i. Investigate the effect of transparent, translucent, and opaque objects on light through activity.	**3. Light and sound** 3.1 Materials and light *(Scope: Concept and the transmission of light through transparent,*	**Planning and carrying out investigations** The learners investigate different objects and its effect on the light.	**Using physical tools** The learners explore transparent, translucent, and

	translucent, and opaque objects)		opaque objects around them.
i. Explain the duration of day and night during summer and winter.	**4.The Earth and Heavenly Bodies** 4.1 Day and night (*Scope:* duration of day and night during summer and winter)	**Obtaining, Evaluating and Communicating Information** The learners observe and identify the features of day and night.	**Exploring digital resources** Learners use the internet to explore about the duration of day and night.

9.2 Key Stage 2 (IV-VI)

9.1.1 9.2.1 Strand: Life processes

Competency Based Standard

By the end of Key Stage 2 (Class VI), the learner should be able to:

1. study things in the surrounding to identify the variations among individuals based on their characteristics to acquire the skill of classification and recognise the diversity.

2. examine different habitats, the mode of adaptations in plants and animals and feeding relationships of organisms to analyse the interdependence of living things with their environment.

3. explain teeth and different life processes occurring in humans to understand their crucial roles in human survival.

4. investigate the necessary conditions required for the growth, transport of water and minerals, and reproduction in plants to recognize their importance in the continuity of life.

Class-wise Competency

Class IV

By the end of class IV, the learner should be able to:

1. **Classification and Variation.**
   Explore the characteristics of things to classify them into living and non-living, biodegradable, non-biodegradable things.
2. **Living Things and their Environment**
   explore habitat, feeding habits and the adaptive features of plants and animals to identify the interdependence in nature.
3. **Human and Animal**
   explain nutrition and food groups, and structure and function of teeth to understand the importance of eating all food groups and maintaining oral hygiene.

4. Green Plants

investigate the conditions required for the growth of plants, and identify parts of a flower to understand its role in reproduction.

Table 13. *Learning objectives and process/essential skills for Life processes, class IV*

Learning Objectives	Core Concepts (Chapter/ Topics/Themes)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and technology
i. Identify the characteristics of living and non living things. ii. Classify things in the surrounding into living and non-living things according to their characteristics. iii. Explain the significance of living and non-living things.	**1.1 Classification and Variation** 1.1.1 Living and Non-Living Things *(Scope: This topic focuses on what living and non-living things are and their characteristics with examples and their significance.)*	**Planning and Carrying out Investigations** Investigate and observe things in the surrounding.	
i. Classify things in the surrounding into biodegradable and non-biodegradable things. ii. Investigate the role of microorganisms in decomposition of biodegradable waste by making a compost. iii. Identify the consequences of improper waste management and suggest ways to address the problem related to waste. iv. Explain that biodegradable and non	1.1.2 Biodegradable and Non-Biodegradable Things *(Scope: This topic begins with the introduction of biodegradable and non-biodegradable things with examples. It also covers the role of microorganisms in decomposition and making compost, production of greenhouse gases due to improper waste management and the importance of managing waste.)*	**Analysing and Interpreting Data** Analyse and interpret the data collected to classify things into biodegradable and non-biodegradable. **Constructing Explanation and Designing Solution**	**Using Physical Tools** The learners examine biodegradable and nonbiodegradable things, using the materials available in the surrounding area.

biodegradable waste contribute to production of greenhouse gases v. Explain the consequences of improper waste management and suggest solutions.		Using the concept of decomposition to prepare compost.	**Exploring Digital Resources** The learners explore information on compost preparation from the internet.
i. Explore different types of habitat for plants and animals. ii. Describe the adaptive features of plants and animals. iii. Explore the effects of climate change on habitats (water, land, desert, forest and snow) i. Explain producers, consumers and types of consumers. ii. Describe the feeding relationship of organisms in different habitat iii. Create food chains based on the organisms found in the locality.	**1.2 Living things and their Environment** 1.2.1 Animal and Plant Habitat *(Scope: This topic introduces habitat, types of habitats such as water, land, desert, forest, and snow. It also includes adaptive features of plants and animals.)* 1.2.2 Food Chains and Feeding Habits *(Scope: This topic begins with the introduction of producer, prey, predator, herbivore, carnivore and omnivore and their examples. It also discusses the trophic levels of a food chain [producer-primary consumer-secondary*	**Panning and carrying out investigations** The learners explore different habitats for plants and animals and investigate their adaptive features. **Analysing and Interpreting Data** The learners analyse and interpret adaptive features for plants and animals **Obtaining, Evaluating, and Communicating Information** The learners explore and observe different feeding habits in the locality to classify organisms and study the food chain.	**Exploring digital resources** The learners use the surroundings and the internet to explore the habitats and the adaptive features of plants and animals. **Serving Human Values and Influence Value Formation** The learners study the local animals and their feeding relationship. **Serving Human Values and Influence Value Formation**

iii.Interpret the trophic levels of a food chain to understand the interdependence of living things. i. Explain nutrition. ii. Classify foods into food for activity, growth and protection. iii. Explain the importance of eating foods from all food groups to maintain good health. i. Identify the different types of teeth and explain their functions. Explore the importance of maintaining oral hygiene.	*consumer-tertiary consumer].)* **1.3 Human and Animal** 1.3.1 Nutrition *(Scope: This topic begins with the introduction of nutrition and different food groups [food for activity, food for growth, food for protection]. It also highlights the importance of eating food from all food groups.)* 1.3.2 Teeth *(Scope: This topic covers the types of teeth and their functions as well as ways to maintain oral hygiene.)*	**Obtaining, Evaluating, and Communicating Information** The learners discuss and list all kinds of food and group them to learn their importance and their functions from reliable resources. **Developing and Using Models** The learners observe a picture of the teeth to compare with their teeth and learn the functions and share them with the class.	The learners study all kinds of food in the locality and explore the eating habits in their family. **Exploring Digital Resources** The learners seek advice from elders and use the internet to develop good oral hygiene.
i. Investigate the effect of light on the growth of a plant ii. Investigate the effect of air on the growth of a plant. iii. Investigate the effect of temperature on the growth of a plant iv. Investigate the effect of water on the growth of a plant	**1.4 Green Plants** 1.4.1 Conditions for Growth *(Scope: This topic emphasises on the conditions such as light, air, temperature and water which are necessary for the growth of a plant.)*	**Planning and Carrying out Investigations** The learners conduct an experiment to study the conditions required for the growth of plants. **Analysing and Interpreting Data** Analyse and interpret the data collected to	**Exploring Digital Resources** The learners relate and validate experimental findings with the observation in the environment and information from the internet.

v. Explain the interdependence of various growth factors for healthy plant development.		state necessary conditions required for proper growth of plants.	
i. Identify the basic parts of a flower using different flowers from the surroundings. ii. Explain a flower with the help of a well labelled diagram. iii. Explain the importance of flowers in a plant's life. iv. Explain the impact of climate change on the flowering of plants. v. Explain the ways to reduce the impact of climate change on plants.	1.4.2 Flower *(Scope: This topic focuses on different parts of a flower such as pedicel, sepal, petal, filament, anther, stigma, style, and ovary. It also focuses on the impact of climate change on flowering and ways to mitigate it.)*	**Obtaining, Evaluating, and Communicating Information** The learners observe different parts of the flower and learn their names.	**Using Physical Tools** The learners collect flowers and study the parts.

Class-wise Competency

Class V

By the end of class V, the learner should be able to:

1. **Classification and Variation**
   explore variations among organisms and their traits to understand the significance of the existence of diversity in life forms.
2. **Living Things and their Environment**
   explain the feeding relationships and interdependence of organisms to understand the impacts of human activities on their feeding relationship
3. **Human and Animal**
   explain different life processes (circulation, movement and reproduction), nutrients, and types of nutrients to recognize their roles in proper functioning of an organism.
4. **Green Plants**
   describe the functions of root, stem and different parts of flower to recognise their importance for the survival and continuity of plant life.

Table 14: *Learning objectives and process/essential skills for Life processes, class V*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and technology
i. Explore the variations in plants and animals based on their size,colour and shape. ii. Explain the significance of diversity of plants and animals in the ecosystem. iii. Explain how climate change affects the diversity of plants and animals with suggested measures to mitigate the effect. iv. Explain how climate change affects the diversity of plants and animals.	**1.1Classification and Variation** 1.1.1 Variations *(Scope: This topic focuses on what variation is, and features of different plants and animals and significance of diversity of plants and animals. It also discusses on the impact of climate change on biodiversity and mitigation measures.)*	**Planning and Carrying out Investigations** The learners observe and investigate humans, plants, and animals to study characteristics and variation. **Analysing and interpreting data** The learners then analyse and interpret data collected.	**Serving human values and influence value formation** The learners observe organisms in their surroundings.
i. Construct a food web using organisms found in the locality. ii. Interpret the interdependence among different organisms in the food web. iii. Explain the impacts of human activities on the feeding relationships in	**1.2 Living things and their Environment** 1.2.1 Food Web *(Scope: This topic introduces what a food web is and discusses the interconnectedness of food chains to form a food web, impacts of human activities on their feeding relationship)*	**Planning and Carrying out Investigations** The learners investigate the food web and the impact of human activities on habitat through field visit. **Analysing and Interpreting Data** The learners then analyse and interpret the data collected to advocate community on	**Promoting Socio-cultural, Economic, and Human Values** The learners study the presence of endangered or threatened species in the locality.

nature. i. Explain various human activities that cause climate change and pose a threat to habitat. ii. Discuss measures to conserve the habitat. iii. Justify that climate change influences the health of the environment. iv. Identify the threatened animals and plants in the locality. v. State the significance of saving the threatened animals and plants in the locality. vi. Identify national initiatives (interventions and legal) undertaken in protecting the environment. vi. Design a poster on the reduction of threats to habitats.	1.2.2 Threat to Habitat *(Scope: This topic begins with the study of the various human activities that cause climate change and destruction of habitats and measures to save habitats.* *It includes threatened plants and animals and measures to save them.*	conservation of the habitat of plants and animals. **Obtaining, Evaluating, and Communicating Information** The learners gather the information on feeding relationships in the locality, draw a food web based on the feeding relationship observed and communicate the information to the class.	**Exploring Digital Resources** The learners explore different feeding relationships in the locality and construct a food chain using suitable presentation software.
i. Explain macronutrients and micronutrients in animals with examples.	**1.3 Human and Animal** 1.3.1 Nutrition *(Scope: The topic introduces food nutrients [macro and micro] which includes carbohydrates, proteins, fats, vitamins, minerals, and water with examples. It also deals with a balanced diet and food guide pyramid with significance for the body.)*	**Obtaining, Evaluating, and Communicating Information** The learners gather and evaluate information to categorise the food they have seen into various food categories and communicate the information by designing a poster on the adverse effects of junk food.	**Serving Human Values and Influence Value Formation** The learners study all kinds of food in the locality and explore the eating habits in their family.

ii. Construct a food guide pyramid to promote healthy eating habits. iii. justify the importance of eating a balanced diet. iv. Identify the junk food waste produced at home to understand its negative impacts on the environment.			
i. Discuss the impacts of consuming junk foods, tobacco, alcohol, and drugs on our health. ii. Discuss the causes, impacts and prevention of malnutrition based on undernutrition and overnutrition. iii. Calculate Body Mass Index (BMI) and explain the significance of knowing their BMI to maintain good health. iv. Justify why a healthy eating habit is necessary for one's own health.	1.3.2 Healthy Habits *(Scope: This topic focuses on the impacts of consuming junk food, tobacco, alcohol, drugs on our health and lifestyle. It also discusses the causes, impacts and prevention of malnutrition [undernutrition and overnutrition] and calculation of Body Mass Index [BMI] and its significance.)*		**Exploring Digital Resources** Design a poster on the negative impact of junk food using a suitable ICT tool. **Exploring Digital Resources** The learners use the internet and other resources to gather information.
i. Identify different parts of the circulatory system and explain their roles. ii. State the importance of circulation in humans.	1.3.3 Circulation *(Scope: This topic introduces circulation and deals with the function of the heart, arteries, veins, and their roles in blood circulation.)*		

i. Identify different parts of the skeleton in the human body. ii. State the functions of the skull, rib cage, and backbone. iii. Explain the importance of the skeleton in our life. iv. Identify biceps and triceps of muscles and relate the functions of muscles to the important movement of the body.	1.3.4 Movement *(Scope: This topic focuses on the functions of the skeleton, and the names and functions of different parts of the skeleton - skull, ribcage, backbone; and muscle - biceps, triceps.)*	**Developing and Using Models** The learners develop a human circulatory system model using available materials to explain its various parts. The learners design an arm model to explain the function and working of muscle.	
i. Explain fertilisation and reproduction in animals. ii. Explain the life cycle of an animal. ii. Explain the significance of reproduction in animals.	1.3.5 Reproduction *(Scope: This topic begins with the introduction of fertilisation and reproduction and includes the different stages of a life cycle and importance of reproduction in continuity of life.)*		
i. Identify the parts of a plant using different plants found in the surroundings. ii. State the functions of roots in plants. iii. State the functions of the stem in plants. iv. Explain the importance of root and stem in the growth of a plant.		**Constructing Explanation and Designing Solution** Learners study the life cycle of butterflies. They create a life-stage calendar for the butterfly. They observe, and draw, examine their pupa, and compare with that of the emergent butterflies. They draw the complete lifecycle of the butterfly.	

i. Explain the primary functions of different parts of a flower using a flower. ii. Explain calyx and corolla. iii. Explain the importance of flowers in plants.	**1.4 Green Plants** 1.4.1 Water and Mineral Transport *(Scope: This topic deals with the parts of a plant, and general functions of root and stem.)*	**Planning and Carrying out Investigations** The learners carry out an activity to explain the functions of roots and stem. **Analysing and Interpreting Data** The learners analyse and interpret the collected data. **Obtaining, Evaluating, and Communicating Information** The learners explore different parts of a flower and evaluate by observing and dissecting the flower.	**Exploring Digital Resources** The learners use the internet and other resources to gather information. **Using the Physical Tools** The learners use plants from the locality to study the role of roots and stem in transporting water and minerals.
	1.4.2 Reproduction *(Scope: This topic focuses on functions of different parts of a flower. It also introduces the terminologies such as calyx and corolla.)*		**Using the Physical Tools** The learners collect different flowers from the locality and compare the parts.

Class-wise Competency

Class VI

By the end of class VI, the learner should be able to:

1. **Classification and Variation**
   classify plants and animals into distinct groups according to their characteristics to foster an appreciation for the diversity of life in nature.
2. **Living things and their Environment**
   analyse the trophic levels of the ecological pyramid and their roles in maintaining the ecological equilibrium to understand the flow of energy in the ecosystem.
3. **Human and Animal**

explore nutrition by age and gender, puberty and different life processes (double circulation, reproduction) to relate their importance in proper growth and functioning of a body.

4. **Green Plants**

explain nutrients and different life processes (photosynthesis, and reproduction) in plants to understand their significance in growth and continuity of plant life.

Table 15: *Learning objectives and process/essential skills for Life processes, class VI*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	**Society and Technology**
i. Explore the characteristics of vertebrates and invertebrates. ii. Classify different animals into vertebrates and invertebrates based on their characteristics. iii. Examine the characteristics of different animals found in the locality. iv. Classify animals into different groups (reptiles, fish, amphibians, birds, and mammals) based on their characteristics. v. Identify the differences and similarities in animals within the same group. i. Examine the characteristics of different plants found in the locality. ii. Classify different Plants into different groups (mesophytes, hydrophytes, xerophytes, epiphytes, and lithophytes) according to their characteristics.	**1.1 Classification and Variation** 1.1.1 Classification of Animals *(Scope: This topic introduces the classification of animals into vertebrates and invertebrates, and into five classes [reptiles, fish, amphibians, birds, mammals] based on their characteristics with examples.)* 1.1.2 Classification of Plants *(Scope: This topic introduces the classification of plants into five classes [mesophytes, hydrophytes, xerophytes, epiphytes, and lithophytes] based*	**Obtaining, Evaluating, and Communicating Information** Learners collect and analyse knowledge through observation in order to identify animals and plants into five classes each and list their characteristics.	**Exploring Digital Resources** The learners use the internet to learn more about different classes of animals and plants.

iii. Identify the differences and similarities in plants within the same group.	*on their characteristics with examples.)*		
i. Explain the trophic level of the ecological pyramid using examples from the locality. ii. Examine the impact of climate change on the trophic levels in the food chain . iii. Explore various ecological pyramids and trophic levels. iv. Explain the significance of energy flow in maintaining ecological equilibrium.	**1.2 Living Things and their Environment** 1.2.1 Feeding and Relationships *(Scope: This topic introduces the trophic levels (producer-primary consumer-secondary consumer-tertiary consumer-quaternary consumer) and explains the significance of each level to balance the ecosystem. It also includes the ecological pyramids: pyramid of numbers, pyramid of biomass and pyramid of energy with examples.)*	**Obtaining, Evaluating, and Communicating Information** Obtain information on food chain pyramids and pyramids of numbers by using the internet or reading books to explain the concept.	**Using Physical Tools** The learners observe different food chains in the locality and use information gathered from the internet to learn and construct food chain pyramids and pyramids of numbers. **Promoting Socio-cultural, Economic, and Human Values** The learners gather information from the locality and other available resources to study significance of energy flow in maintaining ecological equilibrium.
i. Discuss the nutritional requirements for people in different age groups and gender.	**1.3 Human and Animal** 1.3.1 Nutrition *(Scope: This topic deals with the dietary requirements of people of different age groups*	**Constructing Explanation and Designing Solution** The learner's design a food guide pyramid to explain the importance of a balanced diet and	**Using Physical Tools** The learners compare their dietary habits of friends in the class with the food guide pyramid that

ii. Explore the nutritional label and shelf life of processed food to understand the nutritional values. iii. Relate our eating habits to physical, mental, emotional, and social well-being.	*and gender. It also includes how to read the nutrition label and shelf life of foods in the market to be aware of healthy eating habits.)*	dietary requirement based on age and gender.	they have designed.
i. Explain the chambers of heart with the help of a labelled diagram. ii. Explain double circulation with the help of a diagram. iii. Explain the significance of double circulation in the human body.	1.3.2 Double Circulation *(Scope: This topic introduces four chambers of heart, double circulation (pulmonary circulation and systemic circulation), and includes the directional flow of oxygenated blood and deoxygenated blood)*	**Developing and Using model** The learners design a model to show double circulation. **Obtaining, Evaluating, and Communicating Information** The learners gather and evaluate information about the skeleton and muscles by using the model of a skeleton and chart on muscle.	**Exploring Digital Resources** The learners watch a video on human blood circulation. **Exploring Digital Resources** The learners watch a video on the function of the skeleton and muscles.
List down the physical and emotional changes occurring during puberty. List down ways to cope with physical and emotional changes. Advocate on good touch and bad touch to create a safe social environment and living.	1.3.3 Puberty *(Scope: This topic introduces puberty, the physical and emotional changes that occur in males and females and ways to cope with the changes. It also includes the attributes of good touch and bad touch.)*	The learners create a video on good and bad touch.	**Exploring Digital Resources** The learners explore the digital resources for further information on puberty, good touch and bad touch and create a video using a suitable ICT tool on good and bad touch.

i. Explain primary nutrients and its significance in plants. ii. Identify the roles of primary nutrients in plants. iii. Analyse the deficiency symptoms and effects of primary nutrients on the health of plants through observation.	**1.4 Green Plants** 1.4.1 Nutrition *(Scope: This topic introduces the primary nutrients- Nitrogen, Phosphorus, and Potassium [NPK] and their roles and deficiency symptoms in plants.)*	**Obtaining, Evaluating, and Communicating Information** Explore or use any media to obtain information on the role of NPK in the growth of a plant.	**Exploring Digital Resources** The learners observe different plants in the environment to study the deficiency symptoms of NPK; and watch the video on photosynthesis.
i. Explain the role of chlorophyll in photosynthesis. ii. Examine the presence of chlorophyll in leaves and describe photosynthesis using the essential elements required for this biological process. iii. Justify the importance of photosynthesis for the survival of organisms.	1.4.2 Photosynthesis *(Scope: This topic begins with the introduction of chlorophyll, photosynthesis, and its equation [word and chemical] and significance.)*	**Obtaining, Evaluating, and Communicating Information** Refer reliable resources to study the process of photosynthesis, importance of photosynthesis and communicate the information to others using drawings that provide detail about scientific ideas.	**Exploring Digital Resources** The learners observe different flowering plants and seeds dispersal in the locality, and use the internet to explore more information.
i. Explain pollination and its significance in plants. ii. Identify the agents of pollination and the characteristics of flowers for pollination. iii. Explain the formation of seeds iv. Identify the agents for seed dispersal. v. Explain the term germination and the importance of seed in plants.		**Obtaining, Evaluating, and Communicating Information** Use any multimedia to observe the agent and	

vi. Investigate germination and the factors affecting it. vii. Explain the impacts of climate change on germination.	1.4.3 Reproduction *(Scope: This topic begins with the concept of pollination, pollinating agents [wind, water and animals] and the characteristics of flowers to be pollinated. It also includes the formation, dispersal, and germination of seeds.)*	characteristics of flowers for pollination, and communicate the information to others. **Planning and Carrying out Investigations** Investigate conditions required for germination of seed through an activity. **Analysing and Interpreting Data** Analyse and interpret the data collected to describe the conditions required for germination of seed.	

9.1.2

9.1.3

9.1.4 Strand: Materials and their Properties

Competency Based Standard

By the end of Key Stage 2 (Class VI), the learner should be able to:

1. classify different materials based on the physical and chemical properties to develop the skills of sorting and understanding the nature of substance for various uses in daily life.
2. explain physical processes (heating and cooling), types of mixtures, and physical and chemical changes to understand their effects in nature.
3. explore scientific and local practices of separating mixtures based on the characteristics of their components, and relate these practices in their everyday life.

Class-wise Competency

Class IV

By the end of class IV, the learner should be able to:

1. **Classifying Materials**
   investigate the transmission of light through materials and state of matter to understand their application in daily life.

2. **Materials and Change**
   investigate the physical process (heating and cooling) and types of mixtures to understand the importance of physical processes in daily life.

3. **Separating Mixtures**
   demonstrate various methods of separation of mixtures (sedimentation, decantation and filtration) to illustrate their applications in everyday scenarios.

Table 16: *Learning objectives and process/essential skills materials and their properties, class IV*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and Technology
i. Explore various materials in the surrounding to study the transmission of light through it. ii. Classify the materials in the surroundings into transparent, translucent, and opaque objects based on the transmission of light. iii. Explore the use of transparent, translucent, and opaque objects in daily life. i. Explain matter and classify the states of matter. ii. Verify that all three states of matter have mass.	**2.1 Classifying Materials** 2.1.1 Materials in Our Surroundings *(Scope: This topic begins by observing the things in the surrounding and sorting them into transparent, translucent, opaque, etc.)* 2.1.2 States of Matter *(Scope: This topic begins with understanding the characteristics of matter through*	**Planning and Carrying out Investigations** The learners-observe and classify different things around them based on different properties, and investigate the properties of different states of matter. **Planning and Carrying out Investigations** Investigate different things in the surrounding to classify them based on material transparency; design an experiment to prove that solid, liquid and gas are matters; investigate the properties (volume and shape) of different states of matter.	**Using Physical Tools** The learners collect different things around them to study their properties. **Exploring Digital Resources** Browse relevant sources to gather information on transparency of materials, the states of matter based on volume and shape.

iii. Investigate the shape and volume of three states of matter.	*investigation, its states [solid, liquid, gas, and plasma] and their characteristics [mass, volume and shape].)*	**Analysing and Interpreting Data** Use observation data to classify the things. Analyse the data from experiments to construct the concept of matter. Analyse the properties to differentiate the three states of matter.	
i. Explore the process of heating and cooling. ii. Investigate the effects of heating and cooling on materials. ii. Explain the importance of heating and cooling in daily life. i. Explain pure substances and mixtures with examples. ii. Classify the mixtures into solid-solid, solid-liquid, and liquid-liquid mixture with examples. iii. Distinguish between soluble and insoluble substances using simple experiments. iv. Relate the importance of mixtures and solutions in daily life.	**2.2 Materials and Change** 2.2.1 Heating and Cooling *(Scope: This topic introduces the learner to the processes of heating and cooling which results in melting and freezing.)* 2.2.2 Materials in Mixtures *(Scope: This topic focuses on investigating pure substances, soluble and insoluble substances. Also mixtures and their types [solid-solid, solid-liquid, and liquid-liquid mixture])*	**Planning and Carrying out Investigations** The learners investigate the effects of heating and cooling on the properties of substances. **Planning and Carrying out Investigations** Observe the effect of heating and cooling on substances. **Analysing and Interpreting Data** Develop a hypothesis, Analyse, and interpret the data collected from the investigation. **Engaging in Argument from Evidence** Discuss various mixtures such as curry, tea, muddy water, orange juice, etc.to categories them into different types.	**Using Physical Tools** The learners use different things available locally and other information to learn the concepts. **Using Physical Tools** May use apparatus from the laboratory or improvise to carry out investigation

i. Explain the process of sedimentation, decantation, and filtration. ii. Demonstrate separation of insoluble solid from the solution by sedimentation, decantation, and filtration. iii. Explain the application of sedimentation, decantation, and filtration in everyday life.	**2.3 Separating Mixtures** 2.3.1 Methods of Separation *(Scope: This topic begins with introducing what separation is,and different techniques of separating mixtures such as [sedimentation, decantation, and filtration] for separating insoluble solid from the solution.)*	**Planning and Carrying out Investigations** The learners investigate different ways of separating mixtures.	**Using Physical Tools** May use apparatus from the laboratory or improvise to carry out experiments.
i. Explain ways to make water safe for drinking. ii. Design a simple filter for purifying muddy water to make it drinkable. iii. Justify that safe drinking water is important for people. iv. Justify the occurrence of waterborne disease due to climate change. v. Relate climate change with occurrence of waterborne diseases.	2.3.2 Making Water Safe for Drinking *(Scope: This topic incorporates ways to make water safe and clean for human consumption.)*	**Engaging in Argument from Evidence** Discuss with evidence why unclean water is not safe for drinking. And what would happen if we drink unclean water. **Planning and Carrying out Investigations** Design a poster to protect and promote clean drinking water sources.	**Promoting Socio-cultural, Economic, and Human Values** May visit nearby water sources to protect and promote clean drinking water and make water safe for drinking by filtration and boiling.

Class-wise Competency

Class V

By the end of class V, the learner should be able to:

1. **Classifying Materials**

   classify common substances into elements and compounds based on their atomic composition to understand their applications in daily life.

2. **Materials and Change**

   explore the properties of matter, various changes, and the interconversions occurring in and around oneself to understand their effects in nature.

3. **Separating Mixtures**

   explore the separation techniques for separating solid – solid mixtures according to their characteristics to purify the mixtures for appropriate use in everyday situations.

Table 17: *Learning objectives and process/essential skills for materials and their properties, class V*

Learning Objectives	Core Concepts (Chapter, Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering	Society and Technology
i. Explain atoms, elements, and compounds with examples. i. Classify substances found in the locality into elements and compounds to understand their significance	**2.1 Classifying Materials** 2.1.1 Element and Compound *(Scope: This topic begins with an introduction of atoms, and classification of substances into elements and compounds based on the types of atoms present in them.)*	**Obtaining, Evaluating, and Communicating Information** Observe and classify different substances into elements and compounds.	**Exploring Digital Resources** The learners observe the substances around them to learn. **ExploringDigital Resources** May browse relevant sources to gather information to validate the classification of substances done.

i. Identify various processes involved in interconversion of matter. ii. Investigate the process of melting, freezing, evaporation, condensation, and sublimation using experiments. iii. Explain the properties of solid, liquid, and gas based on particle iv. Examine the influence of climate change on the interconversion of matters in the local environment.	**2.2 Materials and Change** 2.2.1 Matter *(Scope: This topic deals with matter and its interconversion through the processes of melting, freezing, evaporation, condensation, sublimation, and deposition. In addition, it explains the characteristics of three states of matter based on the arrangement of particles in them.)*	**Planning and Carrying out Investigations** Observe and investigate the different processes that bring changes in the states of matter. Investigate properties of matters using available resources. Explore and classify things in the surrounding into natural and man-made things, and investigate and verify various physical changes happening around them.	**Promoting Socio-cultural, Economic, and Human Values** Observe different natural phenomena happening in the surrounding and identify the processes of change and their properties.
i. Investigate physical change based on its physical properties. ii. Investigate conditions of physical change iii. Identify natural and artificial changes in the locality. iv. Explain the significance of different types of change in everyday lives.	2.2.2 Physical Changes *(Scope: This topic covers what natural and artificial changes are with their examples. It also includes what is physical change, condition of physical change and its properties such as reversible and irreversible physical change.)*	**Analysing and Interpreting Data** Analyse and interpret the data collected.	**Exploring Digital Resources** Use digital resources to obtain relevant information to differentiate the three states of matter and to explain the physical change.

i. Identify methods for separating solid-solid mixture based on the characteristics of constituents. ii. Demonstrate the methods of separating solid-solid mixtures. iii. Explain the importance of separating mixture and separation techniques.	**2.3 Separating Mixtures** 2.3.1 Methods of Separation *(Scope: This topic emphasises on separating solid-solid mixtures by using methods such as [hand-picking, sieving, winnowing, threshing and magnetic separation]based on the characteristics of the components of the mixture.)*	The learners verify the applicability of methods in separating various mixtures. **Planning and Carrying Out Investigations** Carry out experiments to learn the process and methods of separation. **Engaging in Arguments from Evidence** Discuss the applicability of different methods in separating various mixtures in the daily world.	**Promoting Socio-cultural, Economic, and Human Values** May explore traditional ways of separating mixtures (threshing and winnowing) though field visits. **Exploring Digital Resources** May use relevant digital resources to supplement the learning derived from experimentation and field visit.

Class-wise Competency

Class VI

By the end of class VI, the learner should be able to:

1. **Classifying Materials**
   study symbols and molecular formulae of elements and compounds, and categorise acids and bases, to understand their uses in daily situations.
2. **Materials and Change**
   examine the features of chemical changes, as well as distinction between hard water and soft water inorder to discern their significance within the natural environment.
3. **Separating Mixtures**
   examine the concept of solutions, liquid-liquid mixtures and techniques of separating them according to their characteristics for appropriate use in daily life.

Table 18: *Learning objectives and process/essential skills for materials and their properties, class VI*

Learning Objectives	**Core Concepts (Chapter/ Topic/Theme)**	**Process/Essential Skills**	
		Scientific methods and Engineering Practices	**Society and Technology**
i. Explain elements, compounds and molecular formulae with examples. ii. Identify elements and compounds using atomic symbols and molecular formulae. iii. Develop a model of simple molecules and describe their atomic composition.	**2.1 Classifying Materials** 2.1.1 Elements and Compounds *(Scope: This topic consists of names and symbols of common elements such as carbon, hydrogen, oxygen, nitrogen, iron, gold, silver, copper, magnesium, lead, zinc, aluminium, sodium, chlorine, iodine, fluorine, etc. In addition, students explore the concept of molecules and the names and chemical formulae of common elements and compounds [C, O_2, H_2, CO_2, H_2O, NaCl, and $C_{12}H_{22}O_{11}$* etc.*]. It also includes differences between atomic symbols and molecular formulae.)*	**Obtaining, Evaluating, and Communicating Information** Use different relevant sources to explore the names and symbols of elements and molecule formation. **Planning and Carrying out Investigations** Investigate acidic and basic nature of substances using different indicators. **Developing and using Models** Use locally available material to develop models of simple molecules. **Constructing explanations and designing solutions** Use the model of simple molecules from science laboratories or the model developed (improvised) to explain the formation of molecules.	**Exploring Digital Resources** The learners explore and learn to name elements and molecules using the internet, and use ready-made and locality available indicators. Explore the names and symbols of elements from relevant digital resources. **Using Physical Tools** Explore and use ready-made and locality available indicators

i. Explore acid and base based on their properties. ii. Classify substances into acids and bases using different indicators. iii. Prepare indicators using the locally available materials to test acid and base. iv. Explain the importance of acid and base in daily life.	2.1.2 Acids and Bases *(Scope: This topic introduces acid and bases with its properties such as taste and pH. Furthermore, the students test acid and base using different indicators like litmus, universal indicator, methyl orange, and phenolphthalein.)*	Use different locally available materials to prepare indicators to determine whether the given substance is acid or base. **Analysing and Interpreting Data** Observe the colour change in the indicator and determine the nature of substance (acid or base)	**Carrying out STEM Activities** May use a virtual lab simulation to study the colour change in indicators to determine whether the substance is acid or base.
i. Explain chemical change with examples. ii. Investigate the characteristics of a chemical change. iii. Justify the significance of chemical changes in everyday situations. i. Explore the characteristics of soft water and hard water. ii. Carry out an experiment to remove the hardness of water. iii. Evaluate the advantages and disadvantages of hard water and soft water.	**2.2 Materials and Change** 2.2.1 Chemical Change *(Scope: This topic will cover the concept of chemical change, its properties, and its significance.)* 2.2.2 Hard water and soft water *(Scope: This topic covers the concept of soft water and hard water with their distinctive characteristics followed by a process to remove hardness of water through distillation and boiling. Also study the advantages and*	**Obtaining, Evaluating, and Communicating Information** Refer grade-appropriate texts or digital media to obtain scientific information about chemical change, and soft water and hard water. **Planning and Carrying Out Investigations** Explore and investigate various chemical changes taking place in nature. Explore and investigate the characteristics and methods of removal of hardness in water.	**Promoting Socio-cultural, Economic, and Human Values** Observe chemical changes happening in the environment, and use available materials to carry out the activity. **Exploring Digital Resources** Use relevant digital sources to obtain information on chemical changes and hard water.

	disadvantages of hard water and soft water.)	Design experiments and investigate characteristics of a chemical change. **Analysing and Interpreting Data** Analyse the observation data to determine the characteristics of chemical change and to explain different ways to remove hardness of water. **Engaging in argument from evidence** Argue with scientific justification the characteristics of a chemical change and its significance in daily lives. Construct an argument to justify whether the hard water is beneficial to us or not.	
i. Explain solute, solvent, solution and solubility with examples. ii. Classify liquid-liquid mixtures into miscible and immiscible liquids based on their solubility.	**2.3 Separating Mixtures** 2.3.1 Mixtures in Liquids *(Scope: Mixtures in liquids focus on the concept of solute, solvent, solution and solubility. Additionally, this topic includes the exploration of soluble solids and separation using the process of evaporation and distillation, immiscible and miscible liquids, and ways of separating these*	**Obtaining, Evaluating, and Communicating** **Information** Refer grade-appropriate texts and/or digital media to obtain scientific information on mixture and the mixture separation method. **Planning and Carrying Out Investigations**	**Exploring Digital Resources** Use relevant digital sources to obtain information on mixture and the methods of separating mixtures. **Promoting Socio-cultural, Economic, and Human Values**

iii. Demonstrate the methods of separating soluble solid from solution, and miscible and immiscible liquid mixtures. iv. Design a separation technique that is environmental friendly.	*types of mixtures [using separating funnel for immiscible liquids and distillation for miscible liquids].)*	Investigate different methods of separating mixtures in liquids. **Analysing and interpreting data** Observe and analyse the different mixtures in everyday life to determine the separation method.	May explore different traditional methods of separation of mixture.

9.1.5 9.2.3 Strand: Physical Processes

Competency Based Standard

By the end of Key stage 2 (Class VI), the learner should be able to:

1. carry out experiments to understand force and density to recognise their effect in daily life.
2. investigate the forms of energy and their transformation to understand the law of conservation of energy, and relate their significance in daily activities.
3. explore the sources of electricity and explain the generation of electricity, circuits, and properties of magnets, and recognize their uses in our daily life.
4. examine the sources, properties of light and sound, composition of light to understand their applications.
5. explore the movement of the Earth, lunar phases and eclipses to comprehend the cycles of day and night, changes in season and their correlation with culture and traditional beliefs that influences daily life patterns in societies.

Class-wise Competency

Class IV

By the end of class IV, the learner should be able to:

1. **Forces and Motion**
   investigate the effects of forces and floating and sinking phenomena, to comprehend the impact of both force and density.
2. **Energy**
   Demonstrate the understanding of different forms of energy and its uses to recognise the importance of saving energy.
3. **Electricity and Magnetism**
   explore the sources of electricity, components of simple circuits and its construction, properties of magnets and magnetic substances to understand their applications in society.

4. **Light and Sound**

explore the concept of light and sound and their sources and properties to understand the significance in daily life

5. **The Earth and Beyond**

explore the shape and movement of the Earth to understand their effects on the earth and life of people.

Table 19: *Learning objectives and process/essential skills for Physical Processes, class IV*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and Technology
i. Explain force and motion. ii. Explore the types of force with examples. iii. Investigate the effects of force. iv. Explain the significance of force in everyday life.	**3.1 Forces and motion** 3.1.1 Types of Forces. *(Scope: This topic begins with the introduction of the concept of force and motion and types of forces [contact and non-contact forces]. The contact force includes push and pull, and the noncontact force includes gravitational and magnetic forces. It also discusses the effects of force.)*	**Planning and Carrying out Investigation** The learners investigate different types of forces involved in daily activities	**Exploring Digital Resources** Use digital resources to obtain more information on forces and its impact.
i. Explain density of a substance. ii. Investigate the density of different solids in liquid. iii. Justify the effects of density to demonstrate the understanding of floating and sinking.	3.1.2 Floating and Sinking *(Scope: This topic introduces the concept of floating and sinking based on the density of an object in relation to a liquid.)*	**Analysing and Interpreting Data** The learners analyse and interpret the data to identify objects based on their densities.	**Exploring Digital Resources** May browse a video of objects with different densities showing floating and sinking nature.

i. Explain energy. ii. Explore various forms of energy with examples. iii. Investigate the use of energy in daily activities. iv. Suggest ways to save energy. v. Explain the importance of sustainable use of energy. vi. Explain why the government encourages the use of renewable energy.	**3.2 Energy** 3.2.1 Forms of energy *(Scope: This topic introduces energy, forms of energy and ways to save energy)*	**Obtaining, Evaluating, and Communicating Information** Observe and gather information from the surrounding to state the forms of energy and share with the class. **Obtaining, Evaluating, and Communicating Information.** Gather and evaluate information on how energy can be saved from reliable sources.	**Exploring Digital Resources** May browse relevant sources to gather information on saving energy.
i. Identify different sources of electricity. ii. Explain the roles of natural resources to produce electricity. iii. Discuss the importance of electricity for a healthy lifestyle. i. Explain the electrical circuit. ii. Construct a simple electric circuit to demonstrate the flow of electricity.	**3.3. Electricity and Magnetism** 3.3.1 Sources of Electricity *(Scope: This topic includes the sources of electricity such as battery, wind, water and solar. It also deals with the importance of electricity for a healthy lifestyle.)* 3.3.2 Circuits *(Scope: This topic consists of the concept of a circuit and its components. It further includes the construction of simple circuits to demonstrate the flow of electricity.)*	**Obtaining, Evaluating, and Communicating Information** Observe and list the electricity generating methods practised in the country and share the information to the class. **Developing and Using Models** Design a simple circuit to study the flow of electricity.	**Using Physical Tools** Use an ammeter to determine the flow of current in a circuit. **Exploring Digital Resources** May browse relevant sources to gather information on sources of electricity.

i. Explore magnets, magnetic and non - magnetic substances. ii. Identify home appliances that use magnets. iii. Explore the uses of magnets in green technology that mitigates climate change.	3.3.3 Magnet *(Scope: This topic deals with what magnet is, magnetic and non-magnetic materials, and examples of things that use magnets.)*	**Obtaining, Evaluating, and Communicating Information** Collect information on magnetic and non-magnetic properties and communicate the results.	**Exploring Digital Resources** May browse relevant sources to gather more information on attracting property of objects.
i. Explain light as a form of energy. ii. Identify different sources and primary sources of light. iii. Explain the importance of light. i. Explore the properties of light. ii. Investigate the properties of light to understand its nature. iii. Explain the formation of shadows. i. Explain sound as a form of energy. ii. Investigate how sound is produced. iii. Explain the importance of sound in people's life.	**3.4. Light and Sound** 3.4.1 Sources of Light *(Scope: This topic begins with light as a form of energy that helps us see, sources of light, the primary source of light, and explains the importance of light.)* 3.4.2 Properties of Light *(Scope: This topic deals with properties of light and formation of shadow)* 3.4.3 Sound *(Scope: This topic begins with sound as a form of energy and production of sound through vibration.)*	**Obtaining, Evaluating, and Communicating** **Information** Observe and list the gathered information on the sources of light and sound. **Planning and Carrying out Investigations** Design various experiments to study the properties of light.	The learners use materials around them and the internet to gather more information on the concept. **Exploring Digital Resources** Using digital resources to gather more information on the sources of light and sound along with their properties.

i. Explain the shape of the Earth. ii. Demonstrate rotation and its effect on the Earth. ii. Demonstrate the revolution and its effects on the Earth. iv. Explain the importance of the movement of Earth in our daily life.	**3.5 The Earth and Beyond** 3.5.1 Our Earth (Scope: *This topic includes the shape of the earth, rotation and revolution of the earth and their effects.)*	**Planning and Carrying out Investigations.** The learner designs a model to investigate the effect of rotation and revolution of the Earth.	**Exploring** **Digital Resources.** The learners use the internet to explore more information on the effect of rotation and revolutions of the Earth.

Class-wise Competency

Class V

By the end of class V, the learner should be able to:

1. **Forces and Motion**

   investigate frictional force, ways to enhance or reduce it, and compare the density of liquids to understand the effect of both frictional force and densities in daily activities.

2. **Energy**

   examine various forms of energy transformations and relate the law of conservation of mass based on energy transformation to recognize the significance of energy changes in everyday life.

3. **Electricity and Magnetism**

   explain circuits, conductor, insulator, magnetic poles, generation of electricity from renewable sources and construct a series circuit to understand their uses in different appliances.

4. **Light and Sound**

   investigate the composition and reflection of light and production of sound from musical instruments to understand the nature of light and sound.

5. **The Earth and Beyond**

   explore the lunar phases and lunar cycle to understand the scientific facts and local beliefs.

Table 20: *Learning objectives and process/essential skills for Physical Processes, class V*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	**Society and technology**
i. Explain frictional force. ii. Suggest ways to increase or decrease the frictional force. iii. Investigate the effects of frictional force. i. Explain density of a liquid. ii. Design and carryout simple experiments to compare the density of different liquids. iii. Analyse how densities of liquids affect the floating and sinking among the liquids.	**3.1 Force and Motion** 3.1.1 Frictional Force (*Scope: This topic begins by introducing what friction is, then explores effects of frictional force and its application. It also deals with methods on how to increase and decrease friction.*) 3.1.2 Floating and Sinking (*Scope: This topic begins by explaining what density is and compares density of different liquids.*)	The learners investigate the effects of frictional forces, design an activity to investigate the properties of liquids with different densities. **Constructing Explanations and Designing Solutions** Observe the surrounding and list a few objects in the surrounding (must include both static and dynamic objects). Explain how frictional forces acting on each object could be changed with assistance from PhET simulation. **Analysing and Interpreting Data** Observe the property of different types of liquid in water and analyse the reason for its floating or sinking characteristic.	**Exploring Digital Resources** Use PhET simulation to understand more on ways to increase and decrease friction.

i. Explore various forms of energy transformation. ii. Explain the law of conservation of energy based on the transformation of energy. iii. Justify the importance of transformation of energy in everyday situations. iv. Analyze how transformation of energy can cause climate change. v. Suggest climate smart lifestyle to conserve energy.	**3.2 Energy** 3.2.1 Forms and transformation of energy *(Scope: This topic deals with forms and transformation of energy to explain the law of conservation of energy, importance of energy transformation.)*	**Obtaining, Evaluating, and Communicating Information** Explore and use a variety of examples from the locality to describe various transformations of energy that take place in daily life.	**Exploring Digital Resource** Use digital resources to gather more information on energy transformation.
i. Explain the generation of electricity using hydropower. ii. Explain the generation of electricity using solar energy. iii. Explain the generation of electricity using wind energy. iv. Explain the transportation of electricity from the source to consumers. v. Justify hydropower, solar and wind energy as clean energy sources. i. Conduct an experiment to identify conductor and insulator. ii. Demonstrate the construction of open and closed circuits using available materials.	3.3 **Electricity and Magnetism** 3.3.1 Generating Electricity *(Scope: This topic introduces the process of generating electricity using hydropower, solar and wind energy, its transportation to our homes and its significance.)* 3.3.2 Circuits *(Scope: This topic covers the concept of conductors and insulators, differences between*	**Obtaining, Evaluating, and Communicating Information** Interview a community and report on the sources of electricity the community uses or is aware of. **Developing and Using Models** Construct a model that depicts the functions of different parts of a circuit. Incorporate locally available	The learners use available materials in the locality and the internet to explore and investigate the concepts. **Promoting Socio-cultural, Economic, and Human Values** Gather information on the significance of generating electricity and its sustainable use.

iii. Construct a series circuit using available materials to determine its characteristics. iv. Suggest safety measures of using electricity safely.	*open and closed circuits, construction of series circuits and safety measures.)*	materials (may replace the switch) to complete the circuit and determine if the used material is a conductor or an insulator.	
i. Explore the magnetic poles using bar magnets to identify its poles. ii. Conduct an experiment to prove that unlike poles attract each other and like poles repel each other.	3.3.3 Magnet *(Scope: This topic focuses on attraction and repulsion of magnets based on their polarity.)*	**Engaging in Argument from Evidence** Interpret the magnetic properties of some of the locally available objects based on its materials.	**Exploring Digital Resources** May browse relevant sources to gather information on earth as the biggest magnet and its magnetic properties.
i. Explore the composition of white light using prisms and Newton's disc. ii. Explore and list some properties of light and investigate reflection of light from even and uneven surfaces.	3.4 **Light and Sound** 3.4.1 Properties of Light *(Scope: This topic begins with composition of white light (VIBGYOR) , [Newton's disc, light through prism,] and some properties [reflection from even and uneven surfaces].)*	**Planning and Carrying out Investigations** Execute Newton's Disc Experiment and analyse the phenomena observed	**Exploring Digital Resources** Use reliable sources to obtain more information on the concepts.
i. Describe the production of sound using different musical instruments. ii. Construct a simple musical instrument to study the variation in volume and pitch of sound.	3.4.2 Sound *(Scope: musical sound, concept of volume and pitch through activity, activity on musical instruments [percussion, stringed*	**Constructing Explanation and Designing Solutions** Draw conclusions based on the significance of sound in conversation and music creation.	

iii. Explore the significance of sound produced by musical instruments.	*and wind], sound production and its significance.)*	Propose methods to make a certain music instrument sound a certain way.	
i. Explain the moon as one of the heavenly bodies in the universe. ii. Describe different phases of the moon. iii. Make a model to understand different phases of the moon. iv. Recognize its significance in Bhutanese socio-cultural settings.	3.5 **The Earth and Beyond** 3.5.1 Moon *(Scope: This topic deals with the nature and properties of the moon, its phases in different weeks and their significance in Bhutanese belief system.*)	**Planning and Carrying out Investigations** The learner observes different phases of the moon, and designs activity to investigate the phases of the Moon.	**Promoting Socio-cultural, Economic, and Human Values** The learner asks adults in the locality about the significance of different phases of the moon, and uses the internet to play online simulations on the phases of the moon.

Class-wise Competency

Class VI

By the end of class VI, the learner should be able to:

1. Forces and Motion

explain mass, weight, gravity, and gravitational force, density, their relationships, and analyse their effects in nature and human's life.

2. Energy

investigate potential energy and kinetic energy, factors affecting potential energy and kinetic energy to understand their application in life.

3. Electricity and Magnetism

construct a parallel circuit in contrast to a series circuit and explore methods of preparing permanent, temporary magnets, and enhancing the electromagnetic power to improve functionality in home appliances.

4. Light and Sound

demonstrate refraction of light and propagation of sound through different media to understand their significance in our daily life.

5. The Earth and Beyond

explain the equator, poles of earth and eclipses to understand the Earth's features, climate, and their roles in our daily life.

Table 21: *Learning objectives and process/essential skills for Physical Processes, class VI*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and technology
1. Explain mass, weight, gravity and gravitational force. 2. Investigate the effects of mass on gravitational force to understand the impact of gravity on daily activities. 3. Explore the relationships between mass, weight and gravity. 4. Investigate the effects of altitude on gravitational force to understand the impact of gravity on daily activities. i. Conduct an experiment to compare the density of solid in different liquids. ii. Recognise the importance of floating and sinking objects in liquid.	**3.1 Forces and Motion** 3.1.1 Gravity and Factors *(Scope: This topic begins by introducing the concept of mass, weight, gravity, and gravitational force. Further the relationship between mass and gravity, mass and weight, altitude and gravity shall be discussed in this topic.)* 3.1.2 Floating and Sinking *(Scope: This topic deals with the comparison of the density of a solid with that of density of different liquid, importance of floating and sinking)*	**Obtaining, Evaluating, and Communicating Information** Record the time taken for each item of different weights to reach the ground when released from various surroundings. Justify the difference in time taken. **Engaging in Argument from Evidence** Justify the density of different solids based on the property it exhibits in liquids of different densities.	**Using Physical Tools** The learners use objects collected from their locality to conclude the density of an object.

i. Explain potential and kinetic energy with examples from the surrounding. ii. Investigate the factors affecting potential energy and kinetic energy. iii. Relate the significance of PE and KE to our daily activities.	**3.2 Energy** 3.2.1 Forms of Energy *(Scope: This topic introduces potential and kinetic energy, investigation and factors influencing potential and kinetic energy.*	**Planning and Carrying Out Investigations** Explore the mechanical energy in daily life and illustrate the law of conservation of energy.	Use PhET simulation to explore the concepts of mechanical energy. Exploring Digital Resources to understand the law of conservation of energy with examples.
i. Explore the characteristics of parallel circuits in contrast to a series circuit. ii. Construct a parallel circuit using available resources and compare it with the series circuit. iii. Explore the advantages of parallel circuits in comparison to series circuits. iv. Examine the types of circuit used at home or school, and justify its appropriateness. i. Explore the concept of temporary and permanent magnets, magnetic strength, and magnetic field. ii. Carry out an experiment to demonstrate the magnetic field of a magnet.	**3.3 Electricity and Magnetism** 3.3.1 Circuits *(Scope: This topic focuses on the construction of a parallel circuit and its comparison with a series circuit. Further it includes identifying types of circuits at home and school and understanding the advantages of using circuits* 3.3.2 Magnet *(Scope: This topic focuses on preparing temporary magnets and ways of increasing the strength of a magnet. Further it also deals with study of magnetic field, shapes of magnet and use of magnets in*	**Constructing Explanations and Designing Solutions** Determine the type of circuit suitable under various conditions and construct the relevant circuits. **Obtaining, Evaluating, and Communicating Information** Gather information on magnets with different strengths from reliable sources and share them with the class.	**Using Physical Tools** Use materials available at the school laboratories to construct relevant circuits.

iii. Prepare temporary magnets using available resources. iv. Identify the uses of magnets in everyday life. v. Explore the uses of magnets in green technology that mitigates climate change.	*various home appliances.)*		
i. Explain the phenomenon of reflection and refraction of light. ii. Design an experiment to investigate refraction of light. iii. Explain the significance of refraction of light in our daily life. i. Explore the propagation of sound through different media. ii. Design and carry out an experiment to demonstrate how pitch and volume of the sound changes in different media. iii. Explain the significance of sound in our daily life.	**3.4 Light and Sound** 3.4.1 Properties of Light *(Scope: The topic explains the concept of reflection, refraction, and explores experiments on bending of light).* 3.4.2 Properties of Sound *(Scope: This topic explains how sound travels through different media. [Solid, liquid, and gas]. Variation of pitch and volume in different media)*	**Planning and Carrying Out Investigations** Explain the formation of images at circus mirrors and observation of a bending phenomenon of objects when immersed in liquid. **Obtaining, Evaluating, and Communicating Information** Conduct the tuning fork experiment in various media and observe the properties of sound exhibited in terms of its pitch and volume.	**Exploring Digital Resources** Explore the web to understand the concept of image formation and bending of light. **Using Physical Tools** Use materials available at the school laboratories and home to conduct the tuning fork experiment.
i. Explore the concepts of poles, polar days,polar night and equator of earth.	**3.5 The Earth and Beyond** 3.5.1 Solar Eclipse & Lunar Eclipse *(Scope: This topic introduces poles, polar days and night*	**Obtaining, Evaluating, and Communicating Information.** The learner explores and identifies the causes of solar and lunar eclipse, and constructs a	**Promoting Socio-cultural, Economic, and Human Values** The learner investigates local narratives on the

ii. Construct a model to demonstrate and explain the causes of solar and lunar eclipses. iii. Compare the scientific causes of solar and lunar eclipse with local belief of the community.	*and equator of earth. It also includes the causes and formation of solar and lunar eclipse.)*	scientific explanation for such natural phenomena.	formation of solar and lunar eclipse. Exploring digital resources such as the internet to explore the cause and formation of such natural phenomena.

9.3 Key Stage 3 (VII-VIII)

9.1.6 9.3.1 Strand: Life processes

Competency Based Standard

By the end of Key stage 3 (Class VIII), the learner should be able to:

1. Explain the types of cells, collaboration amongst the cells, tissues, organs, organ systems of an organism to understand their interdependence for the proper growth and development of an organism.
2. explain on nutrition, health, organ systems and their roles in proper functioning of humans to foster a healthy lifestyle.
3. investigate the conditions necessary for photosynthesis, nutrition, germination, reproduction, and explain their significance in the proper growth and development of plants.
4. Explain the absorption and reproduction in plants and farming practices to understand their importance in survival of plants and practising sustainable farming respectively.
5. study the means of adaptation and feeding strategies adopted by species in an ecosystem to understand the importance of interdependence of living beings, among themselves and with their environment.

Class-wise Competency

Class VII

By the end of class VII, the learner should be able to:

1. Cells

explore various cell types and compare the plant and animal cells to grasp the importance of cells in the survival of organisms.

2. Humans as Organism

explore nutrition, health, and organ systems to understand how they contribute to the proper functioning of the human body.

3. Green Plants

investigate the conditions required for the photosynthesis and germination of seeds to understand their importance in plant life.

explain nutrients, its type and deficiency diseases to understand the significance in growth and development of plants.

4. Living things and their Environment

analyse adaptation, variation and ecosystem to understand the significance of interdependence for the survival of organisms.

Table 22: *Learning objectives and process/essential skills for Life processes, class VII*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and Technology
i. Explain the cell. ii. Compare unicellular and multicellular organisms. iii. Explore different shapes and sizes of the cells. iv. Examine different parts of an animal cell. v. State the significance of animal cells in maintaining the life processes of an organism. vi. Examine different parts of a plant cell. vii. Compare plant cells and animal cells. viii. State the importance of plant cells for the survival of organisms. ix. Identify the parts of the microscope and their scientific uses. x. Prepare a temporary slide of onion cell and cheek cell. xi. Draw to compare an onion cell and cheek cell as observed under the microscope.	**1.1 Cells** 1.1.1 Types, Structures and Functions *(Scope: This topic introduces cells, unicellular organisms and multicellular organisms, the shapes and size of cells, structures and parts of plant and animal cells. It also focuses on how to handle a compound microscope during the activity of preparation and observation of temporary slides.*	**Obtaining, Evaluating, and Communicating Information** Observe permanent slides of plant and animal cells under a compound microscope to obtain information on plant and animal cells and communicate the information by drawing the cell observed.	**Using Physical Tools** Use a microscope to observe plant and animal cells. **Exploring Digital Resources** Explore digital resources to further study the structural differences between plant and animal cells.
i. Explain the significance of nutrition for proper growth and development of the human body. ii. Explain the causes of diseases related to insufficient	**1.2 Humans as Organisms** 1.2.1 Nutrition *(Scope: This topic covers food nutrients [carbohydrates, proteins, fats,*	**Planning and Carrying Out Investigation** Explore the need for various nutrients and food groups through investigations.	**Serving human values and influence value formation** The learners explore all kinds of food in the locality and the eating habits in their family and the

consumption of food nutrients. iii. Investigate the presence of carbohydrates, fats, and proteins in foods. iv. Explain how human nutrition is related to food security.	*minerals, vitamins, water, roughage /fibre] and their deficiency diseases and excess consumption of food nutrients significance in organisms' survival. It also focuses on testing foods for the presence of carbohydrates, fats, and proteins.)*		community to advocate a healthy food habit.
i. Identify the different parts of the human skeleton. ii. State the functions of the parts of the human skeleton. iii. Describe the importance of the human skeleton.	1.2.2 Movement *(Scope: This topic deals with the parts of the human skeleton: Axial Skeleton-skull (cranium and facial bones), rib cage [true ribs, floating ribs, and sternum], and vertebral column (back bone). Appendicular Skeleton-pectoral girdles (clavicle and scapula), pelvic girdles (hip bone, sacrum, and coccyx), bones of limbs [forelimbs and hind limbs] and their functions.)*	**Obtaining, Evaluating, and Communicating** **Information** Observe and record the role of the skeleton in daily activities and share the information through demonstration or in written form.	**Exploring Digital Resources** Explore digital resources for additional information on the significance of skeleton in day -to-day activities.
i. Identify different parts of the human respiratory system.	1.2.3 Breathing and Respiration *(Scope: This topic highlights what breathing and*	**Obtaining, Evaluating, and Communicating** **Information**	**Exploring Digital Resources** The learners use the internet to explore

ii. List the functions of different parts of a human respiratory system. iii. Demonstrate the mechanism of breathing with the help of a model of the human respiratory system. iv. Explain the significance of the human respiratory system.	*respiration are, parts of the human respiratory system and their functions. It also includes the mechanism of breathing.)* 1.2.4 Reproduction	Observe and record the role of the respiration and the breathing in daily activities and share the information through demonstration or in written form.	more information on the respiratory system. **Using Physical Tools** Use locally available resources to design a model to explain the mechanism of breathing.
i. Identify different parts of human reproductive organs. ii. Mention the functions of the human reproductive organs. iii. Differentiate between primary and secondary sexual characteristics. iv. Describe the phases of the menstrual cycle. v. Recognize ways of maintaining personal health and hygiene during menstruation.	*(Scope: This topic includes the functions of different parts of the male and female reproductive systems. It also touches on the phases of the menstrual cycle and the ways to promote health and hygiene.)*	**Obtaining, Evaluating, and Communicating** **Information** Use any reliable resources to study parts of male and female reproductive system and explore ways to maintain health and hygiene during menstruation. Communicate the obtained information through songs, posters, arts, etc.	**Using Digital Resources** The learners explore more information on the concepts using the internet.
i. Describe the structures and functions of the human nervous system. ii. Identify different types of nerves and their function. iii. Relate how the health of the nervous system is significant for	1.2.5 The Nervous System *(Scope: This topic highlights the parts of the human nervous system - brain (limited to cerebrum, cerebellum and medulla oblongata), spinal cord*(just a cross-sectional structure in terms of long and	**Obtaining, Evaluating, and Communicating** Information The learners use human brain models to identify the parts and gather information on parts of the nervous system and their functions.	**Exploring Digital** Resources The learners use the internet to gather more information on the nervous system and its significance.

the emotional well-being of a person.	cylindrical structure made of fluids, tissues, and nerve cells); *nerves, types of nerves and their functions - sensory nerves, motor nerves and mixed nerves.)*	Design an activity to recognise and remember to further cater the functions of the nervous system.	
i. Explain causes, symptoms, and preventions of communicable diseases. ii. Explain causes, symptoms, and preventions of non-communicable diseases. iii. *Design strategies to mitigate the outbreak of communicable diseases due to climate change.*	1.2.6 Health *(Scope: This topic introduces communicable and non-communicable diseases and their causes, symptoms, and preventions. Common communicable diseases include diarrhoea, typhoid, AIDS, common cold and chickenpox, ringworm, malaria. Common non-communicable diseases include diabetes, blood pressure, asthma, cancer, stroke and obesity.)*	**Planning and Carrying Out Investigation** Survey the Prevalence of communicable and non-communicable diseases in the locality. **Analysing and Interpreting Data** Design a poster using programming language to create awareness on the prevention of communicable disease.	**Serving human values and influence value formation** The learners use local settings to explore the concept and create awareness on communicable and non-communicable disease in the community.
i. Explain macronutrients and micronutrients. ii. Identify the source, roles and deficiency symptoms of macronutrients and micronutrients. iii. Explain photosynthesis.	**1.3 Green Plants** 1.3.1 Nutrition and Photosynthesis *(Scope: This topic covers macronutrients - primary and secondary, micronutrients* *- and their roles and deficiency symptoms in plants. It also*	**Planning and Carrying Out Investigation** Carry out the investigation on conditions required for photosynthesis **Analysing and Interpreting Data** List down the conditions necessary for	**Exploring Digital Resources** Use the digital resources to further explore the role of nutrients in the growth and development of plants.

iv. Explain the significance of photosynthesis v. Investigate the factors affecting the process of photosynthesis. i. Compare hypogeal and epigeal germination. ii. Investigate conditions necessary for epigeal and hypogeal germination. iii. Explain the significance of germination. iv. Explain the impact of climate variation on germination.	*includes photosynthesis, equations - word as well as chemical, and factors affecting the process of photosynthesis and its importance.)* 1.3.2 Germination *(Scope: This topic begins with what germination is, hypogeal and epigeal germination, and the conditions required for germination of seeds.)*	photosynthesis to occur from the collected data. **Planning and Carrying Out Investigation** Observe the role of nutrients through field visit in the locality and study its deficiency symptoms. **Analysing and Interpreting Data** Identify the essential nutrients required for proper growth of plants and its deficiency symptoms **Planning and Carrying Out Investigation** Carry out an investigation to study the conditions required for the germination of seed by conducting an experiment. **Analysing and Interpreting Data** List down the conditions required for germination of seed from the collected data.	**Serving human values and influence value formation** The learners understand the importance of plants in the environment based on their potential to absorb carbon dioxide and produce oxygen gas. **Using Physical Tools** Use the locally available resources to investigate the conditions necessary for germination.
I. Explain adaptation and variation and their significance for the balance of the ecosystem. II. State the adaptive features of organisms in different habitats.	**1.4 Living things and their environment** 1.4.1 Adaptation and Variation	**Planning and Carrying Out Investigation** The learners investigate different adaptive features of organisms in different habitats through field visits.	**Exploring Digital Resources** The learners use the surroundings and the internet to explore the adaptive features

III. *Explain climate change as the cause of global warming.* *IV.* Explain the causes and impacts of climate change. V. Suggest measures to mitigate the human activities that contribute towards climate change impact. i. Explain biotic and abiotic components of an ecosystem. ii. Investigate the biotic and abiotic components in an ecosystem in the locality. iii. Identify different types of ecosystems. iv. Discuss the strategies to protect ecosystems that are vulnerable to climate change.	*(Scope: This topic introduces adaptation, and variation. It includes the study of adaptive features of organisms. It further discusses global warming and the causes and risk of climate change)* 1.4.2 Ecosystems *(Scope: This topic introduces biotic and abiotic components and types of ecosystems.)*	**Analysing and Interpreting Data** Identify various habitats o animals in the locality and compare the features of animals to understand the variation. **Planning and Carrying Out Investigation** Carry out an investigation in the locality to identify some ecosystems. **Analysing and Interpreting Data** List down the ecosystems found in the locality and come up with some strategies to conserve them. **Obtaining, Evaluating, and Communicating** **Information** Observe the surroundings or refer to any reliable resources to study the role of the food chain in the balanced nature. Share the obtained information to others **Planning and Carrying Out Investigation** Investigate ways to mitigate the threat to ecological balance due to human activities.	and various kinds of habitats. **Promoting Socio-cultural, Economic, and Human Values** Observe the habitats of animals in the environment and realize the significance of conserving the environment. **Promoting Socio-cultural, Economic, and Human Values** The learners use the local environment to learn about ecosystems and create awareness on the conservation of ecosystems. **Promoting Socio-cultural, Economic, and Human Values** The learners explore the threat posed by human activities on the ecological balance in their locality and suggest ways to mitigate threats

		Analysing and Interpreting Data State the strategies to minimise ecological threat posed due to human activities.	

Class-wise Competency

Class VIII

By the end of class VIII, the learner should be able to:

1. **Cells**

   explain the levels of organisation of cells of an organism to understand their relationships in maintaining the overall function and survival of an organism.

2. **Humans as Organisms**

   explain various life processes (digestive system, movement, respiratory system and reproduction), sense organs, environment, lifestyle and health to understand their significance in proper functioning of the human body.

3. **Green Plants**

   Explain the functions of roots, reproduction, and its types in plants, highlighting their roles in the growth and development of plant life.

   Analyse the functions and significance of farming types in delivering valuable benefits to human agriculture and ecosystems.

4. **Living Things and their Environment**

   examine how species within an ecosystem adapt and employ feeding strategies to comprehend the crucial interdependence among living organisms, both among themselves and with their surroundings.

Table 23. *Learning objectives and process/essential skills for Life processes, class VIII*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and Technology
i.Identify the structures and functions of plant cells and animal cells.	**1.1 Cells** 1.1.1 Levels of Organisation	**Obtaining, Evaluating, and Communicating** **Information** Observe the cells using the microscope	**Using Physical Tools** Use a microscope to observe permanent slides of plant and animal cells and tissues.

ii. Construct a model of plant and animal cells. iii. Examine the level of organisation in organisms. iv. Identify the structure and functions of different plant tissues. v. Observe the permanent slides of plant tissues under the microscope (limited to dicot stem). vi. Describe the structure and functions of animal tissues vii. Observe the permanent slides of animal tissues under the microscope.	*(Scope: This topic covers the functions of cell organelles, levels of Organisation: cells, tissues, organs, organ systems of both plants and animals with greater emphasis on plant and animal tissues and their functions.)*	to identify the cell organelles. Share the functions of each cell organelle with others. Observe the permanent slides of plant and animal tissues under the compound microscope. **Planning and Carrying Out Investigation** Carry out an investigation to study the relationship of cells, tissues, organs, and organ systems to understand the development of organisms. **Analysing and Interpreting Data** Explain the development of organisms from the data collected.	**Exploring Digital Resources** The learners use the internet to explore more on the concept and investigate the relationship.
i. Explain the structures and functions of the human digestive system. ii. Explain the significance of the digestive system in humans.	**1.2 Humans as Organisms** 1.2.1 Human Digestive System *(Scope: This topic covers what digestion is, parts of the digestive system and their functions, and the process of digestion in the mouth, stomach, and small intestine.)*	**Developing and Using a Model** Construct a human digestive model to identify the parts and describe the function of each part.	**Using Physical Tools** The learners use available resources in the locality to design a model. **Exploring Digital Resources** Explore digital resources to further understand the mechanism of digestion.

i. Identify different types of muscles. ii. Describe the characteristics and the functions of muscles. iii. Explain the working principle of antagonistic muscles. iv. Explain the types, characteristics, and functions of joints. v. Describe the significance of muscles and joints for the survival of organisms.	1.2.2 Muscle, Joints, and Movements *(Scope: This topic includes the types of muscles and joints, their characteristics, and functions. It also includes the working of antagonistic muscles in the body.)*	**Obtaining, Evaluating, and Communicating** **Information** Observe a model or video to explore the functions of muscles and joints and to understand the working of antagonistic muscles. Communicate the information obtained through demonstration or verbally.	**Exploring Digital Resources** Further explore the functions of muscles and joints and the working of antagonistic muscles to relate the movement of the body in everyday life.
i. Explain external respiration, internal respiration, and cellular respiration. ii. Explain how ATP is generated during cellular respiration. iii. Explore respiration and its types in plants and animals. iv. Differentiate between aerobic respiration and anaerobic respiration in the plants and animals. v. Explain the significance of respiration for the survival of an organism.	1.2.3 Respiratory System *(Scope: This topic focuses on the process of external respiration, internal respiration, and cellular respiration. It also includes the types of respiration in plants and animals- aerobic respiration and anaerobic respiration.)*	**Developing and Using a Model** Develop and use a model The learners explore the concept of gaseous exchange through the development of a model to demonstrate the exchange of gases in alveoli and the consequences of two types of respiration. **Obtaining, Evaluating, and Communicating** **Information** Refer any resources to gather information on two types of information. Explain the effects of two types of respiration on everyday activities.	**Exploring Digital Resources** The learners use the internet to explore more on the concept.

i. Explain fertilisation and its process. ii. Explain the different stages of foetal development. iii. Discuss the consequences of teenage pregnancy and ways to prevent it.	1.2.4 Reproduction *(Scope: This topic introduces fertilisation, stages of foetal development and teenage pregnancy.)*	**Obtaining, Evaluating, and Communicating** Information Use a relevant video on fertilisation and implantation to collect information on fertilisation and implantation. The learners observe, explain, and describe the concept of fertilisation and foetal development. **Obtaining, Evaluating, and Communicating** Information Observe a model or watch a video to obtain information on stages of foetal development and share the information gathered.	**Exploring Digital Resources** The learners explore more information on the concepts using the internet. **Using a Physical Tools** Use tools available in the locality to understand the concept of sense organs.
i. Develop models that explain the structures and functions of human eyes and ears. (Limited to structures of eyeball; external, middle, and internal structures of a ear) ii. Explains the structures and functions of the human nose, tongue, and skin (hair and basic internal chambers of nose; parts of tongue and taste buds, and	1.2.5 Sense Organs *(Scope: This topic includes the structure, parts and functions of eyes, ears, tongue, nose, and skin.)*	**Obtaining, Evaluating, and Communicating** **Information** Use a model to study the basic structures of sense organs and their functions. Further explore the digital resources to gather information on the significance of sense	**Exploring Digital Resources** Use the internet to gather more information and take proper care of sense organs.

skin (hair, epidermis, and dermis). *iii*. Suggest ways to care for the sense organs. iv. Explain the importance of sense organs		organs in the daily functioning of life.	
i. Justify consequences of substance abuse and power dynamics as the causes of domestic violence and social discrimination to suggest ways to prevent them. ii. Examine the effects of the lifestyle of humans on the environment.	1.2.6 Lifestyle and Health *(Scope: This topic deals with health, and effects on health due to substance abuse and domestic violence.*	**Planning and Carrying Out Investigation** Visit the locality to investigate the different sources of pollution that affects the health and lifestyle of human beings. **Analysing and Interpreting Data** List down the sources of pollution and its effect on the lifestyle of human beings from the data gathered. **Constructing Explanations and Designing** Solutions Construct the explanation for the pollution and its effect on health and lifestyle based on evidence gathered and suggest solutions to reduce pollution, health, and lifestyle issues.	**Exploring Digital Resources** Use digital resources to explore the environment that leads to an unhealthy lifestyle.

i. Identify different parts of a root. ii. Explain the types of roots in plants. iii. Explain the functions of roots. iv. Demonstrate the functions of a root through osmosis.	**1.3 Green Plants** 1.3.1 Absorption by Roots *(Scope: This topic includes the types of roots, and their functions.)*	**Obtaining, Evaluating, and Communicating Information** Refer any resources to obtain information on different parts of the root and their functions. Share the function of roots in the absorption of nutrients. **Planning and Carrying Out Investigations** Conduct an experiment to show the process of diffusion and osmosis. **Analysing and Interpreting Data** Explain how diffusion and osmosis help in the absorption of water and minerals by the root hairs.	**Exploring Digital Resources** Use digital resources to further understand the concept of absorption by roots.
i. Explain organic and inorganic farming to understand their advantages and disadvantages. i. Explain different methods of organic farming and their significance. i. Assess the impacts of inorganic farming on the quality of soil and the environment. iv. Explain how agricultural practices are affected by climate change.	1.3.2 Organic and Inorganic Farming *(Scope: This topic introduces organic and inorganic farming, methods of organic farming, and advantages of organic farming and disadvantages of inorganic farming.)*	**Planning and Carrying Out Investigation** Visit your locality to investigate organic and inorganic farming practices. **Analysing and Interpreting Data** Indicate the advantages and	**Promoting Socio-cultural, Economic, and Human Value** Advocate locality on disadvantages of inorganic farming practises and advantages of organic farming practices

i. Explain sexual and asexual reproduction in plants. ii. Explain the natural and artificial vegetative propagation in plants. iii. Investigate the propagation of plants through stem cutting.	1.3.3 Reproduction *(Scope: This topic includes sexual and asexual reproduction. An asexual reproduction highlights natural vegetative propagation - stems, roots, leaves; and artificial vegetative propagation - stem cutting, layering, grafting. It also deals with advantages and disadvantages of vegetative propagation.)*	disadvantages of organic and inorganic farming. **Constructing Explanations and Designing Solutions** Construct an explanation and suggest some strategies to promote organic farming in the locality. **Obtaining, Evaluating, and Communicating** Information Refer any reliable resources to obtain information on vegetative propagation and understand its application. Spell out the various methods of propagating plants to your friends. **Planning and Carrying Out Investigation** Conduct an experiment to further investigate the application of vegetative propagation of plants in agriculture. **Analysing and Interpreting Data**	**Exploring Digital Resources** Use any digital resources to explore more information on propagation of plants. **Using Physical Tools** Use the locally available resources to conduct an experiment on application of vegetative propagation of plants in agriculture.

		List down the application of vegetative propagation of plants in agriculture of the data collected.	
i. Explain how plants and animals adapt to their habitats. ii. Differentiate between intraspecific and interspecific competition. iii. Explore the effects of climate change on intraspecific and interspecific competition. i. Explain the causes and effects of biomagnification.	**1.4 Living Things and their Environment** 1.4.1 Adaptation and Survival *(Scope: This topic highlights on adaptation - structural, physiological, behavioural; adaptive features and natural selection through competition - intraspecific, interspecific, and predation.)* 1.4.2 Feeding and Relationships *(Scope: This topic includes what biomagnification is, its*	**Obtaining, Evaluating, and Communicating** Information Refer any reliable resources to gather information on adaptation and spell out how adaptive features help organisms survive in the harsh climatic conditions. **Planning and Carrying Out Investigation** Observe your locality to study the different types of competitions existing in the locality. **Analysing and Interpreting Data** Sort out the differences between intraspecific and interspecific competition. **Obtaining, Evaluating, and Communicating** Information	**Exploring Digital Resources** Use the internet to explore the adaptive features and various kinds of competition faced by organisms in their locality. **Exploring Digital Resources** Use the internet to explore more

ii. Analyse the impacts of biomagnification in an ecosystem. I. Explain biodiversity and its role in the ecosystem. II. Evaluate sustainable development practices in the locality in conserving the local biodiversity. III. Evaluate the religious and cultural practices that contribute to conservation of biodiversity. i. Explain selective breeding. ii. Identify examples of hybrid plants and animals. iii. Discuss advantages and disadvantages of selective breeding.	*causes and effects with examples.)* 1.4.3 Biodiversity *(Scope: The topic introduces biodiversity, its role in the ecosystem and how sustainable development helps in conserving biodiversity.)* 1.4.4 Breeding *(Scope: The topic covers what breeding is, selective breeding and its role in crop and livestock improvement. It also includes the merits and demerits of selective breeding.)*	Explore any digital resources or any other resources to obtain information on biomagnification and its effects. Share the information obtained to others verbally. **Obtaining, Evaluating, and Communicating** Information Explore reliable resources to study the importance of biodiversity and significance of practising sustainable development in conservation of environment. Evaluate data obtained by conducting an activity. Communicate the information by creating awareness on the concept. **Planning and Carrying Out Investigation** Visit your locality to investigate the breeding methods practised by the farmers. Further refer digital resources to collect data on	information on the concept. **Exploring Digital Resources** Use the internet to learn global practices. **Promoting Socio-cultural, Economic, and Human Value** Compare and contrast the sustainable practices between Bhutan and global practices. Then advocate the significance of sustainable practices. **Exploring Digital Resources** Use the internet to learn the concept. **Promoting Socio-cultural, Economic, and Human Value** Advocate and promote the advantages of practising selective breeding in

		breeding practices in agriculture **Analysing and Interpreting Data** Discuss benefits and drawbacks of selective breeding in crops and animals from the data collected.	agriculture in your locality.

9.1.7 9.3.2 Strand: Materials and their Properties

Competency Based Standard

By the end of Key Stage 3 (Class VIII), the learner should be able to:

1. Investigate the properties of matter based on particle theory and explore concepts of elements compounds and atomic structure to understand their uses in daily life.
2. Investigate the characteristics of physical and chemical change to relate their effects on the changes occurring in the natural environment to recognise their significane in day-to-day life.
3. Analyse the patterns in the periodic table to understand the properties of elements and classify them into different groups and periods.
4. Investigate the properties of acids and bases to understand the concept neutralisation reaction and their applications in everyday life.
5. Investigate mixtures and their properties and explore methods of separation to separate the mixtures into components, and relate those techniques in everyday life.

Class-wise Competency

Class VII

By the end of class VII, the learner should be able to:

❖ **Classifying Materials**

- demonstrates the understanding of particle theory of matter to understand the interconversion of matter, gas pressure and diffusion, and relate its relevance in everyday life.
- illustrate the atomic structure using models to understand metals and nonmetals and their uses in everyday life of people.

❖ **Materials and Change**

investigate the conditions and characteristics of physical and chemical changes, and relate them to everyday phenomena occurring in the natural environment.

❖ **Patterns in Chemistry**

- analyse the patterns of the periodic table to explain the trends across the period and down the groups.
- analyse the properties of acids and bases to provide scientific reasons for their uses in day-to-day life.

- **Separating Mixtures**
  explain solution and solubility, types of solution and mixtures, and different separation techniques to understand their applications in the real-life setting.

Table 24: *Learning objectives and process/essential skills for materials and their properties, class VII*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	**Society and Technology**
Explain the states of matter based on the particle theory of matter. i. Investigate the process of interconversion of matter, gas pressure and diffusion based on the particle theory. ii. Relate diffusion and gas pressure to everyday life experiences to understand their significance.	2.1 **Classifying Materials** 2.1.1 Particle Theory of Matter *(Scope: This topic introduces the particle theory of matter. It covers interconversion of matter i.e., melting, freezing, evaporation, condensation, sublimation, and deposition. It also explores gas pressure and diffusion based on particle theory.*)	The learners observe, explore, and investigate properties of matter through various activities. **Planning and Carrying out Investigations** Design experiments to investigate the intermolecular space, interconversion of matters, gas pressure and diffusion. Determine the dependent, independent, and controlled variables if needed in the experiment. **Analysing and Interpreting Data** Analyse and interpret the data collected from the experiment.	The learners examine material around them to study their properties. **Using Physical Tools** Use the apparatus from the science laboratory or improvise the apparatus from the locally available materials.
i. Identify names, symbols, atomic numbers, and mass numbers for the first 30 elements in the periodic table. ii. Develop models to describe the atomic	2.1.2 Elements and Atomic Structure *(Scope: This topic covers elements and their symbols [first thirty elements] along with their atomic and mass number. Furthermore, it delves into atomic structure representing the location of the subatomic particles [proton, neutron and*	**Constructing Explanation and Designing Solutions** Provide scientific explanation using the data collected from the experiment. The learners classify metals and nonmetals and construct a model to represent the atomic structure.	**Exploring Digital Resources** Explore and use digital plate form or tools to obtain information to supplement learning and/or validate findings

composition of atoms of common elements. iii. Classify elements as metals and non-metals based on their physical properties. iv. Evaluate the significance of metals and nonmetals in daily life.	*electron, and their charges]. This topic also includes the properties of metal and non-metal, and their examples.)*	**Obtaining, Evaluating, and Communicating Information** Refer grade-appropriate texts and/or digital media to obtain scientific information about common elements, atomic structure, and the classification of elements into metal and non-metal **Engaging in Argument from Evidence** Based on the scientific information gathered through grade-appropriate texts and/or through relevant digital resources, construct an argument with evidence to develop an atomic model and to differentiate metals and non-metals. **Developing and Using Models** Develop atomic models based on scientific knowledge, acquired through exploration from various sources and involvement in the argument, to illustrate the components of atoms.	developed through experiments. The learners use information from the internet and construct a model showing the atomic composition using available resources. **Use of Physical tools** Use tools and materials provided and/or locally available to design an atomic structure that can be used in explaining the composition of an atom. May use ready-made models of atoms from the laboratory as well. **Exploring Digital Resources** May obtain information from reliable digital sources to develop knowledge on the core concepts provided and on the designing of atomic models. **Carrying out STEM Activities**

			May explore and use software to design simulation, illustration and/or graphic models of an atom.
i. Differentiate between physical and chemical change. ii. Explore various conditions necessary for physical and chemical changes. iii. Design an experiment to demonstrate physical and chemical changes. iv. Relate the changes to everyday phenomena occurring in the natural environment.	**2.2 Materials and Change** 2.2.1 Physical and Chemical Change *(Scope: This topic highlights the characteristics of physical and chemical change, and the conditions required for physical and chemical change - moisture, heat, temperature, pressure, force, and air, etc.)*	Learners observe and investigate characteristics of physical and chemical changes and the conditions required for change **Obtaining, Evaluating, and Communicating** **Information** Obtain and combine information from books and other reliable digital media to explore the characteristics of physical and chemical changes and the conditions required for these changes to take place. **Planning and Carrying Out Investigations** Investigate to obtain data which support explanations for characteristics of physical and chemical changes and the conditions required for these changes occur. **Analysing and Interpreting Data** Use observations (first-hand and/or from media) for analysing and determining the characteristics of physical and chemical changes and the conditions required for change to relate them to the natural world. **Engaging in Argument from Evidence**	The learners explore and relate characteristics of physical and chemical changes and the conditions required for the changes happening in the surrounding. **Promoting Socio-cultural, Economic, and Human Values** Explore and relate characteristics of physical and chemical changes and the conditions required for these changes happening in the natural world. **Exploring Digital Resources** May explore relevant digital platforms and tools to obtain information on the characteristics of physical and chemical changes and the conditions

		Construct an argument with evidence to determine the characteristics of physical and chemical changes and the conditions required for changes happening in the natural world.	required for change to validate the findings from the investigation.
i. Explore the classification of elements and explain the importance of a periodic table. ii. Explain the group and period features of a modern periodic table to understand the properties of elements. iii. Differentiate between the groups and periods as the fundamental layout of the periodic table. i. Classify acids into organic and inorganic acids with examples. ii. Tests acids and bases to understand their properties through experimental observation.	**2.3 Patterns in Chemistry** 2. 3.1 Patterns in the Periodic Table *(Scope: This section focuses on the arrangement of elements in the periodic table and its early attempts in classification. It also emphasises the features [concept of group and period] of the modern periodic table based on atomic number.*	The learners explore and explain the features of a periodic table. **Obtaining, Evaluating, and Communicating Information** Draw information from a range of grade-appropriate sources to develop coherent conceptual understanding on history of element classification and the features of the Modern periodic table. **Engaging in Argument from Evidence** Engage in argument supported by scientific reasoning, gathered through various sources, to critique and provide explanations for the failure or the acceptance of a particular classification method of elements. The learners observe, explore, and investigate properties of acids and bases. **Obtaining, Evaluating, and Communicating** **Information** Refer grade-appropriate texts and/or relevant digital sources to obtain scientific information	The learner uses the reference books, internet, and videos to learn the concept. **Exploring Digital Resources** May explore relevant digital sources to obtain information on the history of element classification and the features of the Modern periodic table. The learners explore applications of acids and bases in the community.

iii. Explore the application of neutralisation reactions in daily life. iv. Analyse the use of acids and bases in various fields.	2.3.2 Acids and Bases *(Scope: This topic presents the classification of acids into organic and inorganic. It also includes properties and usage of acids and bases. Additionally, the neutralisation reaction and its application and application of pH [in medicines, agriculture, food preservation and living organisms] will be covered.)*	about the acid & base and the indicators. **Planning and Carrying Out Investigations** Plan and carry out experiments to investigate the properties of acid and base using the indicators. Further carry out investigation to determine how acidic or alkaline some of the substances are in the physical world. **Analysing and Interpreting Data** Integrate information from the experimental investigation and the relevant print/digital media to reflect, analyse, determine, and develop conceptual understanding of the properties of acid and base.	**Exploring Digital Resources** May explore and obtain information, from relevant digital platforms, to construct a conceptual understanding of the identified core concepts and to validate the findings from the investigation. **Carrying out STEM Activities** May use a virtual lab to carry out the experiment to explore the properties of acid and base.
i. Explain solution, solubility and types of solutions ii. Prepare different types of solutions. iii. Investigate the effects of temperature, stirring and particle size on the solubility. iv. Explain the significance of solubility and solution in our everyday life.	**2.4 Separating Mixtures** 2.4.1 Solutions and Solubility *(Scope: This topic outlines the concept of solubility and types of solutions - dilute and concentrated, aqueous, and non-aqueous, saturated, and unsaturated solutions. The students also investigate the effect of temperature, stirring and particle size on solubility.)*	The learners observe, investigate, and explore solutions and solubility through various activities, and classify mixtures through investigation. The learners explore types of distillation and demonstrate simple distillation through an experiment. **Obtaining, Evaluating, and Communicating Information** Explore the relevant books and/or digital platform for information to construct the conceptual understanding of solubility, factors affecting solubility and the properties of the homogeneous and heterogeneous	The learners use different solutions and mixtures to learn the concept and learn various types of distillation. **Exploring Digital Resources** May explore and obtain information, from relevant digital platforms, to construct a conceptual understanding of

i. Explain homogeneous and heterogeneous mixtures with examples. ii. Classify various mixtures found in the surrounding into homogeneous and heterogeneous mixture. iii. Explain types of distillation to understand its application in daily life. iv. Carry out an experiment to demonstrate simple distillation.	2.4.2 Mixtures *(Scope: This topic covers mixture and its type - homogeneous and heterogeneous. It also includes its characteristics with examples. This section will also focus on different types of distillation - simple distillation, steam distillation and fractional distillation.)*	mixture, and different types of distillation. **Planning and Carrying Out Investigations** Plan and carry out experiments to explore the factors affecting solubility and the characteristics of the mixture (heterogeneous and homogeneous mixture). Plan and conduct experiments to demonstrate simple distillation. **Analysing and Interpreting Data** Analyse the data to explain the effect of various factors on the solubility of a substance and to differentiate the characteristics to identify the types of the mixture (heterogeneous and homogeneous mixture). Integrate information from the experimental investigation and the relevant print/digital media to reflect, analyse, determine, and develop conceptual understanding on simple, steam and fractional distillation. **Engaging in Argument from Evidence** Construct an argument with scientific evidence to determine whether the identified mixture in the natural world is heterogeneous or homogeneous. Argue with scientific justification on the most preferred form of distillation amongst various forms of distillation for separating a given mixture.	the identified core concepts and to validate the findings from the investigation.

Class-wise Competency

Class VIII

By the end of class VIII, the learner should be able to:

- **Classifying Materials**
  explain the chemical composition and reaction (atomic structure, chemical formula and chemical equation) of chemical substances to comprehend the importance of chemical reactions in daily life.
- **Materials and Change**
  analyse types of chemical reactions and indicators to relate to chemical changes occurring in our everyday life.
- **Patterns in Chemistry**
  demonstrate the understanding of periodic trends to predict the properties and chemical reactivity of elements.

  investigate the properties of acid and base to understand its classification, applications, and impact on the environment.
- **Separating Mixtures**
  investigate different types of mixture and compound, and techniques of separating mixture to relate their significance in our everyday life.

Table 25: *Learning objectives and process/essential skills for materials and their properties, class VIII*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering Practices	Society and Technology
i. Explain mass number and atomic number based on the number of electrons, protons, and neutrons. ii. Draw the atomic structure of common elements to understand their electronic configuration.	**2.1 Classifying Materials** 2.1.1 Atomic Structure *(Scope: This topic explains mass number and atomic number based on the number of electrons, protons and neutrons, and their relationship. It further includes electronic configuration in the form of K, L, M, N notation following electron distribution*	The learners describe properties of atoms by constructing a model, and explore properties of isotopes and their application. The learner describes the properties of the atom, relationship of the mass number, proton number and neutron number in conjunction with electronic configuration of elements through exploration and investigate the properties of isotopes and their	The learners use the internet to play the simulation on atomic structures and learn concepts. **Exploring Digital Resources** Use digital media to explore for simulation, animation, illustration, video lessons, and other information on atomic structure, electron

iii. Explain isotopes and their properties iv. Explain various applications of isotopes in different fields	*rules in shells. Concept of Isotopes and its application.)*	applications. The learner also explores the methods to write chemical formulae for different compounds and explain the law of conservation of mass through balancing of chemical equations.	configuration and isotopes of elements. **Using Physical Tools** Use locally available materials to construct the model. May use ready-made models of atoms from the laboratory.
i. Explain chemical formula, valency, and radicals with examples. ii. Identify the valencies of elements and radicals of compounds. iii. Explain the formation of cations and anions. v. Write the chemical formulae of chemical substances based on the rules. v. Analyze the chemical composition of a compound based on the chemical formula.	2.1.2 Elements, Compounds, and their Formulae *(Scope: This topic explores what valency and radical are, and two types of radicals - simple and compound; and formation of ions - cations and anions. The topic further explains the steps to write chemical formulae for compounds.)*	**Obtaining, Evaluating, and Communicating Information** Evaluate the information gathered through grade-appropriate texts and/or digital media, on the core concepts, to design atomic models, write chemical formulae and balance chemical equations. **Developing and Using Models** Construct a model of atom based on the information gathered to explain the composition of an atom and its electron arrangement. **Obtaining, Evaluating, and Communicating Information** Explore grade-appropriate texts, books and/or digital media to obtain scientific information on the core concepts mentioned herein to provide explanation and/or justification.	**Carrying out STEM Activities** May explore and use software to design simulation, illustration and/or graphic models of atoms. The learner uses the internet to explore more on the concept. **Exploring Digital Resources** May obtain information from reliable digital sources to develop knowledge on the core concepts mentioned herein.
i. Explain the chemical			

equation by identifying reactants and products. ii. Write balanced chemical equations. iii. Explain significance of chemical equation. iv. Explain the importance of the law of conservation of mass in chemical equations	2.1.3 Chemical Equation *(Scope: This topic covers the identification of reactant and product in chemical equations, followed by a procedure to balance chemical equations as per the Law of conservation of mass.)*		**Carrying out STEM Activities** May explore and use relevant interactive virtual simulation software (e.g., PhET, AACT, etc.) to study balancing of chemical equations. The learners use the internet to gather more information and learn the concept to find empirical evidence for the law of conservation of mass in the chemical reaction.
i. Investigate synthesis, decomposition, and displacement reactions. ii. Construct empirical evidence to prove the law of conservation of	**2.2 Materials and Change** 2.2.1 Chemical Reaction *(Scope: This topic underlines the concept and types of chemical reactions - synthesis, decomposition, and displacement. It also*	The learners design an experiment to learn the concept of chemical reaction and safety measures. **Obtaining, Evaluating, and Communicating Information** Gather information from relevant books and/or digital platforms to explain the mechanism of chemical	The learners observe natural phenomena around them and use the internet to gather more information. The learners use the internet to explore more on the concept.

mass in chemical reaction. ii. Identify different types of indicators of chemical reactions. v. Carryout and experiment to demonstrate exothermic and endothermic reaction. v. Relate exothermic and endothermic reactions to daily life applications. vi. Formulate safety measures for managing chemical waste	*encompasses indicators of chemical reactions such as change in colour, odour, state, temperature - exothermic and endothermic; effervescence and importance of disposing chemical waste safely.*	reaction and the types of reaction. **Planning and Carrying Out Investigations** Design an investigation and observe the variation in temperature during the chemical reaction to determine release or absorption of thermal energy by chemical processes. Further design and undertake investigation to explore the types of chemical reaction. Furthermore, design investigation and inquiry processes to explore and construct empirical evidence to prove the law of conservation of mass in chemical reaction. **Analysing and Interpreting Data** Analyse the observation data from investigation to determine and explain the types of chemical reactions. **Constructing Explanations and Designing Solutions** Use empirical information from the investigation carried out to construct evidence-based explanations for the law of conservation of mass in chemical reaction.	**Exploring Digital Resources** May use a digital platform to explore information on chemical reaction and its type. **Using Physical Tools** Use the apparatus and materials from the science laboratory and/or from the locality for carrying out the experiment to investigate the chemical reactions.

		Engaging in Argument from Evidence Observe the patterns of various reactions occurring in the physical world to construct an argument supported by evidence-based information gathered from the investigation and/or from relevant book/digital platforms to determine the type of reaction and explain its mechanism.	
i. Explain atomic radius, metallic and nonmetallic character of elements ii. Explain the trends of atomic radius, metallic character across and down the periodic table. iii. Explain ionisation potential, electronegativity and electron affinity iv. Explain the significance of learning periodic properties of elements.	**2.3 Patterns in Chemistry** 2.3.1 Patterns in the Periodic Table *(Scope: This topic focuses on trends of atomic size,* *metallic and non-metallic character across the period and down the group and introduction to the terms: ionisation potential, electronegativity and electron affinity)*	The learners explore and explain the atomic radius, ionisation potential, electronegativity, and electron affinity metallic and nonmetallic properties of elements across the period and down the group in the periodic table. The learners further investigate different classes of acids and bases, the application of neutralisation, and explore cause, prevention, and impact of acid rain. **Obtaining, Evaluating, and Communicating Information** Gather information from relevant sources to construct the conceptual understanding of the core concepts mentioned herein. **Planning and carrying out investigations** Explore through the web link to explain periodic properties	**Promoting Socio-cultural, Economic, and Human Values** Explore about acid rain, uses of acid and base including the neutralisation reaction to understand their significance and impacts in the real-world. **Exploring Digital Resources** May explore video lessons, and other digital media for obtaining information on periodic properties and for carrying out experiments to explore chemical properties of acid and base.

i. Classify acids and bases based on strength and concentration. ii. Investigate the reaction of acids and bases with other elements and compounds. iii. Explain the causes, impact, and prevention of acid rain. iv. Design a poster or other means to create awareness to mitigate the causes of acid rain.	2.3.2 Acids and Bases *(Scope: This topic focuses on the classification of acids and bases with respect to strength and concentration. It also includes the chemical reactions of acids and bases with metals, metal oxides, carbonates, and bicarbonates. It further includes formation of acid rain.)*	i.e., the atomic radius, and metallic character, ionisation potential, electronegativity, and electron affinity across the period and down the group in the periodic table. Further, investigate the properties of acids and bases and reaction with metal, metal oxides, carbonates, and bicarbonates. Furthermore, explore and explain cause, impact, and prevention of acid rain. **Analysing and Interpreting Data** Compare and contrast the information gained from relevant books, simulations, video, or multimedia sources with that gained from experiments.	**Carrying out STEM Activities** May carry out experiments or practical through simulations using virtual labs to explore the chemical properties of acids and bases including neutralisation reaction. **Using Physical Tools** May use digital media like graphics, audio, visual while making presentations to add interest and enhance understanding of findings, reasoning, and evidence.
i. Differentiate between mixture and compounds. ii. Carry out an experiment to differentiate between compounds and mixture. iii. Carry out an experiment to understand the process of filtration and chromatography.	**2.4 Separating Mixtures** 2.4.1 Separating mixtures *(Scope: This topic focuses on differences between mixture and compound through investigation followed by separation methods like filtration and chromatography with their applications.)*	The learners design various activities using available material to investigate different techniques of separating mixtures. **Obtaining, Evaluating, and Communicating Information** Recall relevant information from experiences or gather relevant information from print and/or digital sources to construct the conceptual understanding of mixture and different techniques of separating mixtures.	The learners explore different techniques used in the locality to separate mixtures and use the internet to gather more information. **Exploring Digital Resources** May explore and obtain information, from relevant digital platforms, on mixtures and

iv. Explore the applications of filtration and chromatography in various fields.		**Planning and carrying out investigations** Design activities to investigate differences between compound and mixture to explore different techniques of separating mixtures. **Analysing and Interpreting Data** Synthesise information obtained from experiments and other relevant sources (text and digital) into a coherent understanding of differences between a mixture and a compound. Further, through the observation of the identified mixture in the real world, determine and justify the techniques required for separating it.	techniques of separation.

9.1.8 9.3.3 Strand: Physics Process

Competency Based Standard

By the end of Key stage 3 (Class VIII), the learner should be able to:

1. investigate more about force, speed, pressure to explain their effects on the motion of an object, calculate the relative density and relate their applications in real life settings.
2. identify the types of simple machines by using examples available in the surrounding and calculate the efficiency of each type of machine to justify their uses in daily lives.
3. explore various forms of energy and their transformations to explain work, power and their relationships in relation to their uses in our everyday life.
4. investigate static electricity, and variables in the flow of current to find their relationship based on Ohm's Law in relation to its use in electrical appliances, and explain the properties of magnets and their uses.
5. demonstrate the understanding of properties of light based on the investigation of reflection and refraction through different media; sound based on propagation, wave patterns and audibility range, and relate their application in various fields of studies and people's lives.

6. explain the formation and planetary motion of the solar system, satellites, and other heavenly bodies to understand their significance in life on the Earth.

Class-wise Competency

Class VII

By the end of class VII, the learners should be able to:

1. Forces and Motion

- ❖ demonstrate the understanding of force, distance, speed, average speed and types of motion, and density of substances, and analyse their applications in our daily activities.
- ❖ identify the types of simple machines, calculate the mechanical advantage, velocity ratio and efficiency of simple machines, and justify how they help us in our daily activities.

2. Work and Energy

- ❖ **Explore various sources of energy, and understand the impact of renewable and non-renewable energy on climate change**
- ❖ explain work by drawing its relationship with force and displacement and relate its application in daily activities.

3. Electricity and Magnetism

- ❖ construct electrical circuits with electrical components like ammeter, voltmeter, resistor, conducting wire, bulb, and switch to understand their functions, investigate electrical energy transformation and the effects of static electricity.
- ❖ explain the molecular theory of magnetism to understand the process of magnetisation, properties and strength of magnets and relate how it is used in our life.

4. Light and Sound

- ❖ investigate the properties of light and sound to draw their significance and applications in daily life.

5. The Earth and Beyond

- ❖ explain the solar system based on its features and distance of planets from the sun to understand their significance in everyday life.

Table 26: *Learning objectives and process/essential skills of Physical Processes, class VII*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering practices	Society and Technology
i. Explore force, distance, speed, and average speed and draw their relationship. ii. Calculate the speed and average speed at different situations.	**3.1 Forces and Motion** 3.1.1 Force and Linear Motion *(Scope: This topic deals with concepts of force, distance and speed and average speed, balanced and unbalanced force,*	Using Mathematics and Computational Thinking Calculate the speed, distance and time taken for appropriate cases of motion observed in the community.	**Exploring Digital Resources** Study the required concepts on speed by browsing the internet for more calculation exercises and by PhET simulation.

iii. Explain balanced and unbalanced force, linear and non-linear motion and rotational motion and their applications in daily life.	*linear and non-linear motion, and rotational motion, and their applications.)*	**Analysing and Interpreting Data** Provide qualitative comparisons of forces, mass, and changes in motion to study the effects of balanced and unbalanced forces. **Planning and Carrying Out Investigations.** Identify examples of rotational motion with intellectual justifications identified in the environment.	**Exploring Digital Resources** Use every day phenomena, frame of reference, and specification of units related to motion in the surrounding to learn the concept, and use related technologies to compute and interpret data.
i. Explore to identify the types of levers. ii. Investigate the mechanical advantage, velocity ratio and efficiency of levers to assess their application in daily life. iii. Demonstrate how levers multiply force and increase efficiency. iv. Explore the concept of pulley and its types. v. Investigate the mechanical advantage, velocity ratio and efficiency of pulleys to assess their	3.1.2 Simple Machine *(Scope: This topic covers the concept of simple machines - lever, pulley: single and fixed, gears; mechanical advantage, velocity ratio, efficiency, calculations, and activity on efficiency of simple machines.)*	**Planning and Carrying Out Investigations.** Explore and investigate how a simple machine multiplies force through activities.	**Exploring Digital Resources** Observe involvement of force in daily activities and relate it to the concept of a simple machine, and use the internet to play simulations related to simple machines.

application in daily life. vi. Demonstrate how pulleys multiply force and increase efficiency. i. Explain relative density with examples. ii. Determine relative density of materials used. iii. Explain the significance of relative density in our everyday life.	3.1.3 Relative Density *(Scope: This topic highlights the concept of relative density, activity on investigating relative density and its applications.)*	**Obtaining, Evaluating, and Communicating Information** Gather information on density and relative density using available materials and relevant sources.	**Using Physical Tools** Use different things around them, and explore the uses of density in the locality.
i. Define displacement. ii. Differentiate between distance and displacement with examples. iii. Calculate the work done with respect to force and displacement in different situations. iv. Justify that the scientific meaning of work is different from everyday meaning of work done in daily life.	**3.2 Work and Energy** 3.2.1 Work *(Scope: This topic deals with concepts on distance, displacement, work done and simple calculations and experimental verification related to work done.)*	Investigate the concept of distance and displacement through an activity, and calculate work.	Observe different situations of work done and explore the involvement of force and displacement.

i. Explore various sources of energy. ii. Classify renewable and non-renewable sources of energy. iii. Identify sources of energy contributing to climate change. iv. Suggest ways to promote the sustainable use of energy.	3.2.2 Sources of Energy *(Scope: This topic deals with the sources and classification of energy. It also evaluates sources of energy contributing to climate change and suggests ways to become a sustainable energy consumer.)*	Explore different sources of energy and classify them in renewable and non-renewable energy.	**Exploring Digital Resources** Explore various sources of energy in the locality and search for other additional sources using the internet.
i. Explain the concept of resistance. ii. Deduce the relationship amongst current, voltage and resistance. iii. Construct parallel and series circuits iv. Compare the current and voltage in parallel and series connection. v. Investigate transformation of electrical energy in different electrical appliances. vi. Develop a model based on the concept of electric circuit to reduce the impact of climate change.	**3.3 Electricity and Magnetism** 3.3.1 Electric Circuits *(Scope: This topic deals with what are electric current, voltage and resistance and their relationship. It also includes measuring current and voltage in series and parallel circuits, and transformation of electrical energy.)*	**Developing and Using Models** The learners construct series and parallel circuits to investigate the role of different variables in circuit, explore their effect and application through activities. **Developing and Using Models** Construct series and parallel circuits to investigate the role of different variables in circuit, explore their effect and application through activities.	**Using Physical Tools** The learners use different electrical appliances to relate the applications of electricity, and use the internet to search further information on the concept and play simulations related to electric current and other variables.

i. Explore the effect and application of static electricity in day-to-day life. I. Explain the molecular theory of magnetism and magnetization II. List some practical applications of magnetism.	3.3.2 Static Electricity (Scope: *This topic deals with the concept of static electricity and its effect and application in natural phenomena.)* 3.3.3 Magnetism *(Scope: This topic comprises the concept of molecular theory of magnetism, magnetisation, and investigation of particle arrangement in a magnet.)*	**Planning and Carrying out Investigations** The learners design an investigation to understand the concept of magnetisation. **Analysing and Interpreting Data** Design an investigation to understand the concept of magnetisation.	**Exploring Digital Resources** The learners use available materials and the internet to gather information to design investigations.
I. Demonstrate the laws of reflection of light. II. Construct a ray diagram to illustrate the formation of images by a spherical mirror. III. List the uses of concave and convex mirrors in a variety of situation.	**3.4. Light and Sound** 3.4.1 Light and its Properties *(Scope: This topic comprises the concept of propagation of light, reflection and its types, investigating laws of reflection, reflection through plane mirror, terms and general rules of spherical mirrors, and uses of spherical mirrors.)*	The learners explore and investigate properties of light and image formation in spherical mirrors, investigate the speed of light in different mediums, and explore the application of laws of reflection. **Obtaining, Evaluating, and Communicating Information** Gather and evaluate information on how the speed of light travels in different mediums, and the application of laws of reflection from reliable sources.	The learners observe natural phenomena due to light and daily applications of light to understand the concept. **Using Physical Tools** Observe natural phenomena due to light and daily applications of light to understand the concept. Carrying out STEM Activities Use digital resources to design or come up with a simulation to show the image

		Planning and Carrying Out Investigations Explore and investigate the image formed by spherical mirrors and the uses of concave and convex mirrors.	formed by a spherical mirror. **Exploring Digital Resources** Use digital resources to identify multiple uses of concave and convex mirrors in the world.
I. Describe the properties of sound waves. II. Explore the wave pattern of sounds produced by different instruments. III. Analyse the different forms of sound based on the wave patterns. IV. Explain how noise pollution causes damage to health V. Propose ways to reduce noise pollution in the locality. VI. Explain the uses of ultrasonic and infrasonic sound.	3.4.2 Sound and Hearing *(Scope: This topic consists of concepts of production and propagation of sound, wave patterns of different sound, range of audibility, uses of ultrasonic and infrasonic sound, and effect of loud sound.)*	**Planning and Carrying Out Investigations** Explore and investigate properties of sound and the propagation of sound through different mediums. **Constructing Explanation and Designing Solutions** Draw conclusions on how noise pollution affects the human ear and design solutions to reduce sound pollution in the community.	**Exploring Digital Resources** Use the internet to get more information on the concept, explore noise pollution in the community and propose ways to reduce it.
I. Describe the formation of the solar system. II. Explore satellites and their types, asteroids,	**3.5 The Earth and Beyond** 3.5.1 Beyond Earth (*Scope: This topic deals with the formation of the solar system, concept of sun, satellites, and types*	**Obtaining, Evaluating, and Communicating Information.** The learner investigates the features of planets and other heavenly	**Exploring Digital Resources.** The learner uses information from the internet /other sources

meteoroids, planets, and the sun. III. Explore the significance of the solar system in the formation of the universe.	*of satellites (Natural and Artificial), asteroids, meteoroids, comets and planets.)*	bodies beyond the Earth through activities.	to learn the concepts and explore more.

Class-wise Competency

Class VIII

By the end of class VIII, the learners should be able to:

1. **Forces and Motion**

- ❖ explore the effects of frictional forces and gravity on a body and establish a relationship amongst force, area, and pressure to comprehend its significance on daily life applications.

2. **Work and Energy**

- ❖ explain the relationship among work, power, and energy through calculation to understand their applications in daily activities.

3. **Electricity and Magnetism**

- ❖ investigate principles and applications of electricity and explain magnets to understand their use in different appliances.

4. **Light and Sound**

- ❖ investigate the properties and effects of light and sound in different situations to use it in daily life.

5. **The Earth and Beyond**

- ❖ investigate sources of light in the solar system and natural forces of planetary motion to understand why the heavenly bodies revolve and are stationed on their respective orbits.

Table 27: *Learning objectives and process/essential skills for Physical Processes, class VIII*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific methods and Engineering practices	**Society and Technology**
i. Explain velocity. ii. Explore the concept of acceleration due to gravity. iii. State the factors affecting the acceleration due to gravity. iv. Interpret the weight of a body in terms	**3.1 Force and Motion** 3.1.1 Force and Linear Motion *(Scope: This topic delves into the concept of velocity, acceleration due to gravity and factors affecting it,*	The learners investigate speed, velocity, and acceleration through activity and interpret distance-time graphs. **Planning and Carrying Out Investigations**	**Exploring Digital Resources** The learners use everyday phenomena related to motion in the surrounding, and use technology to compute and interpret data.

of mass, force and gravity. v. Explain the importance of the gravitational force of the Earth.	*interpreting displacement time graphs (physical quantities: scalar and vector), relating mass and force to gravity.)*	Investigate speed and velocity and highlight their differences using reasonable examples. Engaging in Arguments from Evidence Construct and present scientific reasoning to support the claim that gravitational forces are attractive and are affected by mass and weight of an object.	
i. Explore the concept of fluid friction ii. Explain the factors that affect the fluid friction on moving objects. iii. Investigate the effects of fluid friction on moving objects. iv. Suggest the ways to reduce fluid friction.	3.1.2 Fluid Friction *(Scope: This topic covers the concept of fluid friction, effects of fluid friction, factors affecting fluid friction, and reduction of fluid friction.)*	**Using Mathematics and Computational Thinking** Comprehend the concept of effects on mass and weight due to acceleration due to gravity through calculations.	The learners explore the application of force, pressure and area in the daily activities and locality.
i. Investigate the relationship between force, area, and pressure. ii. State the applications of pressure in daily life.	3.1.3 Force and Pressure *(Scope: This topic deals with the concept of pressure, investigating pressure and factors affecting it, and designing simple machines using the concept of pressure.)*	**Developing and Using Models** Interpret the distance-time graph by drawing conclusions from data generated in GeoGebra simulations. **Planning and Carrying Out Investigations** The learners investigate the relationship between force, area and pressure using available resources.	**Exploring Digital Resources** Use reliable sources to obtain information on application of force, pressure and area in the daily activities and locality.

i. Explore work and power to explain their role in everyday activities. ii. Calculate power in terms of the rate of work done using instances from real-life activities. i. Explore mechanical energy. ii. Calculate potential and kinetic energy. iii. Explain conduction, convection and radiation of heat. iv. Demonstrate the process of conduction, convection and radiation of heat. v. Describe the importance of heat transfer to understand its applications. vi. Explain dissipation of energy. vii. Determine ways to minimise the energy dissipation.	**3.2 Work and Energy** 3.2.1 Work and Power *(Scope: This topic covers the concept of work and power, units for work and power, calculation related to work and power.)* 3.2.2 Mechanical and Heat Energy *(Scope: This topic deals with mechanical energy [potential energy and kinetic energy]. It also deals with transfer of heat energy (conduction, convection, and radiation) and dissipation of energy.)*	**Planning and Carrying Out Investigations** Conduct various activities to explore the concept of energy and power. **Using Mathematics and Computational Thinking** Calculate power for word problems designed using realistic applications. Design an activity to demonstrate different modes of transmission of heat. The learners explore the concept of energy and power through activities, calculate power, and design an activity to demonstrate different modes of transmission of heat.	**Using Physical Tools** The learners use available materials to design activities related to different modes of transfer of heat, and explore the application of heat transfer in daily life.
i. Explain potential difference, electric current and Ohm's law. ii. Investigate the relationship between current, voltage and resistance to	**3.3 Electricity and Magnetism** 3.3.1 Circuits *(Scope: This topic includes the concepts of potential difference, electric current, electric resistance ,Ohm's law and its numerical*	The learners investigate the relationship between current, voltage and resistance and calculate different variables. **Analysing and Interpreting Data**	**Exploring Digital Resources** The learners relate the variations in current, voltage and resistance and the working of different appliances, use the internet to play

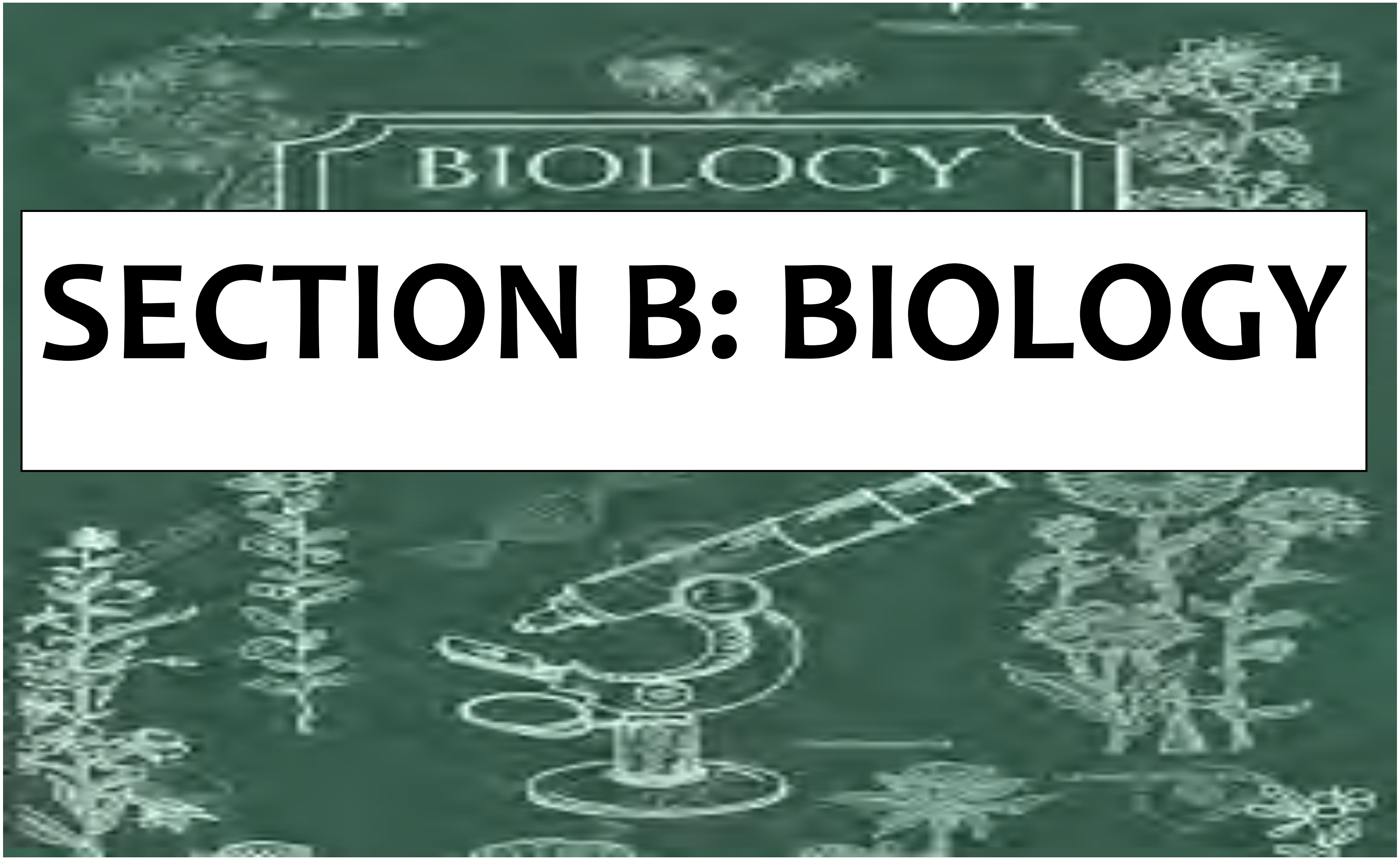
understand Ohm's law. iii. Solve numerical problems related to Ohm's law to determine resistance, current, and voltage. iv. Analyse transfer of energy in a battery and its exhaustion.	*problems. It also includes energy transfer in battery, and construction of simple cell)*	Interpret how change in current or voltage affects the other using the relationship between them.	simulation on Ohm's law, and use technology to compute and interpret data.
	3.3.2 Mains Electricity		
i. Compare direct and alternating current with reference to electricity supply. ii. Explain the use of live, neutral and earth wires in electric circuits. iii. Explain the importance of insulation, earthing, fuses, and circuit breakers used in electric circuits. iv. Calculate electrical energy consumption at home and school based on electric bill.	*(Scope: This topic deals with types of current, domestic electric supply, colour codes of electrical wires, electrical safety, fuse, electrical insulation, earthing, electrical heating for domestic purpose and calculation on electrical energy consumption.)*	**Using Mathematics and Computational Thinking** Compute the missing values for resistance, current or voltage in basic circuits using Ohm's law. The learners investigate the different types of current, design activity to explain functions of different colours, investigate safety measures while using electricity, and calculate electrical energy consumption at home. **Planning and Carrying Out Investigations** Observe and investigate the different types of current. **Analysing and Interpreting Data**	The learners observe the types of electricity at home and schools under the guidance of elders, use the internet to explore for more information on domestic main supply, and explore how electrical energy consumption is calculated in the community. **Promoting Social-Cultural, Economic and Human Value** Observe the types of electricity at home and schools under the guidance of elders and explore how electrical energy consumption is calculated in the community.

		Design activity to explain functions of different coloured wires. **Planning and Carrying Out Investigations** Investigate safety measures while using electricity through various relevant sources. Using Mathematics and Computational Thinking Calculate electrical energy consumption at home.	**Exploring Digital Resources** Use the internet to explore for more information on domestic main supply.
i. Explain the process of magnetization. ii. Differentiate temporary and permanent magnets and their uses at homes and industries iii. Investigate the factors that affect the strength of electromagnets iv. Design and construct a simple electric bell based on the concept of electromagnet.	3.3.3 Magnetism *(Scope: This topic includes concepts of magnetisation, differences and use of temporary and permanent magnet, and application of electromagnet.)*	The learners investigate the uses of different magnets, and design simple magnets. **'Planning and Carrying Out Investigations** Investigate the uses of different magnets in the industry. **Asking Questions and Defining Problems** Ask a question like What happens to the strength of the magnetic forces when a soft iron core is placed into the solenoid? **Developing and Using Model** Design simple magnets using the locally available materials to	**Exploring Digital Resources** The learners explore the uses of magnets in the locality and use the internet to gather information to design a magnet

		study the properties of magnets.	
i. Investigate the refracting properties of light through different media. ii. Describe various natural phenomena around us that occur as a result of refraction. iii. Construct ray diagrams to illustrate the characteristics of images formed by convex and concave lenses. iv. Differentiate between spectral colours and pigments. v. Illustrate the appearance of coloured objects in white light and in other colours of light. i. Explore the concepts of the sound wave, loudness of sound, amplitude, frequency and pitch. ii. Explain the factors affecting the speed of sound.	**3.4 Light and Sound** 3.4.1 Refraction of Light *(Scope: This topic deals with refraction of light through (glass slab, prism, lenses, liquids, and air), formation of image by lenses (ray diagrams), dispersion of white light, colours, and pigments, investigating the transmission of light through different colour filters)*	The learners investigate refraction of light in different media, and explore and construct the formation of images in lenses. **Planning and Carrying Out Investigations** Investigate refraction of light in different mediums through various activities. **Developing and Using Models** Illustrate the appearance of coloured objects in white light. **Developing and Using Models** Explore and construct the formation of images in lenses. The learners explore the relationship between	The learners observe natural phenomena due to light and daily applications of light to understand the concept. **Exploring Digital Resources** May browse relevant sources to gather information on natural phenomena of light and daily applications to understand the concept.

iii. Formulate the relationship between the loudness of the sound and the amplitude. iv. Investigate the relationship between the pitch of the sound and the frequency using tuning forks.	3.4.2 Sound *(Scope: This topic includes sound wave, loudness and amplitude, frequency and pitch of the sound, factors affecting speed of sound - (nature of medium, elastic properties and densities, temperature, wind), investigate variation in sound produced by different tuning forks.)*	loudness of sound and amplitude of vibration, pitch of the sound and frequency of vibration, and investigate how sound causes the eardrum to vibrate through various activities. **Analysing and Interpreting Data** Analyse and interpret the relationship between loudness of sound and amplitude of vibration. **Analysing and Interpreting Data** Explore the relationship between pitch of the sound and frequency of vibration. **Planning and Carrying Out Investigations** Investigate how sound causes the eardrum to vibrate through various activities.	**Exploring Digital Resources** The learners use the internet to get more information on the concept, explore sound with different loudness and pitch to understand its relationship with amplitude and frequency.
i. Explain luminous and non-luminous objects. ii. Explore different sources of light in the universe and their uses. iii. Investigate the natural forces involved in planetary motion. iv. Analyse the significance of	**3.5 The Earth and Beyond** 3.5.1 Planetary Motion *(Scope: This topic discusses the visibility of heavenly objects, luminous and non-luminous objects, and the natural forces in planetary motion:* *- gravity* *- centripetal force*	**Planning and Carrying Out Investigations** The learner explores sources of light in the universe, and investigate the forces in the planetary motion through activities.	**Exploring Digital Resources** The learner uses the internet/other sources to gather information and explore the concepts.

natural forces in maintaining the solar system in position by which the Earth can sustain all forms of life.	*- centrifugal force* *- inertia)*		



SECTION B: BIOLOGY

10 SECTION B: BIOLOGY

10. 1 Key Stage 4 (IX-X)

Competency-based Standard

By the end of key stage 4 (class X), a learner should be able to:

1. Molecules to Organisms: Structures and Processes
   - 1.1 use the understanding and scientific evidence from the cell to explain that all organisms, either simple or complex are made up of single or numerous cells.
   - 1.2 apply the concept and scientific evidence from human biological organisation to explain how the human body is a system of interacting systems and subsystems for its existence.
2. Ecosystems: Interactions, Energy and Dynamics
   - 2.1 apply the understanding of complex and dynamic interacting patterns of biotic and abiotic components of the ecosystem to explain the transfer of energy at various trophic levels.
   - 2.2 use the concept of interdependence to construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect organisms and their environment.
3. Heredity: Inheritance and Variation of Traits
   - 3.1 apply the understanding of the influence of genetic and environmental factors on the structure, function, and behaviour of an organism to explain how variation occurs within the individual and amongst the individuals of the same species.
   - 3.2 use the understanding of the relationship of the gene, DNA and chromosomes in terms of size and sequence, to explain the biological role of the gene, chromosome and DNA in determining a character of an organism through molecular and subcellular processes.
   - 3.3 apply the understanding of cell division with scientific reasons to explain why asexual reproduction results in offspring with identical genetic information while sexual reproduction results in offspring with genetic variation; and the patterns of inheritance of certain traits in an organism.
4. Biological Evolution: Unity and Diversity
   - 4.1 apply the understanding from fossil records, similarity in morphological structures and embryological structures to explain that all organisms have evolved from common ancestors through selection (natural and/or artificial) and adaptation, and they are the basis for the emergence of multiple lines of organisms.
   - 4.2 use the understanding of theories of evolution, to explain how present living forms have evolved from past simple forms and how humans with their modern technology have intervened speciation in the present day with scientific evidence.

Class-wise Competency (Class IX)

By the end of class IX, a learner should be able to:

I. Molecules to Organisms: Structures and Processes

- apply the understanding from the cell to explain that all organisms, either simple or complex are made up of single or multiple cells.
- use scientific evidence to support the explanation that an organism contains several interacting systems and subsystems for its existence.
- use scientific concepts from human biological organization to explain that processes, behaviors, and emotions of an organism are coordinated by several interacting systems and subsystems.

II. Ecosystems: Interactions, Energy and Dynamics

- apply the understanding of an ecosystem to explain that disturbances to any of the physical or biological components of an ecosystem can lead to a shift in all its population, interactions, and energy dynamics. (revised structure)
- use the concept of interdependence amongst organisms to understand the intrinsic value of organisms in an ecosystem.

III. Heredity: Inheritance and Variation of Traits

- apply the understanding of cell division to explain how offspring inherit genes from their parents during reproduction.
- apply the concept of the influence of genetic (mutation, random mating, random fertilization and recombination) and/or environmental factors (nutrition, light etc.) to explain the occurrence of variation within an individual organism or amongst the individuals of the same species.
- use the understanding of the relationship of the gene, DNA and chromosomes in terms of size and sequence, to explain the biological role of the gene, chromosome and DNA in determining a character of an organism through molecular and subcellular processes.
- use the concept of variation of individuals to understand and value the importance of diversity.

IV. Biological Evolution: Unity and Diversity

- apply the understanding from fossil records, similarity in morphological structures and embryological structures to explain that all organisms have evolved from common ancestry lines.
- apply the concept from the theories of evolution to explain how modern organisms have evolved from their ancestral forms.
- use the concept of the influence of genetic and environmental factors on organisms to explain the process of speciation.

Table 1. *Learning Objectives and Dimensions for Molecules to Organisms: Structures and Processes, class IX*

Learning Objectives (LO)	Core Concepts	Scientific methods and Engineering practices	Society and Technology
LO-1. Investigate to provide evidence that living things are made up of cell (s). **LO-2.** Construct scientific explanation that different cells have specific shapes adapted to carry out specific functions. **LO-3.** Communicate the scientific information on the application of stem cells in addressing health issues.	**1. Molecules to Organisms: Structures and Processes** **1.1. Cells in Living Organisms** *1.1.1. Scope: Living things are made up of cells. Cells are considered the fundamental units of life.* *1.1.2. Scope: Cells occur in various shapes and sizes. The structure of a cell determines the nature of its function.* *1.1.3 Scope: Stem cells have unique abilities to differentiate into numerous cells in the body to take up different functions. Therefore, these cells are used for the treatment of certain diseases (e.g., cancer, leukaemia, autoimmune diseases, etc.).*	**Planning and Carrying out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-1)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO- 1,)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses. **(LO-1, LO- 2, LO- 3)**

		variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO- 2)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-3)**	
LO-1. Develop a model that explains the transformation of energy during photosynthesis. **LO-2** Construct an explanation on the significance of photosynthesis for the existence of life.	**1.2. Photosynthesis: Food for Life** *1.2.1 Scope: Plants, algae, and some bacteria use light energy to prepare food (glucose) from carbon dioxide and water during photosynthesis.* *Photosynthesis*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO- 1)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific

LO-3. Construct arguments based on scientific reasons that indoor plants reduce human health issues. **LO-4** Explain with scientific reasons on how photosynthesis helps in combating global warming.	*involves a series of chemical reactions that occur within the structures of the cell. The energy from glucose is later transferred to ATP (adenosine triphosphate), the fundamental fuel of all organisms.* *1.2.2. Scope: Plants that are grown indoors, help in maintaining a clean indoor environment and are known to have a wider range of applications in reducing human health issues. However, some plants have the potential of causing allergic reactions in people.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO- 2)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Construct and defend a claim based on scientific reasons that reflect scientific knowledge and student- generated evidence about the natural world. **(LO-3)**	phenomena, constructing models, and designing solutions. **(LO- 1, LO- 2)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses. **(LO-1, LO- 2, LO-3)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-3)**

LO-1. Construct scientific explanations to demonstrate the relationship between factors and the rate of transpiration (limited to temperature, light and humidity). **LO-2.** Design a solution to obtain clean water based on the concept of transpiration as potential solutions to water scarcity in your locality.	**1.3. Transpiration: Perspiration in Plants** *1.3.1. Scope: Plants undergo transpiration to lose excess heat and the rate of transpiration varies depending on various internal and external factors. Plants are adapted to conserve water.* *1.3.2: Scope: Green plants are often used to remove contaminants(e.g., toxic substances, trace elements, radioactive substances, etc.) from soil and water (Phytoremediation).*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student- generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO- 1)** • Design, evaluate, and refine a solution to a complex real- world problem, based on scientific knowledge, student- generated sources of evidence, prioritised criteria, and trade- off considerations. **(LO- 2)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO- 2)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO- 2)**

LO-1. Construct a model that provides scientific explanations on digestive organs and their roles in the digestion of foods. **LO-2.** Develop a model of a diet plan that provides scientific explanation on healthy eating habits. **LO-3.** Communicate the scientific information on the effects of eating junk or processed food on the growth and development of our body.	**1.4. Digestion: What's on the plate?** *1.4.1. Scope: The digestive system in humans consists of the alimentary canal and accessory organs. Human digestive organs chiefly consist of the mouth, stomach, small intestines, large intestines, and other digestive structures. (mouth produces salivary amylase to break down carbohydrates, stomach produces pepsin and HCl to digest protein, small intestine break down food, absorb nutrients, large intestine absorb water and remaining nutrients)* *During digestion, these organs food we consume is broken down into simpler forms for absorption by the body and assimilated for growth and development.* *1.4.2 . Scope: The growth and development of our body depend largely on the kinds of food we consume, our dietary practices, and our lifestyles. An imbalance in nutritional requirements can result in certain health issues.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-2, LO-4)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO- 1)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g.,.gdatabase, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 2, LO- 3)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO- 4)**

LO-1. Develop a model of the human circulatory system that explains the structures and functions of heart, capillaries, veins, and arteries. **LO-2.** Construct a model of the human respiratory system that explains its organs and their functions. **LO-3.** Develop a model that represents how the circulatory and respiratory systems work in coordination for the transportation and exchange of gases in humans.	**1.5. Transport and Exchange in Our Body** *1.5.1. Scope: The circulatory system of humans comprises the heart, blood, and blood vessels. (Heart has four chambers-two atria to receive blood from the veins and ventricles to pump blood out of the heart. It has two types of valves- atrioventricular/cuspid and semilunar valves to keep the blood flow in unidirectional. Blood vessels are classified as either arteries, capillaries or veins based on structures and function. The artery consists of three layers and carries blood away from the heart except the pulmonary artery. Capillaries-smallest and numerous blood vessels carry blood away from the heart(arteries) and return blood to the heart(veins). Veins are three layer tubes and carry blood towards the heart.* *1.5.2. Scope: The human respiratory system consists of nostrils, nasal cavities, pharynx, larynx, trachea, bronchi, and lungs.It helps in the movement of air in and out of the body. The inspired air is carried to the lungs by the respiratory tract. The exchange of gases occurs in the lungs and tissues. The circulatory and respiratory systems work together to supply oxygen and remove carbon dioxide from the body.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1, LO-3, LO-4)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-2)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-3, LO- 4)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3, LO-4)** **Computational Modeling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues.**(LO-2)**

LO-1. Construct a model that provides scientific explanation on the roles of human endocrine glands *(Limited to pituitary, thyroid, adrenal, pancreas, and gonads).* **LO-2.** Construct a model that explains the structure and functions of the human nervous system (*Restricted to CNS and PNS-somatic and autonomic*). **LO-3.** Communicate the scientific information on the roles of phytohormones in the growth and development of plants.	**1.6. Response and Coordination** *1.6.1. Scope: The endocrine system, through the production of hormones, regulates various processes and functions in the body. Human endocrine glands (eg., pituitary gland, adrenal gland, gonads, pancreas and thyroid) have a significant influence on the human body.* *Scope: The nervous system consists of the brain, spinal cord, sensory organs, and nerves (bundle of neurons) that connect these organs to different parts of the body. The organs of the nervous system play vital roles in the control and coordination of the body.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1, LO-2)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student- generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO- 3)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-2)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1, LO-2)**

LO-5.Develop a model of the human skeletal system that explains the structures and functions of axial and appendicular skeletons. (limit to Skull, vertebral column, collarbone, shoulder blades, rib cage (true & floating ribs), sternum, arms, feet and legs). LO-6. Communicate the scientific information on ligaments, tendon, cartilages and joints (limit to gliding, pivot, hinge ball and socket joint).	1.6.2. *Scope: Plants produce a wide variety of biochemicals (eg., auxin, gibberellin, cytokinin, abscisic acid, and ethylene) that regulate their growth and development. These biochemicals are known as phytohormones. The phenomena such as flowering, fruiting, ageing, etc., are regulated by phytohormones.* *1.6.4 Scope: Human skeletal system consists of axial and appendicular skeletons which includes* skull, vertebral column, collarbone, shoulder blades, rib cage, arms, feet and legs. *Ligaments are elastic and yellow in colour which help to connect bone to bone and tendons are white in colour which is tough and elastic that connect muscle to bones. Cartilage is a soft, elastic and flexible connective tissue. Cartilage cells are called chondrocytes and lack blood supply. Hinge joint occurs between bones of the fingers and toes. It allows restricted movement in one plane only. Gliding joint occurs between the bones of the wrist and ankle. It enables bones to glide over each other. Ball and socket joint is a movable joint where one bone is hooked into the hollow space of another bone. It allows movement in all directions.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-4, LO-6)**	

Table 2. *Learning Objectives and Dimensions for Ecosystems: Interactions, Energy and Dynamic, class IX*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Construct a model that explains the interactions amongst the organisms in the ecosystem (*Limited to food chain & webs, predator-prey, competition, and symbiosis*). **LO-2.** Investigate the impacts of anthropogenic activities on the local ecosystems. **LO-3.** Communicate the scientific information on the ways to minimise the impacts of anthropogenic activities on ecosystems.	**2. Ecosystems: Interactions, Energy, and Dynamic** **2.1. Interaction in its Environment** *Scope: Organisms interact with each other and with their environment for food, space, reproduction, etc. A variety of relationships, such as predator and prey relationship, competition, and symbiosis exist in an ecosystem.* *2.1.2. Scope: Food chains and food webs represent the feeding interactions amongst organisms in an ecosystem. They show the transfer of energy from one organism to another in the process.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-2,** **LO-3)**

	2.1.1. *Scope: Humans cause changes in the physical environment in various ways (e.g., construction, pollution, deforestation, etc.) that have significant impacts on the health and functioning of an ecosystem.*	measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO- 2)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-3)**	

Table 3. *Learning Objectives and Dimensions for Heredity: Inheritance and Variation of Traits, class IX,*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Construct a model that provides scientific explanation on cloning and genetic engineering. **LO-2.** Construct an argument with scientific reasons on bioethical, societal, and moral issues associated with cloning and genetic engineering. **LO-3.** Construct scientific explanation on how the adoption of the Biosafety Act of Bhutan contributes towards the conservation of native species.	**3.3. Cloning and Genetic Engineering** *3.3.1 Scope: Genetic engineering involves the use of recombinant DNA technology to manipulate the genetic composition of an individual by the insertion of a foreign gene into its genome. Vectors are used to transfer foreign genes into a host. Cloning (nuclear transfer technique and embryo splitting) is a technique used to multiply organisms to obtain identical individuals in large numbers.* *3.3.2. Scope: There are moral and ethical concerns related to the use of recombinant DNA technology for producing GMOs, clones, and in*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. (**LO-1)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Construct and defend a claim based on scientific reasons that reflect scientific knowledge and student-generated evidence about the natural world. **(LO-2)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models and designing solutions. **(LO-1)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and

	treating diseases. *3.3.3 Scope: The present Biosafety act of Bhutan provides for the protection, conservation, and safeguarding of biodiversity in Bhutan.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-3)**	engage in scientific practises and discourses. **(LO-1, LO-2, LO-3)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-2, LO-3)**

information encoded in DNA differs from one individual to another.	*visible structures called chromosomes.* *3.2.2. Scope: Proteins are synthesised based on the information in the genes of an organism. The type and structure of proteins determine the characters or traits of an organism.* *3.2.3. Scope: A DNA molecule contains two polynucleotide chains formed of nucleotides. A nucleotide consists of phosphoric acid, sugar and nitrogenous bases. Four different types of nitrogenous bases (i.e., adenine, thymine, cytosine, and guanine) are present in a DNA molecule. The arrangement pattern of these bases ultimately determines each organism's unique characteristics.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student- generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-2)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3)**

Table 4. *Learning Objectives and Dimensions for Biological Evolution: Unity and Diversity, class IX*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practises	Society and Technology
LO-1. Construct an explanation on the existence of diversity, evolution and extinction of life forms using data from pictorial fossil records. **LO-2.** Design a model that explains the change in the environmental conditions over time based on fossil records. **LO-3.** Construct an explanation using scientific evidence to show the evolutionary relationships amongst modern organisms either through convergent or divergent evolution.	**4. Biological Evolution: Unity and Diversity** **4.1 Evidence of Common Ancestry** *4.1.1. There are various lines of evidence that show the evolution of organisms. One of them is fossil records. Fossil records provide scientific basis for existence, diversity, extinction, and change of many life forms throughout the history of life on Earth.* *4.1.2. Scope: The nature of fossils can be related to understanding how an environment of a particular area has changed over time. The geographical distribution of living species reflects the pattern of origins of*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student- generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1, LO-3)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-2)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist

LO-4. Analyse pictorial data to compare patterns of similarities in embryological development across organisms.	*species in a particular geographic location.* *4.1.3. Scope: Fossils are used to depict the structural similarities and differences amongst organisms. Fossils represent the vast diversity of life forms that existed on Earth.* *4.1.4. Scope: Similarities in the embryonic structure and appearance of the embryonic stages of different organisms show the evolutionary relationship that is not evidently seen in fully developed organisms.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human- designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-2)** **Using Mathematics and Computational Thinking** Mathematical and computational thinking for statistical analysis to represent or model data using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to analyse data; support, revise, or refute explanations and claims. **(LO-4)**	in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3, LO-4)** **Computational Modeling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio- scientific issues. **(LO-4)**

LO-1. Make a claim to support or refute which amongst Lamarckism, Darwinism, mutation theory is the credible theory of evolution.	**4.2 Theories that Explain Evolution** *4.2.1. Scope: Several theories (e.g. theory of natural selection, theory of inheritance of acquired characters, mutation theory, etc.) explain the mechanism of evolution.* *4.2.2. Scope: According to Lamarckism, evolution occurs as a result of the inheritance of characteristics that an organism obtains during one's lifetime.* *4.2.3. Scope: Darwinism builds on the idea that an organism is suited to live in an area to survive and reproduce, while others do not. The ratio of individuals that survive increases in future generations.* *4.2.4. Scope: Mutation theory is based on the concept that change in the structure or arrangement of genetic materials results in change in physical traits. The changes caused by mutation could be useful or harmful for an organism and therefore, determines their chances to survive and reproduce.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1)**

Class-wise Competency (Class X)

By the end of class X, a learner should be able to:

I. From Molecules to Organisms: Structures and Processes

- apply the understanding of the cell structure to explain the differences between prokaryotic and eukaryotic cells, and processes at the cellular level contribute to the functioning of the organism.
- argue based on empirical evidence and scientific reasoning to support an explanation for how subsystems of organisms coordinate different biological processes; and regulate the state of emotions.

II. Ecosystems: Interactions, Energy and Dynamics

- apply the understanding of the ecosystem to explain that organisms grow, reproduce, and perpetuate their species by obtaining necessary resources through interdependent relationships with other organisms and the physical environment.
- sustainable use of natural resources is essential and any disturbance in the ecosystem can influence the quality and sustainability of natural resources.
- use the concepts of interdependence amongst organisms to develop solutions to mitigate environmental pollution.

III. Heredity: Inheritance and Variation of Traits

- apply the understanding of cell division to explain that growth, development, and repair as the results of a mitotic division of cells.
- apply the understanding of cell division to explain that reproduction, stability of chromosome number, and continuity of life are maintained by meiotic division of cells.
- use the understanding of patterns of inheritance to explain that offspring receive half of the chromosome from each parent and genes received from either of the parents is expressed.

IV. Biological Evolution: Unity and Diversity

- use the understanding of the mutation, genetic drift, and gene flow to explain how the evolution of species occurs.
- apply the understanding of natural selection to explain how humans have used technology to influence speciation.

Table 1. *Learning Objectives and Dimensions for Molecules to Organisms: Structures and Processes, class X*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Develop a model that compares prokaryotic and eukaryotic cells. **LO-2**. Communicate scientific information on the role of prokaryotes in maintaining the health of the environment. **LO3.** Identify the applications of prokaryotes as potential solutions to mitigate the impacts of climate change**.**	**1. Molecules to Organisms: Structures and Processes** **1.1. Prokaryotic Cells and Eukaryotic Cells** *1.1.1. Scope: Prokaryotic cells differ from eukaryotic cells in their structure and functions. Prokaryotic cells have a simple structure with DNA forming a nucleoid and do not have well developed structures (organelles) to carry out specific functions. Eukaryotic cells, on the other hand, contain a nucleus and membrane-bound organelles specialised to carry out specific functions.* *1.1.2. Scope: Prokaryotes play important roles in sustaining life and maintaining the quality of the soil. They help in the recycling of nutrients (i.e., carbon, nitrogen and phosphorus) as they are a major part of nutrient cycles. Some bacteria live in the digestive system of other organisms (e.g., humans) and aid in digestion*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **LO-2)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**

LO-1. Design a model that demonstrates the movement of substances in and out of a cell (*Limited to diffusion, osmosis, active transport system, passive transport system)*. **LO-2.** Design a solution to increase the shelf life of fruits and vegetables based on the concept of membrane transport.	**1.2. In and Out of the Cell** *1.2.1 Scope: The movement of substances in and out of the cells occurs by various membrane transport mechanisms (e.g., diffusion, osmosis, active transport system, passive transport system). The selective nature of the cell membranes helps in regulating all the membrane transport mechanisms.* *1.2.2. Scope: The shelf-life of fruits and vegetables depend on the ability of the cell membrane to regulate the movement of substances and therefore, maintaining the concentration of solute inside a cell. The movement of substances across a membrane is regulated based on their relative concentrations inside and outside of the cell.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Constructing Explanation and Designing Solution** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade off considerations. **(LO-2)**	**Using Physical Tool** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-2).**

LO-1. Develop a model that explains light dependent and light independent phases of photosynthesis. **LO-2**. Investigate to show how external factors affect the rate of photosynthesis. (*Limited to carbon dioxide concentration, temperature, and light intensity*). **LO-3.** Design solutions to improve crop yield using the concept of photosynthesis. **LO-4:** Analyse impacts of climate change on food production to understand food security challenges.	**1.3. Photosynthesis: Food for Life** *1.3.1. Scope: Plants synthesise their food by photosynthesis. There are two phases in photosynthesis (i.e, light-dependent and light- independent phases), each of which involve a series of chemical reactions. The light-dependent phase (light reaction) occurs in the thylakoid while the light-independent phase (dark reaction) occurs in the stroma.* *1.3.2. Scope: The rate of photosynthesis is affected by various internal and external factors (limited to intensity of light, the concentration of carbon dioxide and temperature). External factors can be controlled to alter the rate of photosynthesis.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-2)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-2)**

LO-1. Provide scientific explanations on the structures and functions of xylem and phloem (*Focus on elements of xylem and phloem*). **LO-2.** Construct scientific explanation on the mechanisms of the transportation of food (Munch flow of hypothesis) and water(transpiration pull theory and root pressure theory) **LO-3.** Investigate to show the movement of food and water in plants.	**1.4. Transportation of Substances in the Plant** *1.4.1. Scope: Distribution of substances (e.g., water, minerals, food, etc) in plants are carried out by vascular tissues (i.e., xylem and phloem). Xylem transports water and mineral salts from the roots up to other parts of the plant, while phloem transports food from source to sink. The xylem consists of tracheids, vessels, parenchyma, and fibres. Sieve tube elements, companion cells, and fibers constitute the phloem structure.* *These structures facilitate the transport of water, minerals and food in the plant.* *1.4.2.Plants transport water, minerals, and food through various mechanisms. The pressure-flow mechanism, also known as Munch's mass flow hypothesis, is widely accepted for food translocation in the phloem. The cohesion-tension theory and root pressure theory elucidate water transport from roots to other plant parts. Mineral absorption is explained by the contact exchange ion theory and the carbonic acid exchange theory.*	**Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. ● Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-1)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1)**

LO-1. Construct a model that provides scientific explanations on the reproductive parts of humans. **LO-2.** Develop scientific explanations on fertilisation, embryonic developmental stages, and menstruation cycle in humans. **LO-3.** Construct a model that provides scientific explanations on the parts of flowers. **LO-4.** Develop scientific explanations on the typical structure of pollen grains and ovules, and double fertilisation in angiosperms.	**1.5. Reproduction in Humans and Plants** ***Scope 1.5.1:*** *The male reproductive system comprises the testes, vasa efferentia, epididymis, vasa deferentia, seminal vesicles, ejaculatory duct, prostate gland, Cowper's gland, and urethra, each serving distinct functions in sperm production, maturation, storage, and transportation, as well as the secretion of seminal fluid. In contrast, the female reproductive system consists of ovaries, fallopian tubes, uterus, and vagina, where ovaries produce eggs, fallopian tubes facilitate egg transport, the uterus supports foetal development, and the vagina serves as the birth canal and facilitates copulation.* ***Scope 1.5.2:*** *Human beings reproduce sexually. It starts with the production of gametes in* *the reproductive organs followed by fertilisation and the development of foetus in the womb. If the ovum is not fertilised, menstruation begins. There are four phases of the menstruation cycle including menstruation phase, follicular phase, ovulation phase and luteal phase.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1, LO-2)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-3, LO-4)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-2)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., .gdatabase, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 3, LO- 4)**

	Scope 1.5.3: *The male reproductive parts of plants include the anther, where pollen is produced, and the filament, supporting the anther. The female reproductive parts consist of the stigma, which receives pollen, and the ovary, where ovules are housed. These structures collectively facilitate pollination, fertilisation, and seed formation in plants.* ***Scope 1.5.4:*** *Double fertilisation is a complex and coordinated series of events that involves both the physical transfer of pollen and the biological interactions between male and female reproductive structures.* *It is a unique reproductive process in flowering plants (angiosperms) involving the fusion of two male gametes with two different female gametes. This process results in the formation of both a zygote and a triploid cell, which later develops into the endosperm.*		

LO-1. Develop a model that provides scientific explanation on the chemical digestion of food *(Limited to carbohydrates, fats, and proteins).* **LO-2.** Communicate scientific information on the mechanisms of cellular respiration (*limited to basic concepts of glycolysis, Krebs cycle, and electron transport*).	**1.6. Digestion: What's on the plate?** *1.6.1. Scope: During digestions, large insoluble food particles (e.g., carbohydrates, fats, and proteins) are broken down into smaller soluble forms to be absorbed easily by the cells. Digestion occurs in the mouth, stomach and small intestine. Various hydrolytic enzymes (e.g. saliva, lysozyme, gastric enzymes, etc.) are an aid in the chemical breakdown of carbohydrates, proteins and fats. The inner walls of the small intestine are adapted for efficient absorption of digested food.* *1.6.2. Cellular respiration encompasses crucial processes such as glycolysis, occurring in the cytoplasm, the Krebs cycle, which takes place in the mitochondria, and the electron transport chain spanning the inner mitochondrial membrane. In glycolysis, a glucose molecule yields two pyruvate molecules, generating a net of two ATP. The Krebs cycle oxidizes pyruvate, producing NADH and FADH2 as electron carriers, along with a modest ATP output. The electron transport chain utilizes these carriers to produce substantial ATP, concluding cellular respiration with water and carbon dioxide as byproducts.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Use models to illustrate the relationships between systems or between components of a system. **(LO-1,)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-2)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**

LO-1. Construct a model that provides scientific explanations on the composition of human blood. **LO-2.** Provide scientific explanation on ABO blood typing based on the presence of antigens and antibodies.	**1.7. Transport and Exchange in our Body** *1.7.1. Scope: Human blood* Cellular components *(i.e, WBC, RBS and platelets). The blood cells are adapted to carry out specific functions.* *1.7.2. Scope: The ABO system of blood grouping is based on the antigens (i.e., A and B) present on the surface of RBCs. The body has antibodies (i.e., a and b) for these antigens. These antigens and antibodies determine the compatibility during a blood transfusion. Blood transfusion is performed for a variety of reasons (e.g., injuries, disease, bleeding disorders and during surgery).*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-2)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-2)**

LO-1. Communicate scientific information on the use of synthetic hormones (steroids) by humans for various life processes. **LO-2.** Construct scientific explanations on the biological, psychological, and social impacts of using steroid hormones. **LO-3.** Communicate scientific information on the application of synthetic hormones in enhancing agricultural productivity. **LO-4.** Develop scientific explanations on the structure and functions of a neuron, and types of neurons	**1.8. Response and Coordination** *1.8.1 Scope: Synthetic hormones (eg. adrenocorticosteroids, corticosteroids, testosterone, medroxyprogesterone, pills, etc…) serve diverse roles in human physiology, playing crucial functions in hormone therapy and birth control. Corticosteroids, manage inflammatory conditions such as arthritis and allergies. Adrenocorticosteroids, including prednisone, suppress immune responses and treat autoimmune disorders. Testosterone, a male sex hormone, is administered for hormone replacement therapy in hypogonadal individuals.* *Medroxyprogesterone, a progestin, is used for contraception and hormonal imbalance correction.* *Oral contraceptive pills, containing synthetic estrogen and progestin, are widely employed for birth control. The use of certain hormones, like steroids, entails physical and psychological implications.* *1.8.2. Anabolic steroids, synthetic versions of the male hormone testosterone, can exert significant biological impacts, including increased muscle mass and strength, but may lead to adverse effects such as liver damage, cardiovascular issues, and hormonal imbalances.* *Psychologically, steroid use can contribute to mood swings, aggression, and heightened risk*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **LO-1, LO-3)**	**Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-1, LO- 3)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-2)**

based on their functions. **LO-5**. Communicate scientific information on the conduction of nerve impulse *(Limited to myelinated neuron)* and reflex action.	*of psychiatric disorders. Socially, individuals abusing steroids may face stigmatization, strained relationships, and legal consequences. Emphasizing the dangers of steroid abuse is crucial for public health, as it poses serious threats to both individual well-being and societal harmony.* *1.8.3. Scope: Synthetic chemicals (e.g., synthetic hormones) are used to manipulate the biological systems of plants and study the influence of phytohormones on plant growth and development. Synthetic hormones are used in commercial farming for improving food production.* *1.8.4 Neurons exhibit a distinct structure and function vital for information processing and transmission. Structurally, neurons consist of a cell body, dendrites, and an axon. Functionally, they can be categorized into sensory neurons, conveying sensory information; motor neurons, directing muscle movements; and interneurons, facilitating communication between neurons. Nerve impulses, driven by changes in membrane potential, involve the myelination of axons, ensuring efficient conduction. This process includes polarization, where the neuron is at rest, followed by depolarization triggered by a stimulus, and subsequent repolarization. Reflexes, crucial for rapid responses, operate through a reflex arc involving sensory receptors, afferent neurons, interneurons, efferent neurons, and effectors.*	**Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-2)**	

LO-1. Develop a model that explains the structures and functions of kidneys in humans. **LO-2**. Construct a model that describes the structures and functions of nephrons. **LO-3**. Communicate scientific information that kidney failure is linked to unhealthy lifestyle.	**1.9. Excretion: Removal of Waste** *1.9.1. Scope: Kidneys regulate the concentration of solute in body fluids. Different parts of nephrons function differently, to alter the concentration of urine in order to maintain the required osmotic concentration in the body fluids. The nature of urine does not remain the same. The section of kidney comprises outer cortex and inner medulla. The majority of cortex is made up of renal corpuscles and renal tubules (Proximal and distal)whereas the inner medulla comprises renal pyramids, columns,tubules(Loop of Henle) and blood vessels.* *1.9.2. Scope: Lifestyle practices are linked to the health of the excretory system in various ways. Unhealthy practices such as low physical activity, smoking, alcohol consumption, etc. are associated with kidney dysfunction.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-2)**	**Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-1, LO- 2)**

LO-1. Communicate the scientific information on the contemporary microbial diseases of humans in terms of pathogens, transmission, and preventive measures *(Limited to STIs, COVID, gastritis, and stomach cancer)* **LO-2.** Communicate scientific information on ways to deal with social stigma related to STIs and COVID-19.	**1.10. Microorganisms: Diseases and Drugs** *1.10.1. Microbes (e.g., HIV, coronavirus, Helicobacter Pylori, etc.) cause various types of diseases. Some diseases (e.g., STIs, COVID-19, gastritis, stomach cancer, etc.) are common these days. STIs are caused by bacteria, viruses, or parasites, primarily transmitted through sexual contact. Preventive measures involve safe sexual practices, vaccination, and regular screenings. COVID-19, caused by the SARS-CoV-2 virus, primarily spreads through respiratory droplets, emphasizing the importance of vaccination, mask-wearing, and social distancing. Gastritis, often linked to Helicobacter pylori infection, is preventable through hygiene practices, while stomach cancer, associated with chronic inflammation, necessitates early detection and lifestyle modifications for prevention.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-1)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **LO-2, (LO-3)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences.**(LO-2, LO-3)**

Table 2. *Learning Objectives and Dimensions for Ecosystems: Interactions, Energy and Dynamics, class X*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Construct a model that represents biotic and abiotic components of a local ecosystem. **LO-2**. Develop a theoretical model that describes the types of ecosystems and the stages of ecological successions. **LO-3**. Explain using scientific reasons that the health of the ecosystems depends on the biodiversity.	**2. Ecosystems: Interactions, Energy, and Dynamics** **2.1. Organisms in its Environment** *2.1.1. Scope: Organisms interact amongst themselves and with their physical environment for their survival. The biotic and abiotic components of an ecosystem are interdependent and interact to maintain the balance in nature.* *2.1.2 Scope: Ecosystems broadly classified into terrestrial and aquatic realms. Terrestrial ecosystems encompass diverse landscapes (eg. forests, grasslands, etc…) showcasing a rich array of flora and fauna adapted to land- based environments. On the other hand, aquatic ecosystems (eg. freshwater bodies, etc), host a myriad of species adapted to life in water. Ecological successions, the dynamic process of ecosystem development, progress through stages: Nudation, the initial exposure of a bare environment; Invasion, marked by the arrival of pioneer species; Competition and Co-action, where various species vie for resources; Reaction, involving*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3)**

LO-4. Investigate the species richness and evenness of a local ecosystem using Simpson's diversity index. **LO-5.** Construct an argument with scientific reasons to support or refute the idea that the introduction of exotic species in an area impacts the native species.	*environmental changes; and Climax or Stabilization, the establishment of a relatively balanced and self-sustaining ecosystem. These stages collectively depict the evolving journey of ecosystems towards a state of equilibrium.* *2.1.3. Scope: The biodiversity of an area is studied at different levels (e.g., genetic diversity, species diversity and ecosystem diversity.). Ecosystem services (e.g., oxygen, water, nutrient cycles, wastewater treatment, etc) are benefits that are obtained either directly or indirectly from the ecosystem.* *Understanding species richness and evenness in a local ecosystem through Simpson's diversity index involves learning the fundamentals of biodiversity assessment. Species richness refers to the number of different species present, and evenness, representing the relative abundance of each species. The application of Simpson's index aids to quantify the diversity and distribution patterns within the ecosystem.* *2.1.4. The introduction of exotic species in an area can have severe impacts on native species. It often disrupts established ecosystems, leading to competition for resources, predation, and the alteration of ecological dynamics, posing a threat to the delicate balance of the local biodiversity.*	investigations, models, theories, simulations, peer review) and the assumption that theories and • laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-2, LO-4, LO-5)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-3)**	**Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-4, LO-5)**

LO-1: Construct a model representing strategies for conserving biodiversity, including in-situ and ex-situ conservation methods. **LO-2.** Evaluate the roles of indigenous practices in biodiversity conservation.	2.2. Biodiversity and sustainability Scope: *This topic discusses the conservation roles of relevant national and community organisations in Bhutan. It also explores the roles of indigenous practices in the conservation of biodiversity.*		

Table 3. *Learning Objectives and Dimensions for Heredity: Inheritance and Variation of Traits, class X*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Develop a model that explains the production of body cells through mitotic division. **LO-2**. Develop a model that explains the production of sex cells through meiotic division.	**3. Heredity: Inheritance and Variation of Traits.** **3.1. Growth, Development, and Reproduction** *3.1.1. Scope: Cell division involves a series of events leading to the division of a mother cell into two or more daughter cells. During these events, the behaviour of*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate

LO-3. Construct an argument with scientific reasons to support or refute the concept that body cells have the same genetic composition, while sex cells have different genetic composition.	*chromosomes and centrioles change.* *3.1.2. Scope: The growth and development of organisms occur by mitotic division of the body cells and therefore, contain the same genetic composition. A somatic cell contains chromosomes that are arranged in the form of homologous pairs. In humans, a body cell contains 23 pairs of chromosomes. Each pair contains maternal and paternal chromosomes.* *3.1.3. Scope: In animals (e.g. humans), sexual reproduction involves the formation of sex cells (i.e., sperm and ovum) by meiotic division of germ cells. When cells divide by meiosis, crossing over occur between the maternal and paternal chromosomes which results in the mixing of the genes. The daughter cells (e.g. sex cells) produced by meiosis differ in genetic composition from each other and also from the mother cell (i.e., germ cells).*	obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1, LO-2)**	information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**
LO-1. Develop a model that explains the patterns of inheritance of characters of an organism based on Mendel's laws of inheritance.	**3.2. Inheritance and Variation of Traits** *3.2.1. Scope: During sexual reproduction, each parent contributes half the number of chromosomes (at random) to the offspring. Therefore, each chromosome of a homologous pair comes from one of the parents. Each chromosome in a pair contains one copy of a gene (allele) inherited either from father or mother.* *3.2.2. Scope: Each allele in a pair expresses protein. The structure of a protein determines the traits of an individual and may produce different phenotypes (physical appearance).*	**Using Mathematics and Computational Thinking** Mathematical and computational thinking for statistical analysis to represent or model data using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools. Simple computational	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs

LO-2. Explain the inheritance of sex-linked diseases, such as haemophilia and colour blindness using Punnett squares and probability statements.	*When a trait has two different alleles, one allele may dominate its effect on another allele, and masks the effect of another allele. Therefore, one looks similar either to the father in certain features and mother in other features. The genes located on sex chromosomes (X and Y) influence inheritance patterns in specific ways, creating unique patterns for sex-linked traits*	simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to analyse data; support, revise, or refute explanations and claims. **(LO-1, LO-2)**	and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**

Table 4. *Learning Objectives and Dimensions for Biological Evolution: Unity and Diversity, class X*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Explain using scientific reasons that natural selection influences the frequency of certain alleles and their corresponding traits in a population.	**4. Biological Evolution: Unity and Diversity** **4.1. Genetic Basis of Natural Selection** *4.1.1.Scope: Natural selection supports the organisms with favourable character to survive in an area. This leads to the change in the frequency of certain alleles. Organisms with favoured traits have a higher probability to survive and reproduce.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-1)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1)**

LO-1. Construct scientific explanations using Hardy- Weinberg's principle on how organisms evolve through a change in allele frequency of a population over time. **LO 2** Construct scientific explanation how evolutionary forces, including climate change lead to speciation (limited to mutation, natural selection, isolation, migration, genetic drift theory).	**4.2. Factors Responsible for Speciation** *4.2.1. Scope: Evolution is influenced by a variety of evolutionary factors (e.g, genetic drift, genetic variations, mutations, natural selection, etc.). According to the Hardy-Weinberg principle, the gene frequency in a population remains constant when no evolutionary forces are operating on it.* *4.2.2. Scope: Artificial selection, hybridization and the use of recombinant DNA technology in agriculture have led to the production of improved varieties of plant and animal species.*	**Using Mathematics and Computational Thinking** Mathematical and computational thinking for statistical analysis to represent or model data using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools. Simple computational simulations are created and used based on mathematical models of basic assumptions. **Asking Questions and Defining Problems** Asking questions and defining problems in formulating, refining, and evaluating questions and understanding problems, supported by scientific reasons, models and simulations. Ask questions to define constraints and specifications for a solution. **(LO-2)** • Use mathematical and/or computational representations of phenomena or design solutions to analyse data; support, revise, or refute explanations and claims. **(LO-1)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories.	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**

		• Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-2)**	

10. 2 Key Stage 5 (XI-XII)

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Competency-based Standard

By the end of key stage 5 (class XII), a learner should be able to:

1. From Molecules to Organisms: Structures and Processes

1.1. explain with scientific reasons that all organisms either unicellular or multicellular, simple or complex are made up of cells; and are composed of biomolecules that form the essential basis for cellular processes.

1.2. provide explanations using scientific reason that an organism is a biological system consisting of interacting subsystems, functioning in a coordinated manner to maintain a balanced internal environment.

2. Ecosystems: Interactions, Energy and Dynamics

2.1. apply mathematical models to demonstrate understanding of fundamentals of carrying capacity, factors affecting biodiversity, and flow of energy amongst organisms in an ecosystem.

2.2. use the understanding of the effect of unsustainable anthropogenic activities on the environment in making scientific, economic, political and social decisions in maintaining biodiversity and a healthy environment.

3. Heredity: Inheritance and Variation of Traits

3.1. use scientific reasons to explain that the variation in the genetic composition leads to the differences in the way organisms look, function and survive in relation to the environment.

3.2. use the understanding of the genetic code to explain that gene expression enables DNA to control biochemical processes in the body and DNA can be manipulated to solve problems pertaining to humanity.

4. Biological Evolution: Unity and Diversity

4.1. Apply scientific evidence to explain that organisms evolved from common ancestors through natural selection and adaptation, artificial selection is the basis for the emergence of multiple lines of organisms.

4.2. use scientific reasons to explain that the trend of evolution is predictable and diversity of organisms are a result of the ratio between various genetic combinations as favoured by natural selection.

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Class-wise Competency (Class XI)

By the end of class XI, a learner should be able to:

I. From Molecules to Organisms: Structures and Processes

- apply the understanding from biomolecules to explain that all organisms contain biomolecules, such as carbohydrates, fats, proteins and nucleic acid which forms the basis for cellular processes.
- provide a scientific explanation that all living organisms are a biological system of interacting subsystems that coordinate the processes, functions, or emotions of an organism.

II. Ecosystems: Interactions, Energy and Dynamics

- use the understanding from interactions, energy and dynamics to explain that the ecosystem is composed of interacting physical and biological components.
- use the understanding from the effects of pollution on the environment to design solutions to minimise anthropogenic impact on the environment and to maintain sustainable use of resources.
- Analyse the relationship between climate change and phenophases, and interpret the change in behaviour of living things based on phenophases.

III. Heredity: Inheritance and Variation of Traits

- apply the understanding of body cell division and sex cell division to explain that growth, repair, reproduction and development of organisms are the result of mitosis and meiosis; and anybody cell contains the same genetic composition while the sex cell contains different genetic information.
- use the understanding of patterns of inheritance to explain that each individual offspring receives half of the genes from each parent and either of the genes received from parents, express and mask the expression of the other gene.
- apply the understanding of the concept of inheritance and variation to explain why individuals of the same species vary in how they look, function, and behave based on the context of genetic inheritance, environmental factors and DNA technologies.

IV. Biological Evolution: Unity and Diversity

- use the knowledge from the phylogenetic relationship of five kingdoms to explain that all the organisms have originated from common ancestors.
- apply the concepts and understanding of classification systems to categorise organisms found in the localities into relative groups and families to demonstrate common line of ancestry.

Table 1. *Learning Objectives and Dimensions for Molecules to Organisms: Structures and Processes, class XI*

Learning Objectives	Core Concepts	Scientific Methods and Engineering Practises	Society and Technology
LO-1. Construct a scientific explanation that biomolecules are formed by the combination of monomers (*limited to carbohydrates-monosaccharides, disaccharides, starch, and cellulose; fats-simple lipids; and proteins-simple proteins*). **LO-2.** Design a 3D model of a protein that demonstrates how interacting forces trigger the formation of stable 3D conformation of protein structure. **LO-3.** Construct scientific explanation on how the structure of the DNA molecule is adapted to store information to make proteins. **LO-4.** Construct scientific explanation on how the structures of RNAs are formed to carry out its biological role in protein synthesis (*limited tRNA, mRNA, and rRNA*).	**1. Molecules to Organisms: Structures and Processes** **1.1 Biomolecules: What makes up living organisms.** *1.1.1. Scope: Carbohydrates are primary sources of energy. Monosaccharides (e.g., glucose, fructose, galactose) are the smallest units that combine to form different types of carbohydrates.* *Polysaccharides (e.g., starch and glycogen) are formed by the combination of monosaccharides through the formation of glycosidic bonds.* *1.1.2. Scope: Lipids are naturally occurring esters that are formed by glycerol and fatty acids. They have widespread functions in organisms (e.g. source of energy, insulation, etc.)* *1.1.3. Scope: Proteins are formed by the combination of amino acids, through the formation of polypeptide chains. Polypeptide chains form larger protein molecules. The folding of polypeptide chains is supported by the interacting forces of protein residues.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1, LO-5)** • Design, evaluate, and refine a solution to a complex real- world problem, based on scientific knowledge, student- generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-3, LO-4)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-4, LO-5)** **Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues **(LO-2, LO-3)**.

LO-5. Discuss application of biomolecules in addressing the impacts of climate change (e.g., green technology)	*The working of proteins is determined by their 3D structural conformations.* *1.1.4. Scope: Scientists and engineers are working to develop and produce molecule-based materials (e.g., plastics, forks, toilet papers, etc.) that can satisfy our high demands for quality and performance while at the same time posing no burden to the environment because they are made of renewable resources and are fully biodegradable.* *1.1.5. Scope: Nucleic acids are formed by the arrangement of nucleotides in the form of a long chain. A nucleotide is composed of a pentose sugar, nitrogenous base, and phosphate group. DNA and RNA are two different nucleic acids.* *1.1.6. DNA contains information that directs the production of proteins. A DNA molecule contains two strands (polynucleotide chains) arranged to form a double helix. The sequence of nitrogenous bases determines the sequence of amino acids in a polypeptide chain.* *1.1.7. RNA contains a single strand of nucleotides. There are three different types of RNA (i.e., rRNA, mRNA and tRNA). Each RNA performs specific roles during protein synthesis.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. (**LO-2**)	

LO-1. Argue with scientific reasons on the credibility of lock and key, and induced fit hypothesis in explaining the mechanism of enzyme action. **LO-2.** Investigate to study the effect of pH, temperature, and substrate concentration on enzyme action. **LO-3.** Design a solution to remove stains *(e.g., betel nut, urine, graffiti, paints, etc.)* using concepts of enzymes.	**1.2. The Power of Enzymes.** *1.2.1. Scope: Enzymes influence biochemical reactions occurring inside and outside of the cells, without themselves undergoing changes. These enzymes are produced by living cells.* *1.2.2. Scope: An enzyme brings reactant molecules together and increases the rate of the intermediate complex by lowering the activation energy. The process of formation of intermediate complexes and the products are explained by some models (e.g. Lock and Key and induced-fit hypothesis).* *1.2.3. Scope: Enzyme activity is affected by certain factors (e.g., temperature, pH, substrate concentration, etc.)* *1.2.4. Enzymes have a wide range of applications, starting from the production of simple homemade and industrial products to being used as tools for technologies involving the manipulation of genes. Enzymes are used to deal with various real-world issues (e.g., oil spillage, bioremediation, etc.)*	**Engaging in Arguments from Evidence** Engaging in arguments with logical reasons in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments (**LO-1**). **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. (**LO- 2)**. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future **(LO-3)**.	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO- 2**). **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences **(LO-3)**.

LO-1. Develop a model that explains the working of the human respiratory system (*Limited to the morphological and anatomical structures of nostrils, lungs and tracks, other interplaying structures*) **LO-2**. Construct scientific explanations on lung volumes and capacities. **LO-3.** Provide scientific information on gaseous exchange, mechanisms for exhalation and inhalation, and transportation mechanisms of oxygen and carbon dioxide.	**1.3. Organs for Breathing** *1.3.1. Scope: The respiratory system comprises of respiratory tract and organs, that are designed to support the movement and exchange of gases.* *1.3.2. Scope: The movement of air while breathing is facilitated by the combined activities of the intercostal (ribcage) and phrenic (diaphragm) muscles. The internal structures of the lungs are well-developed to facilitate the exchange of gases between the alveolar air and the blood. The exchange of gases in the lungs and tissues occurs in a similar manner, depending on the relative concentrations and pressures of respiratory gases.* *1.3.3. Scope: Respiratory disorders range from mild (e.g., common cold, influenza, pharyngitis, etc.) to life- threatening (e.g., pneumonia, lung cancer, asthma, tuberculosis, etc.).* *Respiratory disorders are caused by microbial infections, smoking, pollution, genetic factors, etc. As altitude increases, the number of oxygen molecules per breath is reduced. In order to properly oxygenate the body, the breathing rate has to increase. Since the amount of oxygen required for bodily activity is the same, the body must adjust to having less oxygen. Ascending to higher altitudes without proper acclimatisation can lead to potentially serious, even life- threatening illnesses (e.g., high- altitude pulmonary edema).*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system (**LO-1**) **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly (**LO-2**). **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real world problems, based on scientific knowledge, student generated sources of evidence, prioritised criteria, and trade off considerations (**LO-3**)	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses (**LO-1**) **Computational Modeling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues (**LO-2, LO-3**)

LO-1. Develop a scientific model that explains the composition of human blood (limited to plasma, structures and functions of blood corpuscles). **LO-2.** Construct scientific explanations structures and functions of blood vessels (limited to arteries, veins, and capillaries). **LO-3.** Develop a model that explains the structures and functions of the human heart. **LO-4.** Construct scientific explanations on the origin and the conduct of cardiac impulse and cardiac cycle. **LO-5.** Analyse the electrocardiogram (ECG) to relate to the working of the human heart. **LO-6**. Communicate scientific information about the ABO and Rh blood typing in the field of medicine.	**1.4. Transport System in Human Body** *1.4.1. Scope: The circulatory system in organisms comprises organs and fluids (e.g., hemolymph, blood) that circulate in the body collecting and distributing substances.* *1.4.2. Scope: The sequence of events that take place during a heartbeat is known as the cardiac cycle. The electric impulse is generated in the Sinu-atrial node (SA node) and travels through the conducting system of the heart. Cardiac cycle events can be divided into diastole and systole. Diastole represents ventricular filling, and systole represents ventricular contraction/ejection.* *1.4.3. Scope: An electrocardiogram (ECG) is a simple test to check the heart's rhythm based on the electrical activity. The electrocardiograph detects the electrical activities of the heart during the cardiac cycle and produces its graphical representation.* *1.4.4. Scope: The human heart is designed to pump blood to every part of the body. It is a hollow organ having four chambers (i.e., ventricles and atria) and valves that regulate the flow of blood in a single direction. In certain conditions, one or more valves fail to open or close properly, disrupting the unidirectional flow of blood. Arteries and veins are designed to transport blood to the body and to the heart.* *1.4.5. Scope: RBCs have surface antigens that are classified by the ABO system as antigen A and antigen B. The presence or absence of these antigens has led to the grouping of blood into four different types(A, B, AB, and O). Rh antigens occur in some individuals and the presence or absence of Rh antigen is indicated in the blood group by +ve/* *1.4.6. -ve symbols. These antigens determine the biochemical compatibility amongst individuals.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logical reasoning, to represent relationships between systems or components of a system (**LO-1, LO-3**). • Use models to illustrate the relationships between systems or between components of a system **(LO-2)**. **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically **(LO-4)**.	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions (**LO-1, LO-3**). **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses (**LO-2, LO-4**).

LO-1. Investigate the roles of hormones on growth, development, and reproduction in plants *(limited to auxin, cytokinin, gibberellic acid, ethylene and abscisic acid).* **LO-3.** Develop a model that represents the roles of hormones secreted by major endocrine glands in humans *(limited to pituitary gland, thyroid gland,pancreas, adrenal glands, and gonads)*. **LO-4.** Construct an explanation giving scientific reasons that change in organisms (*e.g., human*) over time, including reproductive capacities and functions; and emotions are regulated by hormones.	**1.6. Chemical Coordination** *1.6.1. Scope: Growth, development, and reproduction in organisms are controlled by hormones. Hormones in plants (e.g., auxin, cytokinin, gibberellic acid, ethylene and abscisic acid) are known as phytohormones and they influence various physiological and cellular activities in plants.* *1.6.2. Scope: Synthetic hormones are used commercially to stimulate metabolic processes associated with increased rate and efficiency of body growth. In plants, synthetic hormones (Indole 3-acetic acid, 1-naphthaleneacetic acid) are used to control plants' growth and development.* *1.6.3. Scope: In animals (e.g., humans) hormones regulate various body functions, such as growth and development, metabolism, electrolyte balances, and reproduction. Hormones are secreted by endocrine glands and carried by the blood to the target cell to regulate physiological processes.* *1.6.4. Scope: The development of secondary sexual characters (e.g., breast development, production of ovum or sperm, growth of body hair, etc.,) are influenced by reproductive hormones. Hormones influence the emotional state of a person during different states of development.*	**Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. (**LO-1**) **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-3).** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and /or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically **(LO-4, LO- 5, LO-2)**.	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses (**LO-1, LO-3, LO-4**). **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences **(LO-5, LO- 2)**.

LO-1. Construct scientific explanations on the structures and functions of human reproductive organs. **LO-3.** Communicate scientific information on the various events during the menstrual cycle.	**1.7. Reproduction in Humans** *1.7.1. Scope: The reproductive system in humans is responsible for the production of gametes (sperm in males, eggs or ova in females). The human reproductive system can be divided into male and female components.* *1.7.2. Scope:The primary reproductive organs in humans are the testes in males and the ovaries in females.* *1.7.3. Scope Menstrual Cycle* *The reproductive cycle in female primates, including monkeys, apes, and human beings, is referred to as the menstrual cycle. The onset of the menstrual cycle occurs at puberty and is known as menarche. In human females, menstruation recurs at an average interval of approximately 28/29 days, constituting the series of events from one menstruation to the next, commonly known as the menstrual cycle.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically **(LO-1,3)**. **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-2).**	**Using Physical Tools.** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions **(LO-1, LO-2, LO-3)**. **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences **(LO-2, LO-3)**

LO-1. Communicate scientific information on the structures and functions of the central nervous system (*for the brain, focus on both parts and lobes*). **LO-2.** Construct scientific information that explains the parts of PNS (focus on SNS and ANS-sympathetic and parasympathetic nervous system). **LO-3.** Design a model that explains the coordination between the central nervous system with visual, auditory, or tactile senses in an organism.	**1.7. Nervous Coordination** 1.7.1. Scope: The central nervous system plays an integral role in the control and coordination of bodily processes. The brain and spinal cord are designed to perform specific functions to enable an organism to adapt according to the changes in the external or internal environment. 1.7.2. Scope: The peripheral nervous system (PNS) acts as a physical link to relay information between the central nervous system, the receptors, and other organs. 1.7.3. Scope: The autonomic nervous system (ANS) contains sympathetic and parasympathetic systems that regulate body processes under different circumstances. The sympathetic system helps the body function during emergencies (fight or flight responses) while the parasympathetic system regulates body processes under normal conditions.	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically **(LO-1)**. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future (**LO-2**).	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions (LO-2). **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses **(LO- 1)**.

LO-1. Construct scientific explanation on how three lines of defence in humans respond to the entry of pathogens. **LO-2.** Develop models that describe the immunological responses of the human body *(Limited to innate, adaptive, active, passive, cell-mediated and humoral responses).* **LO-3.** Construct scientific explanation on how vaccines help to develop immunity against infections. **LO-4.** Communicate scientific information on the causes, transmission (if any), and prevention of diseases *(limited to COVID-19, Hepatitis B, STIs, peptic ulcer, diabetics, and kidney failures).*	**1.8. The Body's Defence System** *1.8.1. Scope: Organisms have systems (immune system) and processes to protect them from pathogenic organisms and related conditions. The immune system in humans comprises the three lines of defence (i.e., first, second and third lines of defences). The first line consists of physical barriers to block the entry of pathogens. The second line of defence consists of cells and proteins of the immune system that are non-specific and work on a variety of pathogens. The third line of defence is the most effective and works to eliminate pathogens in a specific manner. The third involves the formation of antibodies which enables the organisms to have long term protection against a particular pathogen.* *1.8.2. Scope:Immunity is achieved against many pathogens through vaccination. Vaccines are weakened pathogens or their body parts, which when introduced into the body of an organism, trigger an immune response. Immunisation is a process whereby a person develops immunity against a particular disease, possibly by administering a vaccine.* *1.8.3. Communicable diseases are usually caused by microorganisms (e.g., viruses, bacteria, etc) and can be transmitted from one person to another through direct or indirect contacts. The risks of transmission of communicable diseases can be reduced through vaccination and following hygienic protocols.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future **(LO-1, LO-2)**. **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically **(LO-3)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key ideas, scientific quest, and engage in scientific practises and discourses **(LO-1, LO-2)**. **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences **(LO-2, LO-3)**

LO-1. Investigate to study the effect of solute concentration on water potential. **LO-2.** Argue with scientific reasons to support or refute which amongst cohesion-tension theory, root pressure theory and physical force theory is more credible in explaining the ascent of sap. **LO-3**. Design a solution to purify water (*e.g., saline water*) through the application of the concept of reverse osmosis.	**1.9. Transport System in Plants** *1.9.1. Scope: Water potential is a measure of the concentration of free water molecules to diffuse to another area. With the increase in solute concentration in a solution, the value of water potential decreases.* *1.9.2. Scope:Transpiration creates a suction pressure (transpiration pull) that aids in upwards movement of sap in plants.The cohesive force between the water molecules maintains the continuous column of water from the root to the leaves.* *1.9.3. Scope: Inflow of water into the cell creates hydrostatic pressure. When external pressure applied to a solution exceeds osmotic pressure, reverse osmosis is created. Reverse osmosis is used for the treatment of contaminated water.*	**Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly **(LO-1).** **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-3).** Use models to illustrate the relationships between systems or between components of a system **(LO-2)**.	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses **(LO-1, LO-2, LO-3)**.

LO-1. Construct scientific explanations on the floral characteristics of plants using semi-technical terms (Limited to theoretical information on *malvaceae*, *solanaceae*, *leguminosae* and *brassicaceae*).	**10. Reproduction in Plants** *10.1. Scope: Flowers are the reproductive parts of the plants. Scientifically, flowers are applied to identify the families or in classifying plants using the knowledge of floral characteristics. For example, the arrangement of sepals, petals, androecium and gynoecium form some of the floral characters. Each family of a flower has their own floral characteristics.*	**Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly (**LO-1**)- **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically **(LO-1)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key ideas, scientific quest, and engage in scientific practises and discourses

Table 2. *Learning Objectives and Dimensions for Ecosystems: Interactions, Energy and Dynamics, class XI*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Investigate interactions amongst biotic and abiotic components of a local ecosystem. **LO-2.** Construct scientific explanation on interactions amongst organisms (*Limited to predation,mutualism, commensalism, and parasitism*). **LO-3.** Communicate scientific explanation on the types of succession, stages of succession, and examples of succession. **LO-3.** Communicate the scientific information on the environmental, social and economic implications of biodiversity loss. **LO-4.** Design a solution to reduce the impacts of human activities on the environment and biodiversity. **LO-5.** Describe efforts undertaken at both national and international levels to address the impacts of climate change.	**2. Ecosystems: Interactions, Energy, and Dynamic** **2.1. Organism in their Environment** *2.1.1.Scope: An ecosystem consists of biotic and abiotic components that interact with each other. I'he biotic components (e.g., plants, animals,* microorganisms*, etc.) interact amongst each other and also with abiotic factors (e.g., water, soil, air, sunlight, temperature, minerals, etc.) to maintain balance in an ecosystem.* *2.1.2. Scope: The diversity of organisms of an ecosystem depends on its ability to provide support for their needs. The interdependence amongst organisms through various food interactions contributes to the stability of an ecosystem. Energy and biomass transfer occurs from one trophic level to the next. The number of organisms that occupy lower trophic levels exceeds the higher levels.* *2.1.3. Anthropogenic activities are increasing threats to the environment that often result in the loss of biodiversity. Biodiversity loss has several direct and indirect implications on the health of the ecosystem and also human society. Conservation of biodiversity is important to maintain the essential ecological processes, in order to have a sustained life-supporting system and also balance in the environment.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-1).** **Constructing Explanation and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **LO-2)** ● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **LO-3, LO-4).**	**Using Physical Tools.** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions **(LO-1, LO-2, LO- 3, LO-4)**.

LO-1. Communicate scientific information on how pollutants affect the environment. **LO-2.** Investigate how human activities in your locality contribute to pollution. **LO-3.** Design a solution to treat effluents and sewerage before being discharged into water bodies.	**2.2. Environmental Pollution** *2.2.1. Scope: Pollution is an increasing global concern. The increased human activities due to developmental progress have led to large-scale pollution. For instance, air pollution, land pollution, water pollution, etc. are some of the pressing issues that threaten the health of the environment.* *2.2.2. Scope: Pollutants are the agents (e.g., elements, molecules, particles, etc.) that cause pollution. Pollutants are introduced into the environment in many ways, both by natural processes and human activities. Primary pollutants are emitted directly into the environment, while secondary pollutants are formed from primary pollutants and external factors.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-1)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measures the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly considering limitations on y. **(LO-2).**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions (**LO-1, LO-2, LO-3**).

LO-1. Construct scientific explanation on how the introduction of exotic species leads to ecological and economic implications **LO-2.** Discuss the effect of climate change in the spread of invasive species **LO-3.** Design a solution to mitigate the spread of invasive species in your locality.	2.3. **Invasive Species: The Threat to Biodiversity** *2.3.1. Scope: Invasive species pose major threats to biodiversity. The invasive species (e.g, Ageratina adenophora, Mikania micrantha, Cuscuta campestris, invasive carp, etc.) have prolific growing habits out-competing native species and could lead to ecological disturbance.* *2.3.2. Scope: Invasive species hamper crop yield as they compete with the crops for nutrients and space. Some invasive species (e.g., Parthenium sp.) are known to be hazardous to human health.* *2.3.3. Scope: The contamination by exotic genes to a population is a serious concern. The breeding between closely related species results in the production of hybrids that usually dominate the ecosystem. Implementation of strategies to minimise the risk and consequences of genetic pollution is important for the sustainability of native species.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. (**LO-1, LO- 2**)	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses **(LO-1, LO-2)**.
LO-1. Investigate the impact of climate change on the phenophases of plants and animals. **LO-2.** Analyse indigenous agricultural practices carried out based on the phenophases of plants and animals.	2.4. Phenology and Climate change Scope:….		

Table 3. *Learning Objectives and Dimensions for Heredity: Inheritance and Variation of Traits, class XI*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practises	Society and Technology
LO-1. Develop a model that explains the production of body/somatic cells by mitotic division and sex cells (*gametes*) by meiotic division. **LO-2.** Explain with scientific reasons why different body parts of an organism contain the same genetic composition. **LO-3.** Construct a scientific explanation that accounts to why individuals, including siblings, differ from one another.	**3. Heredity: Inheritance and Variation of Traits** **3.1. Growth, Development, and Reproduction** *Scope: Growth, development and reproduction in organisms occur as a result of cell division. Cell division involves several stages marked by a series of changes in chromosomal and centriolar behaviours. Cell division helps in maintaining stability in genetic information.* *3.1.2 Scope: During mitosis, a cell(mother) divides to produce two identical daughter cells. The genetic composition of the daughter cells is identical to that of the mother cell.* *3.1.3 Scope: During meiosis, a cell(mother) divides to produce four daughter cells. There is a reduction in the number of chromosomes to half as compared to the mother. The genetic composition of each daughter cell is different. Meiosis occurs in some animals(e.g. humans) to produce gametes (sperm and egg) that help in sexual reproduction.* *3.1.4. During meiosis, crossing over occurs between non-sister chromatids of the homologous chromosomes whereby genes are exchanged resulting in new combinations (recombinations) of genes. Mitosis leads to growth and repairment in organisms.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-1)**.	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses **(LO- 1)**.

LO-1. Design a model that provides a scientific explanation on the events of DNA replication.	**3.2. DNA Replication** *Scope: Prior to cell division (i.e., during interphase), a DNA molecule undergoes replication producing two identical DNA molecules. This helps in maintaining the same genetic composition in all the somatic cells of an organism.* *3.2.1. DNA replication is a semiconservative process regulated by a group of enzymes and has a high degree of accuracy.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-1)**. **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future (**LO-2, LO-3**).	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses **(LO- 1, LO-2, LO-3).**
LO-1. Develop a model that explains the mechanism of inheritance of characters in humans, based on the concept of expression of alleles.	**3.3.** Inheritance of Characters *3.3.1. Scope: Gene is the unit of heredity. The transmission of genes to offspring is the basis of the inheritance of phenotypic traits (e.g., height, eye colour, hair colour, skin colour, hair quality, etc.).*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s).	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions **(LO-1, LO-3)**.

LO-2. Develop a model that explains the patterns of inheritance of certain traits *(e.g., height, sex-linked diseases, etc.)* based on Mendel's laws of inheritance using Punnett squares and probability statements. **LO-3.** Construct an argument with scientific reasons to support or refute the idea that blending inheritance and codominance deviates from Mendelism.	*In sexually reproducing organisms, offspring receive half of the chromosomes from each of their parents. The chromosomes pair up to form homologous pairs. The alternative form of genes present in each chromosome of a homologous chromosome is known as alleles. Each allele expresses protein and the dominant allele masks the effect of the recessive allele.* *3.3.2. Scope: The mechanism of inheritance of traits is explained by Mendel's laws of inheritance. The Punnett square is a table in which all of the possible outcomes for a genetic cross between two individuals with known genotypes are given.* *3.3.3. Scope: There are certain conditions (blending inheritance, codominance) in which inheritance of characters is not in the way as explained by Mendel's laws of inheritance. These conditions lead to the appearance of unique traits which were not visible in parents and their inheritance show deviation from Mendel's law of inheritance.* *3.3.4. Scope: Sex chromosomes contain a huge number of genes directly linked to physical traits. Abnormalities in these genes are found to cause certain diseases that pass down the family line.*	• Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-1, LO-2)**. **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments **(LO-3).** **Using Mathematics and Computational Thinking** Mathematical and computational thinking for statistical analysis to represent or model data using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools. Simple computational simulations are created and used based on mathematical models of basic assumptions. • Use mathematical and/or computational representations of phenomena or design solutions to analyse data; support, revise, or refute explanations and claims **(LO-2).**	**Computational Modeling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues **(LO-2)**.

LO-1. Develop a model that provides scientific explanations on the process of cloning by somatic cell nuclear transfer and embryo splitting techniques. **LO-2**. Construct arguments giving scientific reasons why cloning is against moral, ethical, religious, cultural, and social values. **LO-3.** Develop a model that provides a scientific explanation on the process of genetic engineering. **LO-4.** Construct arguments with scientific reasons on how the production of GMOs and other aspects are associated with societal, bioethical, and moral issues.	3.4. Gene Cloning and Genetic Engineering *3.4.1. Scope: It is now possible to make clones or exact genetic copies of organisms. Cloning involves the multiplication of organisms to produce offspring with the same genetic makeup. Naturally, it occurs through asexual reproduction while the artificial process involves multiplying genes and also organisms. As animals are multiplied with the same genetic composition by cloning, plants are multiplied by tissue culture techniques.* *3.4.2. Scope: The application of animal cloning (limited to the use of embryonic cells to clone animals) has gained widespread scepticism from moral, ethical, religious, cultural, and societal values, in association with the use or destruction of embryonic cells for stem cells research.* *3.4.3. Scope: Genetic engineering is a technique carried out to manipulate the genetic makeup of the organism through the application of Recombinant DNA technology. Enzymes are employed as major tools for the manipulation of genes. GMOs are produced for their widespread applications in agriculture, medicine, and controlling environmental pollution.* *3.4.3. Scope: The application of GMOs has a lot of societal, bioethical, and moral issues.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system (**LO-1, LO-3)**. **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments (**LO-2, LO-4)**.	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions (**LO-1, LO-3**). **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key ideas, scientific quest, and engage in scientific practises and discourses (**LO-2, LO-4)**.

LO-1. Construct scientific explanations on why variation occurs within an organism or between organisms of the same species.	3.5 Variation of Traits *3.5.1. Scope: Differences that exist within an individual or amongst individuals of the same species. For instance, leaves borne from the same plant at the same time may not be the same. A person's index finger at the right hand may not be alike with that of the index finger of a left hand. Moreover, a person's thumb digits or earlobes may not be identical to the thumb digits or earlobes of another person. These differences are called variations. Variations are caused either by genetic differences (genotypic variation) or by the effect of environmental factors on the expression of the genetic potentials (phenotypic variation).* *3.5.2. Scope: Variations are caused by various environmental factors (e.g., nutrient, light, water, etc.) or genetic factors (e.g., random mating, random fertilisation, recombination of genes, mutation, etc.)* *3.5.3.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-1)**.	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions **(LO-1)**.

Table 4. *Learning Objectives and Dimensions for Biological Evolution: Unity and Diversity, class XI*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practises	Society and Technology
LO-1 Construct scientific explanations on the steps involved in the biochemical origin of life. **LO-2.** Construct an argument giving scientific reasons, to support or refute the idea that life originated in water bodies as a result of chemical reactions. **LO-3** Construct an argument giving scientific reasons to support or refute the idea that the evolution of the oxygenic photosynthetic mechanism had a major impact on the development of the present- day atmosphere.	**4. Biological Evolution: Unity and Diversity** **4.1. Origin of Life** *Scope: Organisms are believed to have originated as a result of some simple and complex chemical reactions. Scientific explanations and evidence direct the origin and evolution of life in three major phases (i.e., chemogeny, biogeny, and cognogeny) as explained by Lederberg. Organisms are believed to have changed the environment and have themselves undergone gradual changes to adapt to new conditions.* *4.1.1. 4.1.2. Scope: The development of oxygenic photosynthetic mechanisms led to major changes in the atmosphere. The change in the atmosphere further led to the evolution and diversification of life forms on earth.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. • Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-1)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments. **(LO-2, LO- 3)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-3)**

LO-1. Design a model that classifies organisms from your locality into five kingdoms based on scientific reasons. **LO-2**. Design a model (*phylogenetic tree or cladogram*) that explains the evolutionary relationship of a group of organisms from the locality.	**4.2. Diversity of Life** *4.2.1. Scope: Living organisms are classified under the five kingdoms (i.e., Monera, Protista, Fungi, Plantae and Animalia). Organisms are classified on the basis of morphological character which shows evolutionary relationships between organisms. The system of classification based on phylogeny organises species or other groups in ways that reflect our understanding of how organisms evolved from a common ancestor. Moving from the point of origin, the groups become more specific, until one branch ends as a single species. These evolutionary relationships are, oftentimes, represented by a phylogenetic tree or cladograms.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future **(LO-1)**. **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system **(LO-2)**.	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions **(LO-1, LO-2)**.

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Class-wise Competency (Class XII)

By the end of class XII, a learner should be able to:

1. From Molecules to Organisms: Structures and Processes

1.1. explain with scientific reason that all organisms either unicellular or multicellular, simple or complex are made of cell; and composes of biomolecules which form the essential basis for cellular processes.

1.2. provide an explanation using scientific reason that an organism is a biological system consisting of interacting subsystems that function in a coordinated manner to maintain balance of internal environment.

2. Ecosystems: Interactions, Energy and Dynamics

2.1. use mathematical models to demonstrate understanding of fundamentals of carrying capacity, factors affecting biodiversity, and flow of energy amongst organisms in an ecosystem.

2.2. use the understanding of the effect of unsustainable anthropogenic activities on the environment in making scientific, economic, political and social decisions in maintaining biodiversity and a healthy environment.

3. Heredity: Inheritance and Variation of Traits

3.1. use scientific reasons to explain that the variation in the genetic composition leads to the differences in the way organisms look, function and survive in relation to the environment.

3.2. use the understanding of the genetic code to explain that gene expression enables DNA to control biochemical processes in the body and DNA can be manipulated to solve problems pertaining to humanity.

4. Biological Evolution: Unity and Diversity

4.1. use scientific evidence to explain that organisms evolved from common ancestors through natural selection and adaptation, artificial selection are the basis for the emergence of multiple lines of organisms.

4.2. use scientific reasons to explain that the trend of evolution is predictable and diversity of organisms are a result of the ratio between various genetic combinations as favoured by natural selection.

Table 1. *Learning Objectives and Dimensions for from molecules to Organism: Structures and Processes, class XII*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Construct scientific explanation on why eukaryotes are more complex than prokaryotes. **LO-2.** Develop scientific explanations that describe about the evolution of eukaryotes from prokaryotes (substantiate with established evidences)	**1. From Molecules to Organisms: Structures and Processes** **1.1. Prokaryotic and Eukaryotic Cells** *1.1.1. Scope: Organisms are made up of cells. Cells are categorised as prokaryotic and eukaryotic cells based on the difference in structure and functions. Prokaryotes contain nuclei and lack well-developed organelles. Eukaryotes have a nucleus and well- developed organelles that are designed to carry out specific functions. Some similar structures are present in both prokaryotes and eukaryotes.* *1.1.2. Scope: Prokaryotes comprise the Kingdom Monera. Eukaryotes are both unicellular and multicellular organisms and constitute the protista, fungi, plant and animal kingdoms. As per the endosymbiont hypothesis, eukaryotes are presumed to have evolved from prokaryotes as a result of some symbiotic associations.*	**Constructing Explanation and Designing Solution** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1)** **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human- designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-2)** • Use models to illustrate the relationships between systems or between components of a system. **(LO-2)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1, LO-2)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models and designing solutions. **(LO-2)**

LO-1. Develop a scientific model that describes the structures and functions of bones (*Limited to the roles of skeletal system, compact and spongy bones, bone cells, chemical composition of bones, and Haversian system*). **LO-2** Develop a scientific model that describes the structures and functions of cartilages (*Limited to hyaline, and elastic and fibrous cartilages*). **LO-2**. Develop a model that relates the arrangement of protein fibres (actin and myosin) in a muscle fibre (*Limited to sarcomere and related structures*). **LO-3.** Communicate scientific information on the biochemical mechanisms of muscle contraction based on the sliding filament theory.	**1.2. Support and Movement Systems** *1.2.1. Scope: The support and movement system of humans is composed of bones, muscles and cartilage. The system provides support, stability, and various internal and external movements.* *1.2.2.Scope: The human skeletal system is the internal framework of the body, providing support, protection, and movement. It is composed of bones, cartilage, ligaments, and tendons. Here are some key aspects of the human skeletal system: Bones: The adult human body typically has 206 bones. These bones can be categorised into two main types: axial and appendicular.* *Axial Skeleton: This includes the skull, vertebral column (spine), and rib cage. It provides central support and protection for vital organs.* *Appendicular Skeleton: This includes the bones of the limbs, shoulder girdle, and pelvic girdle.* *It facilitates movement and interaction with the environment.* *Like any other connective tissue, the skeletal tissues (bones and cartilages) are formed of cells, matrix, and fibres. The nature of bones and cartilages is determined by the types of cells, matrix, and fibres that they are made of.*	**Constructing Explanation and Designing Solution** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1, LO-4)** **Developing and Using Model** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Use models to illustrate the relationships between systems or between components of a system. **(LO-2, LO-3)** • Use models to illustrate the relationships between systems or between components of a system. **(LO-2, LO-3)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-2, LO-3)**

	1.2.3. Scope: Muscle fibres are adapted to undergo contraction and electrical excitation. These muscle fibres are bundled to form larger muscles. Muscle fibres contain contractile proteins (actin and myosin) arranged to form thin filaments (actin and myosin myofilaments). The actin and myosin myofilaments are arranged to form myofibrils. The sliding of myofilaments in myofibrils leads to the contraction and relaxation of muscles.		**Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues. **(LO-4)**
LO-1. Develop a model that explains the structures and digestive roles of the digestive system (*Limited alimentary canals and accessory organs*). **LO-2.** Develop a model that represents the chemical breakdown of various food materials (carbohydrates, proteins, and fats) in the alimentary canal. **LO-3.** Construct scientific explanations on how the end products of digestion are absorbed and assimilated in the cells.	**1.3. Digestion: What is on the plate?** *1.3.1. Scope: The human digestive system comprises the alimentary canal and digestive glands. The alimentary canal is structurally adapted to perform various functions during the digestive process. The secretions of chemicals from different digestive glands aid in chemical digestion.* *1.3.2. Scope: Digestion occurs by physical and chemical breakdown of food. During physical digestion, the larger food chunks are broken down into smaller particles due to chewing and movements. Chemical digestion involves enzymatic hydrolysis of food molecules to soluble forms in different parts of the alimentary canal.*	**Developing and Using Model** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human- designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1, LO-4)**	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1, LO-3, LO-4)**

	1.3.3. Scope: The digested food particles are absorbed into the bloodstream through blood capillaries and lacteals. Blood transports the absorbed food to the liver for detoxification and is ultimately assimilated in the cells. *1.3.4 The growth, development, and health of an organism depend on its food. The human lifestyle is undergoing a rapid change due to which people depend more on processed food (fast foods) that barely meets the dietary requirements. Healthy dietary practices contribute to good immunity and help in preventing diseases (e.g., malnourishment, heart diseases, stroke depressed immune functions, etc.).*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-2, LO-4)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses. **(LO- 1, LO-2, LO-3, LO-4)**
LO-1. Develop a model using scientific evidence that represents the events leading to the breakdown of food during respiration (*Limited to glycolysis, link reaction, Krebs cycle and Electron transport chain*).	**1.4.** Food and Energy *1.4.1. Scope: Food (glucose) is broken down by a series enzyme-controlled biochemical reactions during respiration, to release energy. Respiration occurs in two major phases, i.e., glycolysis and Krebs cycle. Aerobic respiration requires oxygen for the complete breakdown of biomolecules (glucose) and release energy. Glucose is broken down to form pyruvic acid in the cytoplasm (glycolysis). Pyruvate is converted to Acetyl CoA which is oxidised during Krebs cycle through a series of chemical reactions in the mitochondria. Incomplete breakdown*	14 Developing and Using Models Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human- designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1)**	1 Using Physical Tools Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-1)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific

	of food materials occurs during anaerobic respiration (lactic acid and alcoholic fermentation). *1.4.2. Scope: Microbes are economically and environmentally important due to their ability to break down organic materials by aerobic and anaerobic respiration. Using them for the treatment of sewage and other wastes have contributed towards minimising environmental pollution. Due to their abilities to carry out anaerobic respiration, microbes are also applied in a range of food processing industries to synthetically add flavour to processed food.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student- generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-2 LO-3)**	theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses. **(LO- 1, LO-2, LO-3)** **Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio- scientific issues. **(LO-3)**
LO-1. Construct models that describe gross structures and functions of a nerve cell, and the classification of neurons based on structures and functions. **LO-2.** Develop a model that represents the chemical events leading to the transmission of information *(Limited to myelinated and nonmyelinated)*.	**1.5. Perception and Interaction** *1.5.1. Scope: Organisms interact and respond to the changes that occur in their environment in order to survive. Central Nervous System (CNS) coordinates the responses shown by an organism. Receptors sense the changes in the surrounding (stimuli) and generate electrical impulses (sensory) which are transmitted to the CNS. CNS modulates and generates a new impulse (motor) which determines the nature of the response that an organism exhibits.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1, LO-2, LO-3)**

LO-3. Construct a scientific model that explains the structures and functions of human eyes **(***eyeball, image formation, and biological conditions of eyes in connection with the faulty eye lens***)**. **LO-4.** Construct a scientific model that explains the structures and functions of human ears **(***include external, middle, and internal structures, and hearing mechanism***)**.	*1.5.6. Scope: Neurons have electrolytes (Na+, K+, etc.) on the inner and outer sides of their membranes. The distribution of electrolytes determines the potential difference of the membrane. On being stimulated, the pattern of distribution keeps changing, allowing transmission of the impulse. During rest, the membrane is in a polarised state having more positive charge outside the membrane and less inside. During the generation of transmission of impulse, the potential difference is reversed (action potential) and the membrane is depolarised. The transmission of impulses is a result of the movement of electrolytes in and out of the nerve fibres. The electrical state of a neuron keeps changing during impulse conduction*	operate today as they did in the past and will continue to do so in the future. **(LO-1)** **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-2)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-3)**	**Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio- scientific issues. **(LO-2)**

LO-1. Construct a scientific model that explains the internal structures of human kidney **LO-2.** Develop a model that explains how different parts of a nephron in humans are structurally adapted to remove nitrogenous waste (*focus on the urine formation including counter-current mechanism*). **LO-3.** Design a solution to help a person with kidney dysfunctionalitie s attain an osmotic balance of the body fluids.	**1.6. Excretion: The Removal of Waste** *1.6.1. Scope: Excretion involves cellular processes in removing substances that are not required in the body, and maintaining the required concentration of substances in the body fluids. The nature of nitrogenous waste excreted varies amongst different types of species and also depends on the environment that an organism lives in.* *1.6.2. Scope: All vertebrates have kidneys formed of nephrons, that specialise in removing metabolic waste and retaining useful substances. Human kidneys are highly developed and adapted to excrete urea (the main metabolic waste) dissolved in the urine. Urine formation (uropoiesis) occurs by ultrafiltration, tubular secretion, and tubular reabsorption. Substances are retained during uropoiesis by movement across the membrane of nephrons. The exchange of substances occurs depending on the concentration of solutes and in turn regulates the osmotic concentration of urine, blood, and body fluids.* *1.6.3.Scope: Inefficiency/ dysfunction of the excretory organs results in the accumulation of harmful substances in the body causing problems (e.g., anaemia, decreased immune response, etc.). Hemodialyser is used to maintain the osmotic concentration of body fluid during kidney failure.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1)** ● Design, evaluate, and refine a solution to a complex real- world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO- 3)** **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-2)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1, LO-2, LO-3)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-2)** **Computational Modeling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio- scientific issues. **(LO- 3)**

LO-1. Develop scientific comparisons between the functions and the structural arrangements of tissue systems in plants (*Limited to epidermal, vascular, and ground tissues in monocot and dicot stems, roots, and leaves*). **LO-2.** Investigate to examine the structural arrangements of tissue systems in plants (*Limited to epidermal, vascular, and ground tissues in monocot and dicot stems, roots, and leaves)* **LO-3.** Develop scientific models that explain the elements of vascular tissues; and types of vascular bundles (*Limited to radial, conjoint, collateral, concentric, exarch and endarch, and mesarch).*	**1.7. What is inside a Plant?** *1.7.1. Scope: In plants, cells are arranged to form tissues that are integrated to form different organs. The apical part of the plant contains meristematic tissue, that divides indefinitely forming new tissues. The meristematic tissues give rise to permanent tissues that form different parts of the plant and are specialised to take up different functions.* *1.7.2. Scope: Plant tissues are organised to form epidermal, ground, and vascular tissue systems.* *These tissue systems are adapted to take up different functions in the roots, stems and leaves.* *Plants exhibit both physiological and morphological adaptations to survive in various types of environments.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**(LO-1)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. • Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-2, LO-3)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Construct and defend a claim based on scientific reasons that reflect scientific knowledge and student- generated evidence about the natural world. **(LO-4)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1, LO-2, LO-3, LO-4)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-3, LO-4)**

LO-1. Construct scientific explanation on how plant pigments absorb energy from lights of different wavelengths and collectively cause the light reaction. **LO-2.** Design a model that explains the mechanisms involved during light and dark phases (*C3 and C4*) of photosynthesis. **LO-3.** Investigate the impacts of light intensity, carbon dioxide and temperature on the rate of photosynthesis. **LO-4.** Design an investigation to understand what type of plant would be the most effective to take to Mars to produce enough oxygen for aerobes to survive. **LO-5.** Construct an argument with scientific reasons to support or refute the claim that plants can be employed to mitigate global warming.	**1.8. Photosynthesis: Food for Life** *1.8.1. Scope: Some organisms (e.g., plants, algae, bacteria, etc.) are capable of absorbing sunlight and using the energy in synthesizing organic compounds (e.g., glucose), which is used as the source of metabolic energy for cellular activities.* *Plants use light energy from the visible spectrum (PAR) for photosynthesis. Plant pigments absorb energy from different wavelengths of visible light and in a synergistic manner, attain the energy level required for the light reaction to take place. Photosystems make the light reaction very efficient.* *1.8.2. Scope:Photosynthesis is a physicochemical process that involves light and dark phases. The light phase takes place in the thylakoids and involves the transduction of light energy into chemical energy and ultimately storing it into energy carriers (i.e., NADPH and ATP). The dark phase takes place in the stroma and involves the usage of energy from the energy carriers for the fixation of CO2 by the Calvin Cycle(C3 cycle). Glucose is produced as the main product while oxygen is released as a by- product.* *1.8.3. Scope: The rate of photosynthesis keeps changing, depending on a variety of internal and external factors. The external factors are the environmental factors (e.g., light, temperature, CO2 concentration)*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1)** **Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-2)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. ● Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO- 1, LO-2, LO-3, LO-4, LO-5)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO- 3,**

LO-6: Explain carbon trading as a measure to mobilize the resources in Bhutan. **LO-7.** Construct an argument with scientific reasons to support or refute the idea that the cutting down of old trees is useful in addressing climate change.	*while the internal factors are leaf structure and protoplasmic factors. 1.8.4 Scope: Photosynthesis has a wide range of potential applications. The evolution of oxygen is presumed to have a major impact leading to the formation of the present-day atmosphere(oxygen revolution). Due to photosynthetic abilities, plants have potential applications in controlling the rising CO2 concentration in the atmosphere and extra-terrestrial applications such as creating suitable environments for the survival of organisms.*	easurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly. **(LO-3, LO-4)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. ● Construct and defend a claim based on scientific reasons that reflect scientific knowledge and student- generated evidence about the natural world. **(LO-5)**	**LO-4)**

Table 2. *Learning Objectives and Dimensions for Ecosystems: Interactions, Energy and Dynamics, class XII*

Learning Objectives (LO)	Core Concepts	Scientific Method and Engineering Practices	Society and Technology
LO-1. Develop a model (mathematical representation) to quantify biodiversity based on species richness and species evenness of a community. **LO-2.** Communicate scientific information on the social, economic, cultural and spiritual association of your community to the biodiversity around. **LO- 3.** Investigate to identify the plants (*along with their botanochemicals*) that are used for healing practices in your locality.	**2. Ecosystems: Interactions, Energy and Dynamics** **2.1. Our Environment** *2.1.1. Scope: Earth is inhabited by various life forms. The distribution of different species varies in every ecosystem depending on a variety of factors(e.g. ability to adapt, climatic conditions, food availability, etc.). The diversity of species in an area is studied by determining their richness and evenness. The richness and evenness of organisms in a community can be quantified through numerous methods and can determine the health of an ecosystem.* *2.1.2. Scope:Humans share an intricate relationship with their environment. The environment and biodiversity have deeply associated social, economic, cultural, and spiritual importance with the human community. Bhutan's cultural*	**Using Mathematics and Computational Thinking** Mathematical and computational thinking for statistical analysis to represent or model data using algebraic thinking and analysis, a range of linear and non-linear functions, including trigonometric functions, exponentials and logarithms, and computational tools. Simple computational simulations are created and used based on mathematical models of basic assumptions. ● Use mathematical and/or computational representations of phenomena or design solutions to analyse data; support, revise, or refute explanations and claims. **(LO-1)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the	**Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues. **(LO-1)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-2. LO-3)** **Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific

	practices exhibit a lot of connections to the environment. *2.1.3. Scope:Plants and their derivatives (e.g., plant parts, botanic chemicals, etc.) are widely used for traditional healing practices and producing indigenous medicines. The traditional knowledge on the usability of plants has led to the development of recent applications in modern medicine.*	process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-2)** **Planning and Carrying Out Investigations** Planning and carrying out investigations in providing evidence for, and testing conceptual, mathematical, physical, and empirical models. ● Plan and conduct investigations to produce data to serve as the basis for evidence, and in the design to decide on data needed to produce reliable measurements considering limitations on the precision of the data (e.g., variables, resources, number of trials, cost, risk, time), and refine the design accordingly.**(LO-3)**	theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3)** **Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions. **(LO-3)**
LO- 1. Construct arguments supported by scientific reasons to support or refute the claim that socio-economic development impacts the natural environment. **LO- 2** Design a solution to control the environmental	**2.2. Threats on Biodiversity** *2.2.1. Scope:The nature of interactions amongst organisms, has a direct connection to the health of the environment in an area. Natural and anthropogenic disturbances bring changes in the environmental conditions, as a result, numerous*	**Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. ● Evaluate and comprehend claims, evidence, and reasons	**Exploring Digital Resources** Exploring and identifying sources of information (e.g database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, communicate the key

impact caused due to economic development. **LO- 3** Design a solution to protect species (*white- bellied heron, chinese caterpillar, etc.*) that are under threat. **LO- 4** Use the principles of design thinking to solve the human wildlife conflict.	*vulnerable species (e.g., White- bellied heron, Chinese caterpillar, red-panda, etc.) are facing increased threats to their survival. Human efforts for the improvement of plant and animal species has resulted in some visible consequences(e.g., gene pollution) and is an increasing global concern.* *2.2.2. Scope: Anthropogenic activities (e.g,. construction, agriculture, hunting, etc.) cause disturbances to the environment on a greater scale resulting in decline in the population of a lot of species. Numerous species (e.g., White-bellied herons, Red panda, etc.) have reached a staggering low population and are on a continual threat of extinction. Illegal wildlife trade has led to the escalation of illegal activities such as poaching and trafficking and is becoming a growing concern for conservation.* *2.2.3. Scope: Clearing of forests and manipulation of landscapes for industrial growth, human settlement, and agricultural expansion has led to habitat fragmentation and increased incidences of human encounter with wildlife.* *Human-wildlife conflict is increasing global concern over the years and has resulted in the loss of a lot of important species.*	behind scientific explanations or solutions and determine the merits of arguments.**(LO-1)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did human wildlife and will continue to do so in the future. **(LO-2)** ● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-3, LO-4).**	ideas, scientific quest, and engage in scientific practices and discourses. **(LO-1, LO-2, LO-3, LO-4)** **Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues. **(LO-3, LO-4)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-1, LO-2, LO-3, LO-4)**

LO-1. Construct scientific explanation on how sustainable development contributes towards conservation of the environment. **LO-2.** Investigate the challenges in the management of natural resources at your locality. **LO-3.** Design a solution to conserve natural resources at the community level. **LO-4.** Analyse the significance of Gross National Happiness in the sustainable management of natural resources. **LO-5**. Evaluate Bhutan's participation in global negotiations for combating climate change.	**2.3. Sustainable Management of Natural Resources** *2.3.1. Scope: Unsustainable consumption and production patterns have resulted in huge economic and social costs that endanger life on the planet. Sustainable Management of Natural resources meets the needs of the natural resources for the present and future through conservation. Sustainable development requires actions on delivering legitimate strategies for economic and social progress, and at the same time strengthening environmental protection.* *2.3.2. Scope: Sustainable Management of natural resources involves conservation of forest, wildlife, habitats at community and national levels. Strategies developed at community, national and international levels are used to promote conservation. Management of biodiversity and natural resources is hindered by lower literacy rate, poverty, illegal marketing, lack of human resources, and other challenges.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1)** ● Design, evaluate, and refine a solution to a complex real-world problem, based on scientific knowledge, student-generated sources of evidence, prioritised criteria, and trade-off considerations. **(LO-2, LO-3)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses. **(LO-1, LO-2, LO-3, LO-4)** **Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues. **(LO-2, LO-3)**

	2.3.3. Scope: Conservation of the Environment is a pivotal part of Bhutan's Developmental Philosophy. Bhutan's economic development policy is guided by the philosophy of Gross National Happiness (GNH). The country's pursuit of development remains within the limit of environmental sustainability.	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-4)**	**Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO-1, LO-2, LO-3, LO-4)**

Table 3. *Learning Objectives and Dimensions for Heredity: Inheritance and Variation of Traits, class XII*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Construct scientific explanation how the structure of the DNA molecule is adapted to carry out its biological role in coding proteins **LO-2.** Construct scientific explanations on how the genetic information stored in DNA code for proteins that determine traits of the organisms.	**3. Heredity: Inheritance and Variation of Traits** **3.1. DNA: The Blueprint of Life** *Scope: DNA contains information to make proteins that determine our structures and Life processes. The information to make proteins are stored in the form of genetic codes. The genetic codes are formed by four-letter languages of DNA (adenine, guanine, thymine and cytosine). Then nature of genetic information or genetic codes specify the sequence of amino acids in a polypeptide chain. The amino acid sequence, thus, determines the 3D conformation (structure) and function of the proteins.* *3.1.1.*	**Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs. ● Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-1)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**

	3.1.2. Scope: Proteins take a central role in linking the DNA (genes or genetic information) to traits expressed in the organisms. The nature of proteins, including their structure and function, depends on the nature of the genetic information stored in DNA or genes. The nature of protein, in turn, influences the structure and function of cells and tissues, and therefore determines the traits of an organism. This occurs at various stages, including molecular, cellular and subcellular levels catalysed by enzymes. For instance, the colour of our hair or the nature of our earlobes are influenced by the nature of proteins specified by our genetic code.	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1)**	
LO-1. Develop a model that explains how sequence of nucleotides codes for amino acids. **LO-2.** Develop a model that explains the expression of information encoded in DNA through a protein-mediated mechanism (*transcription and translation*).	**3.2. Breaking the Code.** *3.2.1. Scope: DNA contains genetic codes or information to make proteins that determine our structures and Life processes.* *The genetic codes are formed by a long chain of four-letter languages of DNA (adenine, guanine, thymine and cytosine) that occur in groups of three nucleobases or nucleotides. These triplet nitrogenous bases are called codons. There are 64 codons in the human genome. The sequence of codons in a mRNA determines the sequence of amino acids in a polypeptide chain.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). ● Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1, LO-2)** ● Use models to illustrate the relationships between systems or between components of a system. **(LO-1, LO-2)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2)**

	3.2.2. Scope: DNA codes proteins. This is initiated when the information stored in DNA (genetic code or genetic information) is carried into the cytoplasm by mRNA. A part of the template strand of DNA is transcribed to form RNA. Transcription (a process similar to replication), results in the synthesis of a single strand mRNA. The RNA further undergoes post-transcriptional modification to become functional mRNA. Conversion of the genetic information on a mRNA to protein occurs by translation in the cytoplasm, where ribosomes mediate the combination of amino acids in accordance with the sequence of codons on mRNA		**Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues. **(LO-1, LO-2,)**
LO-1. Develop a model that explains the process of gene therapy in the treatment of a genetic disorder. **LO-2.** Communicate the scientific information on the potential uses and implications of CRISPR technology. **LO-3.** Construct an argument giving scientific reasons to compare the advantages and disadvantages of gene	**3.3. Gene Therapy and Genetic Fingerprinting** *3.3.1. Scope: Medical conditions related to genes can potentially be treated by gene therapy. The therapeutic procedures are performed on stem cells and germs cells. There are ethical and moral issues associated with the application of gene therapy.* *3.3.2. Scope: CRISPR (Clustered Regularly Interspaced Short Palindromic Repeats) technology involves techniques that allow the editing of genes with the use of an enzyme (Cas9). It has a wide range of applications in correcting genetic defects, treating medical conditions, and improving the growth and resilience of crops.*	**Developing and Using Models** Developing models in synthesising and predicting relationships amongst variables between systems and their components in the natural and human-designed world(s). • Develop models based on scientific evidence or logic and reasons, to represent relationships between systems or components of a system. **(LO-1, LO-6)** **Obtaining, Evaluating, and Communicating Information** Obtaining, evaluating, and communicating information in evaluating the validity and reliability of the claims, methods, and designs.	**Using Physical Tools** Using physical tools (e.g., laboratory equipment, gadgets, mobile devices, computers, etc.) for observing, explaining, and evaluating scientific phenomena, constructing models, and designing solutions.**(LO-1,LO-6)**

therapy over the use of drugs (i.e., *pharmacotherapy*) for the treatment of diseases. **LO-4**. Communicate scientific information on the prospects and social implications of The Human Genome Project. **LO-5.** Construct an argument with scientific reasons on the ethical issues associated with the application of gene therapy for the treatment of medical conditions. **LO-6.** Develop a model that explains the process of genetic fingerprinting. **LO-7.** Construct scientific explanation that the application of genetic fingerprinting can contribute towards promoting peace and justice in society.	*Epigenetics is a growing field of science that aims at improving organisms without the necessary manipulation of genes.* *3.3.3. Scope: DNA fingerprinting involves sophisticated procedures (e.g., PCR, gel electrophoresis, southern blotting, etc.) to identify the difference amongst organisms through sequencing of DNA and studying the non-coding part of the DNA. It has a wide range of applications in research, medicine, criminology, forensics, and others.* *3.3.4. Scope: The Human Genome Project is an ambitious research project to decipher the chemical makeup of the entire human genetic code. The project is aimed at identifying genes involved in causing different types of diseases.*	• Evaluate the validity and reliability, and communicate scientific information (e.g., about phenomena and/or the process of development and the design and performance of a proposed process or system) through multiple formats such as orally, graphically, textually, or mathematically. **(LO-2, LO- 4)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. • Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments.**(LO-3)** • Construct and defend a claim based on scientific reasons that reflect scientific knowledge and student-generated evidence about the natural world. **(LO-5)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-7)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3, LO-4, LO-5, LO-6, LO-7)** **Promoting Human and Cultural, Socioeconomic, and Environmental Values** Using technology in promoting human, cultural, socio-economic, and environmental values are driven by individual or societal needs, aspirations, and changing expectations and their influences. **(LO- 4, LO-5)**

Table 4. *Learning Objectives and Dimensions for Biological Evolution: Unity and Diversity, class XII*

Learning Objectives (LO)	Core Concepts	Scientific Methods and Engineering Practices	Society and Technology
LO-1. Provide scientific scientific explanation how morphological structures *(homology and analogy)* indicate the common ancestry of organisms. **LO-2.** Construct a model that represents the evolutionary relationships between different groups of organisms using the concept of missing links and connecting links. **LO-3.** Analyse fossils data to understand the pattern of evolution and change in environmental conditions. **LO-4.** Make a claim to support which amongst genetic, biochemical, cytological, and fossil evidence is the most credible approach for deriving evolutionary relationships amongst organisms.	***4. Biological Evolution: Unity and Diversity*** **4.1. Evidence of Common Ancestry** *4.1.1. Scope: Organisms share a lot of similarities in terms of their physical and behavioural characters. The similarities in the organism's morphological structures (homology and analogy) reveal the descendants of organisms from common ancestral forms by evolution. Some organisms are found to contain features of two or more groups of organisms (e.g., duck-billed platypus and Archeotyrex contain the features of reptiles and mammals).* *4.1.2. Scope: The resemblances in the stages of embryonic development and temporary embryonic structures amongst various organisms depict their evolutionary relationships. Embryos of certain organisms provide structural evidence that is not shown by the adults.'* *4.1.3. Scope:Fossils and artefacts left by ancestral organisms are sources of information in understanding evolution. These provide a logical basis for understanding the existence of organisms, diversity, extinction, and change of many life forms throughout the history of life on Earth. Distribution patterns, forms, and ages of fossils are studied to derive the chronological order of evolution (by*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. ● Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**(LO-1, LO-2)** **Analysing and Interpreting Data** Analysing data in introducing detailed statistical analysis, comparing data sets for consistency, and the use of models (e.g., data analysing techniques) to generate and analyse data. ● Apply the concepts of statistics and probability (including	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practices and discourses.(**LO-1, LO-2, LO-3, LO-4)** **Computational Modelling and Simulation** Using programming language and software in coding, robotics, gamification, and simulations to develop models, analyse real-time data samples, and design solutions to address socio-scientific issues.**(LO-3)**

	radioactive carbon dating). *4.1.4. Scope: The nature of fossils (physiology, anatomical structures, or morphological structures) provides substantial information on the nature of change that a region's environment underwent (climate change). Comparing fossils to modern organisms can help to determine the trend of climate change and evolution.* *Scope: Organisms exhibit similarities in a lot of cytological features (e.g., biomolecules, cell structure, etc.). Similarities in genetic and biochemical composition indicate the common ancestry amongst organisms. The understanding of molecular biology, cellular processes, information related to genes and proteins are used in studying evolutionary history and developing relationships.*	determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to science questions and engineering problems.**(LO-3)** **Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. ● Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments. **(LO-4)**	
LO-1. Construct an argument on the reliability of Lamarckism in explaining the mechanism of evolution. **LO-2.** Construct a scientific explanation on the evolution of organisms based on Darwinism.	**4.2. Theories that Explain Evolution** *4.2.1. Scope:Lamarcksim explains evolution as a result of the inheritance of characters that an organism obtains or builds during its lifetime. (e.g., Modern day giraffes are presumed to have evolved from short-necked ancestors with regular elongation of their necks).* *4.2.2. Scope: Darwinism builds up on the idea that the population of an organism that are suited to live in the*	**Engaging in Arguments from Evidence** Engaging in arguments using evidence or logical reasoning in defending and critiquing claims, and explanations about natural phenomena including current scientific and historical episodes in science. ● Evaluate and comprehend claims, evidence, and reasons behind scientific explanations or solutions and determine the merits of arguments.**(LO-1)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3, LO-4)**

LO-3. Construct a scientific explanation on the evolution of organisms based on mutation theory. **LO-4.** Construct an argument with scientific reasons to support which amongst Lamarckism, Darwinism, and mutation theory, is the most credible theory inexplaining the mechanisms of evolution.	*environment survive and reproduce, while others that are not suited do not survive.* *4.2.3. Scope: Mutation theory explains that any change in the genetic material or randomness creates the organisms to bear either useful or harmful characteristics. Those that gain useful characteristics get selected by the environment and survive, while those that are harmful do not.* *4.2.4. Scope: Modern synthetic theory of evolution defines evolution as a result of variation, recombination, natural selection, isolation, and migration.*	• Construct and defend a claim based on scientific reasons that reflect scientific knowledge and student-generated evidence about the natural world.**(LO-4)** **Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student-generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future.**(LO-2, LO-3**)	
LO-1. Construct scientific explanations on how natural selection and artificial selection contribute to evolution of organisms based on allele frequency. **LO-2.** Analyse how the effect of anthropogenic activities on gene frequencies is related to the endangerment of species.	**4.3. Evolution from Allele Frequency** *4.3.1. Scope: In absence of evolutionary forces there is no change in gene frequency and genotype frequency and thus no evolution. Natural selection and artificial selection (Techniques such as gene cloning, hybridization in agriculture and animal husbandry; and other human breeding techniques) influence or alter the frequency of allele, genotype and the corresponding traits.*	**Constructing Explanations and Designing Solutions** Constructing explanations and designing solutions supported by multiple and independent student- generated evidence consistent with scientific ideas, principles, and theories. • Construct and revise an explanation based on evidence obtained from a variety of sources (including students' own investigations, models, theories, simulations, peer review) and the assumption that theories and laws that describe the natural world operate today as they did in the past and will continue to do so in the future. **(LO-1, LO-3, LO-4)**	**Exploring Digital Resources** Exploring and identifying sources of information (e.g., database, journal articles, periodicals, applications, programs and software, websites, etc.) to validate information on the scientific theories and laws that exist in nature, and communicate the key ideas, scientific

LO-3. Construct scientific explanation to show the roles of evolutionary factors in the formation of new species. **LO-4.** Construct an explanation to derive a relation between Mendel's concept of inheritance and Hardy Weinberg's Principle to acclaim the role of inheritance in evolution.	*4.3.1. Scope: According to genetic drift theory, change in allele frequency or genotype frequency; and traits in a population occurs by chance due to factors such as natural calamities (sudden change in seasonal temperature, climate change, acidity, and forest fire), geographical barriers; and human activities contribute to evolution.* *4.3.2. Scope: According to Hardy-Weinberg's principle, if there is no change in allele frequency, a population is said to be in stable or equilibrium. However, if there is a change in allele frequency, the population is said to be in the state of evolution.*	**Analysing and Interpreting Data** Analysing data in introducing detailed statistical analysis, comparing data sets for consistency, and the use of models (e.g., data analysing techniques) to generate and analyse data. ● Apply the concepts of statistics and probability (including determining function fits to data, slope, intercept, and correlation coefficient for linear fits) to science questions and engineering problems.**(LO-2)**	quest, and engage in scientific practises and discourses. **(LO-1, LO-2, LO-3, LO-4)**

SECTION C: CHEMISTRY

2 SECTION C: Chemistry (Materials and their Properties)

11. 1 Key stage 4 (IX -X)

Competency-based Standard

By the end of key stage 4 (class X), a learner should be able to:

1. Classifying Materials

1.1. demonstrate the conceptual understanding of the behaviour of gases and gas laws to relate it to the everyday life.

2. Materials and Change

2.1. interpret the chemistry of alcohol to evaluate its impact on health, economy, society, environment, industry and in the field of medicine.

2.2 outline the basic steps of metallurgy to understand the significance of metals and their alloys in contributing towards human welfare, civilization, culture, and the environmental impact.

3. Patterns in Chemistry

3.1 outline the properties of halogens and transition elements to relate their importance in industries, medicine, and other areas of life.

3.2 Exhibit the knowledge of mole concept and stoichiometry to quantify the substances in chemical reaction for industries and to carry out quantitative analysis in laboratories.

3.3 Relate the fundamental concepts and principles of thermodynamics to understand interconversion of energy and Physical Processes taking place in the universe.

Class-wise Competency (Class IX)

By the end of class IX, a learner should be able to:

1. Classifying Materials

- relate chemical bonding to the properties and usefulness of materials in day-to-day life.

2. Materials and Change

- outline the fundamentals of hydrocarbons and polymers in terms of synthesis, properties and applications to analyze their impact on health, environment and society.
- relate the properties of metals with reference to metal activity series for identifying metals used for different purposes.
- appreciate the bio-geochemical cycles to adopt green practices to reduce the impact on health, society and environment.

3. Patterns in Chemistry

- apply the knowledge of periodic table to study and predict the properties, uses and position of new elements.
- relate the concept of chemical reactions to understand the fundamentals of energy changes, industrial applications and the material change.
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Table 1. *Learning Objectives and Dimension for Classifying Materials, class IX*

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explore the information on definition of chemical bond, types of chemical bond, and duplet and octet rule using relevant sources. ii. Explain the formation of ionic and covalent bond using simulation. iii. Explain the formation of ionic, covalent and coordinate bond using simulation. iv. Construct 2D/3D models that explain ionic bond and covalent in relation to duplet and octet rule. v. Investigate the properties of materials based on types of chemical bond and their applications. vi. Design a device which uses covalent or ionic materials to relate the bonding with the properties of materials.	**1. Classifying Materials** **1.1 Chemical Bond** 1.1.1 Chemical Bond: (*Scope: Definition, types of chemical bond, and formation of cation and anion).* 4.1.1. Duplet and Octet rule: *(Scope: explanation with examples).* 4.1.2. Ionic bond: (*Scope: definition of ionic bond, formation of ionic bonds with examples, general properties of ionic compounds*) 1.1.4 Covalent bond: (*Scope: definition of covalent bond, types of covalent bond, formation of covalent bond and coordinate bond with examples, general properties of covalent compounds*). 1.1.5 Properties of materials based on bonding and the application of materials based on the properties.	**Developing and Using Models** Construct 2D/3D model to explain ionic bond and covalent in relation to duplet and octet rule. **Asking Questions and Defining Problems** Ask questions on properties of materials based on types of chemical bonds. **Planning and Carrying Out Investigations** Observe common materials to investigate properties of materials based on types of chemical bonds. **Analysing and Interpreting Data** Analyse and interpret data collected through investigation **Constructing Explanations and Designing Solutions** Explain the formation of chemical bonds based on the interpretation of data. **Obtaining, Evaluating, and Communicating Information** Share the information through different media. **Developing and Using Models** Design a device which uses covalent or ionic materials to relate the bonding with the properties of materials. **Asking Questions and Defining Problems** Ask questions and define problems based on the significance of chemical bonding in the biological system and existence of life on earth. **Planning and Carrying Out Investigations** Carry out research to relate the significance of chemical bonding in the biological system and	**Exploring Digital Resources** Explore the information on definition of chemical bond, types of chemical bond, duplet and octet rules using relevant resources. **Exploring Digital Resources** Use simulation to explain the formation of ionic and covalent bonds.

vii. Research to relate the significance of chemical bonding in the biological system and existence of life on earth.		existence of life on earth. **Analysing and Interpreting Data** Analyse and interpret data collected through investigation **Constructing Explanations and Designing Solutions** Explain and relate the significance of the biological system and existence of life on earth. **Obtaining, Evaluating, and Communicating Information** Share the information to the class using different media.	

Table 2. *Learning Objectives and Dimension for Materials and Change, class IX*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explore the definition of organic compounds, reasons for existence of a large number of organic compounds, their sources and importance using relevant sources. ii. Explain classification, functional group, nomenclature and homologous series of hydrocarbons through relevant sources. iii. Explain isomerism in hydrocarbons using simulations. iv. Explore the information on physical and chemical properties of methane, ethane, ethene and ethyne using relevant resources. v. Design an experiment to investigate the difference	**2. Materials and Change** 2.1 Organic Compounds (*Scope: definition, reasons for existence of large number of organic compounds, sources of organic compounds, importance of organic compounds)* 2.2 Hydrocarbons (*Scope: definition, classification of hydrocarbons, alkyl group, functional group, homologous series, and nomenclature of hydrocarbons)* 2.2.1Alkanes	**Using Mathematics, Information and Computer Technology, and Computational Thinking** use IUPAC rules to name alcohols. **Analyzing and Interpreting Data** Predict the products of burning alkanes, alkenes and alkynes using relevant chemical equations **Developing and using models** Design molecular models to explain the structures of alkane, alkene and alkyne. **Asking Questions and Defining Problems** Ask questions on differences between saturated and unsaturated hydrocarbons. **Planning and Carrying Out Investigations** Design an experiment to investigate saturated and unsaturated hydrocarbon **Analysing and Interpreting Data** Analyse and interpret data collected	**Exploring Digital Resources** Explore the information on the meaning of Organic compounds, existence of a large number of organic compounds and their sources and importance. **Exploring Digital Resources** Explore information on

between saturated and unsaturated hydrocarbons. vi. Compare the efficiency of saturated and unsaturated hydrocarbons as a fuel in automobiles. vii. Explain monomers, polymers and polymerization by analysing the given information on polymers. viii. Explore on natural and synthetic polymers using relevant sources. ix. Explain the formation of polyethene and PVC using simulation. x. Apply the knowledge of hydrocarbons and polymerization to design physical or computer models of any polymer that may have commercial values. **xi. Evaluate the impacts of synthetic polymer on health, environment and society.** xii. **Research on alternative polymers that can reduce the environmental impact caused by synthetic polymers.** xiii. Locate elements which are metals, metalloids and non-metals based on their characteristic properties using the periodic table. xiv. Construct activity series of metals based on their reactivity.	(*Scope: definition with examples, isomerism in alkanes, methane and ethane: physical and chemical properties (combustion, oxidation, substitution reactions and uses)* 2.2.2 Alkenes (*Scope:definition with examples, isomerism in alkenes,ethene: physical and chemical properties (combustion, oxidation, addition reactions and uses)* 2.2.3 Alkyne (*Scope: definition with examples, isomerism in alkynes, ethyne: physical and chemical properties (combustion, oxidation, addition reactions and uses).* 2.3 Polymers *(Scope: monomers, polymers, polymerization, natural and synthetic polymers, uses, and impacts)* 2.4 Reactivity of metals (Scope: *definition of metals, nom-metals, and*	through experiment. **Constructing Explanations and Designing Solutions** Point out the difference between saturated and unsaturated hydrocarbons. **Obtaining, Evaluating and Communicating Information** Share the findings in the class. **Analyzing and Interpreting Data** Compare the efficiency of saturated and unsaturated hydrocarbons as a fuel in automobiles. **Developing and using models** design physical or computer models of any polymer that might have commercial values. **Asking Questions and Defining Problems** Ask questions and define problems to research on alternative polymers as synthetic polymers have huge environmental impact. **Planning and Carrying Out Investigations** Plan the research. **Analysing and Interpreting Data** Analyse and interpret data collected through research. **Constructing Explanations and Designing Solutions** Suggest alternative polymers which are effective and environmentally friendly. **Obtaining, Evaluating and Communicating Information** Share the findings in the class. **Developing and Using Models** Construct an activity series of metals to arrange the metals based on their reactivity. **Analysing and Interpreting Data**	the classification, functional group, nomenclature and homologous series of hydrocarbons **Exploring Digital Resources** use simulation to explain isomerism in hydrocarbons. **Exploring Digital Resources** Explore the information on preparation and physical properties of methane, ethane, ethene and ethyne **Exploring Digital Resources** Explore on monomers, polymers and polymerisation. **Exploring**

xv. Predict the reaction of metals with air, water and acids using reactivity series of metals. xvi. Explain the uses of metal activity series after exploring the information through relevant sources. xvii. Apply the knowledge of metal activity series to design a chemical process to extract a metal from its compound. xviii. Apply the knowledge of activity series of metals for selecting different types of metals to design medals for the school athletes. xix. Explain the chemistry behind why some metals are more reactive than others. xx. Explore the principles of green chemistry in relation to design and process of goods that reduce or eliminate generation of hazardous substances. xxi. Explain the nitrogen cycle using simulation or a model. xxii. Compare chemical fertilizers and bio fertilizers based on their environmental consequences. xxiii. Explain carbon cycle using simulation or a model. Explain the significance and impact of greenhouse gases.	*metalloids with examples, physical and chemical properties of metals and non-metals)* 2.4.1 Activity series of metals *(Scope: definition of activity series of metals, reaction of metals such as Na, Ca, Mg, Zn, Fe, Pb and Cu with air, water and acids, and application of reactivity series of metals)* 2.5. Green chemistry 2.5.1. Concept and principles of green chemistry *(Scope: concept, principles and practices of green chemistry)* 2.5.2. Nitrogen cycle (*Scope: description of nitrogen cycle, importance of converting nitrogen to ammonia for agriculture).* 2.5.3. Fertilizers *(Scope: sources of fertilizers with examples, uses of fertilizers, environmental*	Predict the reaction of metals with air, water and acids using an activity series of metals. **Asking Questions and Defining Problems** Ask questions and define problems based on the knowledge of reactivity series to design a chemical process to extract a metal from its ore that has been discovered in the locality. **Planning and Carrying Out Investigations** Investigate the ore that is discovered in the locality/investigate . **Constructing Explanation and Designing Solutions** Design a chemical process to extract to a metal from the ore. **Analysing and Interpreting Data** Analyse the data collected from the chemical processes. **Obtaining, Evaluating and Communicating Information** Share the findings to the class. **Asking Questions and Defining Problems** Ask questions and define problems to design a chemical process for producing different types of medals for your school athletes. **Planning and Carrying Out Investigations** Investigate to design a chemical process for producing different types of metals for your school athletes. **Constructing Explanation and Designing Solutions** Design a chemical process for producing different types of medals. **Analysing and Interpreting Data** Analyse the data collected from the chemical processes. **Obtaining, Evaluating and Communicating**	**Digital Resources** Explore the formation of polyethene and PVC using simulation. **Using Physical Tools** Use a periodic table to locate elements which are metals, metalloids and nonmetals based on their characteristic properties. **Exploring Digital Resources** Explore the uses of an activity series of metals. **Exploring Digital Resources** Explore twelve principles of green chemistry in relation to design and processes of

xxiv. Explain global warming using simulation or a model. xxv. Apply the principles of green chemistry to design a Bhutanese house that can keep us warm in winter. xxvi. Research to find out how Bhutan may prepare for the impact of global warming and climate change. xxvii. Explore the adoption of green technologies to reduce the impact on environment due to greenhouse gases.	*consequences of excessive use of fertilizers)* 2.5.4. Carbon Cycle *(Scope: description of carbon cycle, importance and consequence of disturbance to carbon cycle)* 2.5.5. Global Warming *(Scope: greenhouse gases and their importance, explanation of global warming, natural and man-made causes of global warming, effect of global warming, mitigation towards cause of global warming, carbon sequestration)*	**Information** Share the findings to the class. **Engaging in Argument From Evidence** Compare chemical fertilizers and bio fertilizers based on their environmental consequences. **Developing and Using Models** Using the principles of green chemistry, design a Bhutanese house that can keep us warm in winter. **Constructing Explanations and Designing Solutions** Explain the design based on principles of green chemistry. **Asking Questions and Defining Problems** Ask questions to find out how Bhutan may prepare for impact of global warming and climate change **Planning and Carrying Out Investigations** Investigate to find out how Bhutan may prepare for impact of global warming and climate change **Constructing Explanation and Designing Solutions** Review literature and collect data to study the impact of global warming and climate change. **Analysing and Interpreting Data** Analyse the data collected from the investigation. **Obtaining, Evaluating and Communicating Information** Share the findings through different media.	goods that reduce or eliminate the generation of hazardous substances. **Exploring Digital Resources** explain the nitrogen cycle using simulation or a model. **Exploring Digital Resources** Use simulation or a model to explain carbon cycle. **Exploring Digital Resources** Use simulation or a model to explain global warming.

Table 3. *Learning Objectives and Dimension for Patterns in chemistry, class IX*

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explain the variation in the periodic trends across the period and down the group and main features of modern periodic table. ii. Discuss the advantages and limitations of modern periodic table. iii. Create interactive periodic table for the first 20 elements. iv. Study the reaction of group 1 elements with oxygen and water. v. Explore the information on the noble gases and their uses. vi. Discuss the significance and limitations of a chemical equation in relation to chemical reaction. vii. Balance chemical equation using different methods. viii. Design and carry out an experiment to explain the law of conservation of mass. ix. Design and carry out an experiment to explain the rate of reaction in terms of	**3. Patterns in chemistry** **3.1 Periodic Table** 3.1.1 Modern Periodic Table *(Scope: Characteristics of periods and groups, advantages and disadvantages of modern periodic table, and short description of the modern periodic table)* 3.1.2Trends in the modern periodic table *(Scope: Periodicity and causes of periodicity, valence electrons, atomic size, metallic character, ionization enthalpy, electron affinity, and electronegativity)* 3.1.3 Group 1 elements (*Scope: Introduction, electronic configuration, and reaction with oxygen and water)* 3.1.4 Group 18 elements	**Engaging in Argument From Evidence** Discuss the advantages and disadvantages of modern periodic table. **Developing and using models** Create an interactive periodic table for the first 30 elements using any computer software. **Engaging in Argument From Evidence** Discuss the significance and limitations of a chemical equation in relation to chemical reaction. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Balance chemical equations using different methods. **Engaging in Argument From Evidence** Relate collision theory with rate of reaction. **Asking Questions and Defining Problems** Ask questions and define problems to design a chemical process for a pharmaceutical company to optimize the yield of medicine. **Planning and Carrying Investigation** Design a chemical process for a pharmaceutical company to optimize the yield of medicine. **Analysing and Interpreting Data** Analyse the chemical processes to optimise the yield of medicine and interpret the data. **Constructing Explanations and Designing Solutions** Explain the chemical process for optimizing the yield of medicine. **Obtaining, Evaluating and Communicating Information** Share the findings to the class.	**Exploring Digital Resources** Use interactive periodic table to discuss the main features of modern periodic table and the variation in periodic trends across the period and down the group. **Exploring Digital Resources** Explore the reaction of group 1 elements with oxygen and water **Exploring Digital Resources** Explore the periodic properties of group 18 elements **Exploring**

change in mass of reactants or products. x. Deduce the mathematical expression and unit for rate of reaction based on the above experiment and solve the numerical problems. xi. Explain the factors that affect the rate of the chemical reaction by exploring the information through relevant sources. xii. Relate collision theory with the rate of reaction. xiii. Design a chemical process for a pharmaceutical company to optimize the yield of the medicines. xiv. Design and carry out an experiment to identify exothermic and endothermic reactions. xv. Interpret the graphs to explain exothermic and endothermic reactions. xvi. Use the principles of exothermic and endothermic reactions to design a physical model of a hot or cold pack.	*(Scope: Introduction, electronic configuration and uses)* **3.2 Chemical Reactions and Energy Transfer** 3.2.1 Chemical Reactions and Energy Transfer *(Scope: Steps for balancing the chemical equation, law of conservation of mass, significance of chemical equation, limitation of chemical equation, slow and fast reaction with examples, collision theory, rate of a chemical reaction in terms of change in mass of reactant or product factors affecting rate of chemical reaction, thermochemical reaction, definition of exothermic and endothermic reactions with examples and graphs)*	**Asking Questions and Defining Problems** Ask questions and define solutions to design an experiment to identify exothermic and endothermic reactions. **Planning and Carrying Investigation** Design an experiment to carry out and identify exothermic and endothermic reactions. **Analysing and Interpreting Data** Analyse the experiment to identify the exothermic and endothermic reactions. **Constructing Explanations and Designing Solutions** Explain the experimental design with justification and evidence. **Obtaining, Evaluating and Communicating Information** Share the findings to the class **Analyzing and Interpreting Data** Interpret the graph to explain exothermic and endothermic reactions. **Asking Questions and Defining Problems** Ask questions and define problems to design a physical model of hand-warmer/ hot and cold pack **Planning and Carrying Investigation** Design a physical model of hand-warmer/ hot and cold pack using the principles of exothermic and endothermic reaction. **Analysing and Interpreting Data** Analyse the heat content of the model. **Constructing Explanations and Designing Solutions** Explain the heat content of the model and provide evidence. **Obtaining, Evaluating and Communicating Information** Advertise the model through different media.	**Digital Resources** Explore the factors that affect the rate of chemical reaction.

Class-wise Competency (Class X)

By the end of class X, a learner should be able to

1. Classifying Materials

- demonstrate the conceptual understanding of the behaviour of gases and gas laws to relate it to the everyday life.

2. Material and Change

- interpret the chemistry of alcohol to evaluate its impact on health, economy, society, environment, industry and in the field of medicine.
- outline the basic steps of metallurgy to understand the significance of metals and their alloys in contributing towards human welfare, civilization, culture, and the environmental impact.

3. Patterns in Chemistry

- outline the properties of halogens and transition elements to relate their importance in industries, medicine, and other areas of life.
- exhibit the knowledge of mole concept and stoichiometry to quantify the substances in chemical reaction for industries and to carry out quantitative analysis in laboratories.
- relate the fundamental concepts and principles of thermodynamics to understand interconversion of energy and Physical Processes taking place in the universe.

Table 4. *Learning Objectives and Dimensions of Classifying Materials, class X*

Learning Objectives	Core Concepts (Chapter/Topic/Theme)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explore the particle theory and relate it to the behaviour of gases. ii. Explore Boyle's law, Charles' law, Gay-Lussac's law and Avogadro's law to explain the relationship among different variables such as pressure, temperature, volume and number of particles. iii. Design an experiment, formulate data, and represent the result graphically to verify Boyle's	**1. Classifying Materials -** **1.2 Gas Laws** 1.2.1 Particle Theory: (*Scope: statement of particle theory of matter and behaviour of gases)* 1.2.2 Boyle's law *(Scope: statement of Boyle's law, derivation of Bolye's equation, experimental verification of Boyle's law, numerical problems, graphical representation, real-life application of the law)* 1.2.3 Charles' law: (*Scope: statement of Charles' law, derivation of Charles'*	**Asking Questions and Defining Problems** Ask questions and define problems based on gas laws. **Planning and Carrying Out Investigations** Design an experiment to verify gas laws. Using the design, carry out an experiment to verify gas laws. **Analysing and Interpreting Data** Analyse and interpret data collected through experiment. **Constructing Explanations and Designing**	**Exploring Digital Resource** Explore Boyle's law,Charles' law and Avogadro's law to explain the relationship among different variables such as pressure, temperature, volume and number of particles.

law, Charles' law, Gay-Lussac's law, and Avogadro's law. iv. Derive equations for gas laws using mathematical and computational thinking. v. Solve numerical problems using the gas law equations. vi. Use the principles of gas laws to design a device that can be used in your locality. vii. Develop a simulation to demonstrate the behaviour of gas.	*equation, experimental verification of Boyle's law, numerical problems, graphical representation, real-life application of the law*). 1.2.4 Avogadro's law: (*Scope: statement of Avogadro's law, derivation of Avogadro's equation, experimental verification of Avogadro's law, numerical problems, graphical representation, real-life application of the law*). 1.2.5 Ideal gas equation *(Scope: derivation of ideal gas equation and numerical problems).*	**Solutions** Confirm gas law and share findings. **Obtaining, Evaluating, and Communicating Information** Share the design of the experiment to the class through various media. **Using mathematics and computational thinking** Use mathematics and computational thinking to derive equations for gas laws. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Solve numerical problems using the gas law equations	**Promoting Socio-cultural, Economic, Environmental and Human Values** Design a device that can be used in your locality using the principles of gas laws.

Table 5. *Learning Objectives and Dimension for Materials and Change, class X*

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	**Society and Technology**
i. Explain a homologous series of alcohol and functional group to observe a regular pattern in the structure after exploring the information through relevant sources. ii. Classify the alcohol based on the number of hydroxyl group. iii. Design 2D/3D molecular model of alcohol. iv. Use IUPAC rules to name alcohols.	**2. Materials and Change** 2.1 Alcohols 2.1.1Alcohol *(Scope: homologous series and functional group, alcohol as hydroxyl derivatives of alkane, structural representation, classification, nomenclature)* 2.1.2 Properties of alcohol	**Analysing and interpreting Data** Explain a homologous series of alcohol and functional group to observe a regular pattern in the structure. **Developing and Using Models** Design 2D/3D molecular model of an alcohol with its functional group to study the structural formula of alcohol. **Using Mathematics, Information and Computer Technology, and Computational Thinking** use IUPAC rules to name alcohols. **Planning and Carrying Out Investigations** Design an experiment to investigate properties of alcohol **Analysing and Interpreting Data** Analyse and interpret data collected through experiment.	**Exploring Digital tools** Explore a method in which ethanol is made non-consumable to humans through using relevant sources. **Exploring Digital**

v. Design an experiment to investigate the properties of alcohol. vi. Design a breath analyser that may be used by traffic police. vii. Explain the chemistry behind the breath analyser. viii. Formulate a hand sanitizer based on the properties of alcohol. ix. Explain a method in which ethanol is made non-consumable to humans after exploring the information through relevant sources. x. Design an experiment to outline the process for preparation of ethanol. xi. Carry out a case study related to the impact of alcohol on health, economy, society, environment, industry and in the field of medicine. xii. Debate on national policies related to alcohol such as issuance of bar license, sale of alcohol, age limit for drinking, etc. xiii. Advocate on health and social impact of alcohol to educate the community. xiv. Explain the terms metallurgy, ores, minerals, charge, gangue, flux, slag,	*(Scope: physical and chemical properties [combustion, oxidation, esterification, and dehydration] of alcohol)* 2.1.3 Denatured alcohol *(Scope: definition, and identification of alcohol)* 2.1.4 Preparation and uses of ethanol *(Scope: ethanol from starch by fermentation and ethanol from ethene by hydration,and uses).* 2.1.5 Ethanol and its impacts *(Scope: impact on environment, economy, society, and health).* **2.2 Metallurgy** *(Scope: definition of metallurgy, some terminologies such as ores, minerals, charge, gangue, flux, slag, calcination, roasting, basic steps of metallurgy such as dressing of ore, concentration of ores, extraction of metals*	**Constructing Explanations and Designing Solutions** Conclude the properties of alcohols with evidence. **Obtaining, Evaluating and Communicating Information** Share the findings in the class. **Asking Questions and Defining Problems** Ask questions and define problems to design a breath analyzer that can be used by traffic police. **Planning and Carrying Out Investigations** Plan and design breath analyzer **Analysing and Interpreting Data** Analyse the chemical process taking place inside breath analyzer. **Constructing Explanations and Designing Solutions** Explain the working of breath analyser. **Obtaining, Evaluating and Communicating Information** Exhibit the device to the class. **Asking Questions and Defining Problems** Ask questions and define problems to formulate a hand sanitizer that may be used in school. **Planning and Carrying Out Investigations** Plan and design hand sanitizer that may be used in school **Analysing and Interpreting Data** Analyse the formulated hand sanitizer that may be used in school **Constructing Explanations and Designing Solutions** Explain the formulated hand sanitizer. **Obtaining, Evaluating and Communicating Information** Demonstrate for the use to the whole class. **Asking Questions and Defining Problems** Ask questions to design an experiment to outline the process for preparation of ethanol. **Planning and Carrying Out Investigations** design an experiment for preparation of ethanol.	**Resources** Use multimedia tools to create a video for educating the community on health and social impact of misuse of alcohol. **Exploring Digital Resources** Explore the terms metallurgy, ores, minerals, charge, gangue, flux, slag, calcination and roasting to evaluate their significance in the process of extraction of metals. **Using Physical Tools** Use any

calcination and roasting to evaluate their significance in the process of extraction of metals after exploring the information through relevant sources. xv. Explain the steps involved in metallurgy by creating a flowchart using any drawing tools. xvi. Predict reactivity of metals based on the reactivity series. xvii. Design an experiment to demonstrate the electro-refining of metals. xviii. Research on the significance of metals in contributing towards human welfare, civilization, culture, and environment. xix. Explain nano-alloying as an emerging technology. xx. Design a canister for soft drink based on the knowledge of properties of metals/alloys.	*from the concentrated ores, purification of metals including electro-refining, introduction to alloys, nano-alloys, and their uses, significance, and impacts of metals in contributing towards human welfare, civilization, culture and the environment*).	**Analysing and Interpreting Data** Analyse the chemical process taking place. **Constructing Explanations and Designing Solutions** Explain the chemical process for preparation of alcohol. **Obtaining, Evaluating and Communicating Information** Share the findings to the class. **Asking Questions and Defining Problems** Ask questions to explore the uses and impacts of ethanol on social, economy and human health. **Planning and Carrying Out Investigations** Plan to carry out the research. **Analysing and Interpreting Data** Analyse the data collected through the research. **Constructing Explanations and Designing Solutions** construct explanations based on the data analysed **Obtaining, Evaluating and Communicating Information** Share the findings to the class. **Asking Questions and Defining Problems** Ask questions to design an experiment to demonstrate the electro-refining of metals. **Planning and Carrying Investigation** Design an experiment to demonstrate the electro-refining of metals. **Analysing and Interpreting Data** Analyse the chemical process taking place in the electro- refining. **Constructing Explanations and Designing Solutions** Explain the chemical process for electro-refining. **Obtaining, Evaluating and Communicating Information** Share the findings to the class. **Constructing Explanations and Designing Solutions** Carry out a research on the significance of metals in human life and civilization.	drawing to create a flow chart to explain the steps involved in metallurgy.

		Asking Questions and Defining Problems Ask questions and define problems to design a soft drink can. **Planning and Carrying Investigation** Design a soft drink using appropriate metal. **Analysing and Interpreting Data** Analyse drink can designed, suit the properties of metal. **Constructing Explanations and Designing Solutions** Explain the chemical process for designing the soft drink can. **Obtaining, Evaluating and Communicating Information** Exhibit the soft drink can through different media.	

Table 6. *Learning Objectives and Dimension for Patterns in chemistry*, class X

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	**Society and Technology**
i. Describe the variation in periodic properties of halogens using periodic table. ii. Explain the physical properties, chemical properties and uses of halogens using relevant resources. iii. Design an experiment to investigate the displacement reaction of halide salts. iv. Apply the knowledge of halogens to formulate toothpaste. v. Perform qualitative/quantitative	**3. Patterns in Chemistry** **3.1 Patterns in the Periodic Table** 3.1.1 Group 7 - Halogens (F, Cl, Br and I) and Basic information: *(Scope: Occurrence, electronic configuration and stability, safety, and storage)* 3.1.2 Periodic properties: *(Scope: nuclear and effective nuclear charge, atomic size, electronegativity, ionization energy, electron affinity)* 3.1.3 Physical properties: *(Scope: physical state, colour and solubility, density, melting*	**Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate the displacement reaction of halide salts. **Planning and Carrying Out Investigations** Plan and design an experiment. **Analyzing and Interpreting Data** Analyse the experiment designed **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the experiment designed. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Asking Questions and Defining Problems**	**Exploring Digital Resources** se a periodic table to discuss the variation in periodic properties of halogens. **Exploring Digital Resources** Explore the physical and chemical properties and

analysis for iodine in different samples of salts. vi. Research the dietary requirement of iodine for various age group. vii. Explain the electronic configuration of transition elements in s, p, d, f notation after exploring the information through relevant sources. viii. Locate the position of transition elements in the periodic table to relate to their characteristic properties. ix. Explain the characteristics and uses of transition metals after exploring the information through relevant sources. x. Explain the reason for characteristic properties exhibited by transition elements. xi. Perform flame test for transition elements (Fe, Cu, Ni, Mn, Cr and Zn) and relate it to real life application (Miner, Geologist, and Forensic science). xii. Perform alkali test with compounds of Fe, Cu and Zn to examine their properties. xiii. Explore the application, impact, and influence of	*and boiling points, oxidation state).* 3.1.4 Chemical properties: *(Scope: combustibility, as oxidizing and reducing agents, as bleaching agent, displacement reaction, reaction with alkali metals, water, and hydrogen).* 3.1.5 Uses of halogens *(Scope: uses of fluorine, chlorine, bromine, iodine, and astatine).* **3.2 Transition Elements** 3.2.1 Electronic configuration and position in periodic table *(Scope: Electronic configuration in s, p, d, f notation, position in the periodic table)* 3.2.2 Characteristics of transition elements *(Scope: metallic character, melting and boiling points, colour, ionization potential, atomic volume and densities, low reactivity, magnetic properties, variable oxidation state, complex ion formation catalytic properties*). 3.2.3 Reactions involving transition elements: *(Scope: Reaction of Fe, Cu*	Ask questions and define problems to formulate toothpaste that may be used in the school. **Planning and Carrying Investigation** Apply a knowledge of halogens to formulate toothpaste that may be used in the school. **Analysing and Interpreting Data** Analyse the tooth paste formulated and provide chemical processes taking place in tooth enamel. **Constructing Explanations and Designing Solutions** Explain the toothpaste formulated and provide evidence of chemical processes taking place in tooth enamel and safety. **Obtaining, Evaluating and Communicating Information** Exhibit the toothpaste to the class. **Asking Questions and Defining Problems** Ask questions and define problems to perform flame test and alkali test with some compounds of transition elements to draw similarities among transition elements. **Planning and Carrying Out Investigations** Perform flame test and alkali test with some compounds of transition elements to draw similarities among transition elements. **Analysing and Interpreting Data** Analyse the information collected through the investigation. **Constructing Explanations and Designing Solutions** Explain the information collected through the investigation	uses of halogens. **Exploring Digital Resources** Explore the information electronic configuration of transition elements in s, p, d, f notation using relevant sources. **Exploring Digital Resources** Locate the position of transition elements in the periodic table to relate to their characteristic properties. **Exploring Digital Resources** Explore the characteristics of transition metals using relevant sources.

transition elements towards development of human culture and civilization. xiv. Apply the knowledge of properties of transition elements to formulate a catalyst that may be used in industries in Bhutan. xv. Explain relative atomic mass, gram atomic mass, relative molecular mass, Avogadro's number, and number of moles of elements and compounds using relevant mathematical expressions. xvi. Calculate number of moles and number of particles in chemical substances using mathematical data. xvii. Apply the knowledge of stoichiometry to formulate a pharmaceutical product which contains the right proportion of chemical composition xviii. Use mathematical data to calculate percentage composition, empirical formula, and molecular formula. xix. Use balanced chemical equations to calculate mass, volume, and number of particles of chemical substances.	*and Zn with alkali)* 3.2.4 Application: *(Scope: Uses, impact and influence of transition elements towards development of human culture and civilization*). **3.3Chemical Reactions, Conservation of Mass, Mole Concept and Stoichiometry** 3.3.1Terms related to mole concept *(Scope: definition of relative atomic mass, gram atomic mass, relative molecular mass, gram molecular mass, Avogadro's number, mole concept and related numerical problems).* 3.3.2 Percentage composition, empirical formula, and molecular formula (*Scope: definition of percentage composition, empirical formula molecular formula and related numerical problems, differences between empirical formula and molecular formula*). 3.4 Calculation based on chemical reactions: (*Scope: calculations based on mass-mass relationship, mass-*	**Obtaining, Evaluating and Communicating Information** Share the information collected through investigation to the class. **Asking Questions and Defining Problems** Ask questions and define problems to formulate a catalyst that may be used in industries in Bhutan. **Planning and Carrying Out Investigations** Investigate to formulate the catalyst that may be used in the industries of Bhutan **Analysing and Interpreting Data** Analyse the data collected through investigation. **Obtaining, Evaluating, and Communicating Information** Share the catalyst formulated through various media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Explain relative atomic mass, gram atomic mass, relative molecular mass, Avogadro's number and number of moles of elements and compounds using relevant mathematical expressions. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Use mathematical data to calculate number of moles and number of particles in chemical substances. **Using Mathematics, Information and Computer Technology, and Computational Thinking**	**Exploring Digital Resources** Explore the concept and significance of enthalpy, entropy and internal energy to relate to the law of conservation of energy.

xx. Design an experiment to calculate the number of particles in a sample of chemical substance using the knowledge of stoichiometry. xxi. Apply the knowledge of mole concept to calculate the exact amount of nitrogen gas required in the car air bags to protect the driver and the passenger during head on collision. xxii. Use mathematical data to calculate percentage composition, empirical formula, and molecular formula. xxiii. Use balanced chemical equations to calculate mass, volume, and number of particles of chemical substances. xxiv. Design an experiment to calculate the number of particles in a sample of chemical substance using the knowledge of stoichiometry. xxv. Apply the knowledge of mole concept to calculate the exact amount of nitrogen gas required in the car air bags to protect the driver and the passenger during head on collision.	*volume relationship, volume-volume relationship, and mass-number of particles relationship*). 3.4.2 Application: (*Scope: production industries, quantitative analysis in the laboratory, amount of reactants and products*). 3.5 **Energy Transfer in Chemical Reactions** **3.4.1** Internal Energy, Enthalpy and Entropy: (*Scope: description o f Law of conservation of energy, definition of internal energy (E), change in internal energy (ΔE), and sign convention. Definition of enthalpy (H), graphical representation of change of enthalpy, change in enthalpy (ΔH), and sign convention. Definition of entropy (S), change in entropy (ΔS), sign convention and its significance*). **3.4.2** Heat of Reaction: (*Scope: definition of heat of reaction, types of heat of reactions (combustion, neutralization, formation, and stability) with examples, applications of energy change*).	Apply the knowledge of stoichiometry to formulate a pharmaceutical product which contains the right proportion of chemical composition. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Use mathematical data to calculate percentage composition, empirical formula and molecular formula. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Use balanced chemical equations to calculate mass, volume and number of particles of chemical substances. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to calculate the number of particles in a sample of chemical substance using the knowledge of stoichiometry. **Planning and Carrying Out Investigations** Design an experiment to calculate the number of particles in a sample of chemical substance. **Analysing and Interpreting Data** Analyse the information collected through the investigation. **Constructing Explanations and Designing Solutions** Explain the information collected through the investigation. **Using Mathematics, Information and Computer**	

		Technology, and Computational Thinking Apply the knowledge of mole concept to calculate the exact amount of nitrogen gas required in the car air bags to protect the driver and the passenger during head on collision. **Engaging in Argument From Evidence** Analyse the conditions required for sign change with reference to enthalpy and internal energy. **Engaging in Argument From Evidence** Discuss the applications of energy change in daily life.	

11. 2 Key Stage 5 (XI-XII)

Competency-based Standard

By the end of key stage 5 (class XII), a learner should be able to:

1. Classifying Materials

1.1 Apply the concept of ionic equilibria in relation to industries, environment, agriculture, food products and human health.
1.2 Relate the knowledge of Nuclear Chemistry to evaluate the application and impact of nuclear materials with reference to medicine, defense, engineering and source of energy.
1.3 Apply the knowledge of chemical kinetics to evaluate its significance in the field of industry, cosmology, geology, biology, engineering etc.
1.4 Relate the concept of thermodynamics to heat, work and interconversion of energy in understanding the physical and chemical processes taking place in the universe.

2. Materials and change

2.1. Apply the knowledge of organic compounds and their interconversion to relate their importance and impact in daily life.
2.2. Narrate the nutritional value of amino acids to practice healthy dietary habit.

3. Patterns in Chemistry

3.1. Relate the principle of colligative properties to day-to-day applications in improving the quality of life.
3.2. Apply the knowledge of coordination chemistry to enhance the production in industries and understand the functioning of biological systems.
3.3. Apply analytical techniques for qualitative and quantitative analysis in industries, research, space and forensic science.

Class-wise Competency (Class XI)

By the end of class XI, a learner should be able to:

1. Classifying Materials

- Analyse the historical development of different atomic models to interconnect the knowledge in understanding the behaviour of matter and the universe.
- Understand that the bonding of atoms form new substances that have different properties and geometries and significance of bonding in supporting all forms of life.

2. Materials and Change

- apply the knowledge of organic compounds to understand the chemical reactions related to life and the crucial role that the organic compound plays in our daily life.

3. Patterns in Chemistry

- apply the information of the periodic table in the field of material science to understand the properties of elements in designing products and processes.
- use value of oxidation number to predict the reactivity of elements based on loss or gain of electrons by elements.
- apply the knowledge and significance of chemical and phase equilibria in industries, living and non-living systems.

Table 7. *Learning Objectives and Dimension for Classifying Materials, class XI*

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explain the discovery of electrons, protons and neutrons after exploring the	**1. Classifying Materials** **1.1 Atomic structure** 1.1.1 Sub-atomic particles	**Engaging in Argument From Evidence** Compare the properties of electron, proton and	**Exploring Digital Resources** Explore the discovery of

information through relevant sources. ii. Compare the properties of electron, proton and neutron in relation to their charge and mass. iii. Explain the modifications in the theories of atomic structure by designing Thomson's, Rutherford's, and Bohr's atomic models. iv. Compare isotopes, isobars, isotones and isosters in relation to atomic number and atomic mass after exploring the information through relevant sources. v. Narrate the significance of isotopes to day-to-day life. vi. Explain the differences between orbit and orbital using an analogy. vii. Interpret four quantum numbers to evaluate their significance. viii. Explain that the quantum model predicts that electrons do not occupy orbit but orbitals. ix. Construct 2D/3D structure of *s, p* and *d* orbitals to highlight their shapes. x. Write electronic configuration of the given elements using Aufbau's	(*Scope: properties of proton, neutron and electron, discovery of sub- atomic particles, charge on electron 'e/m ratio'*) 1.1.2 Atomic models: (*Scope: Thomson's model of atom, Rutherford's experiment and model, failure of Rutherford's atomic model, Bohr's model of the atom*) 1.1.3 Atomic number and mass number (*Scope: definition of atomic number and mass number, explanation of isotopes, isobars, isotones, isosters with examples*) 1.1.4 Relative atomic mass (*Scope: definition of relative atomic mass based on* C-12 *isotope, calculation of relative atomic mass of an element when relative abundances of its isotopes are given, calculation of relative molecular mass and relative formula mass from atomic masses*) 1.1.5 Concept of atomic orbital (*Scope: definition of orbital, differences between orbit and orbital*) 1.1.6 Quantum numbers (*Scope: description of four quantum numbers - principal quantum number, azimuthal quantum number, magnetic quantum number and spin quantum number, number of orbitals making up s-subshell, p-subshell and d-subshell, and the number of electrons that occupy s-subshell, p-subshell and d-subshell*) 1.1.7 Shapes of orbitals (*Scope: description of shapes of s-orbital, p-orbital and d-orbital*)	neutron in relation to their charge and mass. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Use mathematical data to calculate the relative atomic mass of an element in relation to relative abundance of isotopes. **Engaging in Argument From Evidence** Relate the significance of isotopes to day today life. **Obtaining, Evaluating, and Communicating Information** Use an analogy to explain the differences between orbit and orbital. **Engaging in Argument From Evidence** Interpret four quantum numbers to evaluate their significance. **Developing and Using Models** Construct 2D/3D structure of s-, p- and d–orbitals to highlight their shapes. **Using Mathematics,**	electrons, protons and neutrons. **Using Physical Tools** design Thomson's, Rutherford's, and Bohr's atomic models to explain the modifications in the theories of atomic structure. **Exploring Digital Resources** Explore isotopes, isobars, isotones and isosters in relation to atomic number and atomic mass. **Exploring Digital Resources** Use simulation to explain electrovalent bond and covalent bond with reference to electrovalency and covalency. **Exploring Digital tools** Explore the causes of variable electrovalency, variable covalency and violation of octet

Principle, Pauli's exclusion principle and Hund's rule of maximum multiplicity. xi. Evaluate the importance of atom and atomic structure in explaining the mysteries of life and existence of the universe. xii. Critique any atomic models and put forward a suggestive model. xiii. Explain electrovalent bond and covalent bond with reference to electrovalency and covalency using simulation / video tutorial. xiv. Compare the properties of substances in relation to the nature of bonds such as ionic, covalent and dative bonds. xv. Explain the causes of variable electrovalency, variable covalency and violation of octet rule after exploring the information through relevant sources. xvi. Explore limitations of Lewis concept of covalent bond using relevant sources. xvii. Explain hybridisation of orbitals using an analogy. xviii. Construct 2D/3D structures of molecules to	1.1.8 Energy level diagram for multi-electron atoms *(Scope: description of relative energies of s-orbitals, p-orbitals and d-orbitals for the quantum levels 1, 2, 3 and the 4s- and 4p-orbitals)* 1.1.9 Filling of orbitals (*Scope: statement and application of Aufbau's principle, (n+l) rule, Pauli's exclusion principle, Hund's rule of maximum multiplicity, rule of half-filled and completely-filled orbitals*) 1.1.10 Electronic configuration of elements (*Scope: electronic configurations of the atoms of elements up to atomic number 36*) 1.1.11 Some exceptional electronic configurations (*Scope: study exceptional electronic configuration of elements*) 1.2 **Bonding** 1.2.1 Ionic Bonding (*Scope: types of chemical bond, definition of electrovalent bond, definition of electrovalency, causes of variable electrovalency, general properties of ionic compounds*) 1.2.2 Covalent bonding and dative covalent bonding (*Scope: definition of covalent bonds, Lewis concept, definition of covalency, causes of variable covalency, explanation of violation of octet rule with examples, characteristics of covalent compounds, comparison between the properties of electrovalent and covalent compounds, limitations of Lewis concept of*	**Information and Computer Technology, and Computational Thinking** Use Aufbau Principle,'s Pauli's exclusion principle andHund's rule of maximum multiplicity to write electronic configuration of the given elements. **Engaging in Argument From Evidence** Discuss the importance of atom and atomic structure in explaining the mysteries of life and existence of the universe. **Engaging in Argument From Evidence** compare the properties of substances in relation to the nature of bond such as ionic, covalent and dative bonds. **Obtaining, Evaluating, and Communicating Information** use an analogy to explain hybridisation of orbitals. **Developing and Using Models** construct 2D/3D structures of molecules to explain the shapes of sp, sp^2 and sp^3	rule. **Exploring Digital tools** Explore the limitations of Lewis concept of covalent bond **Explore Digital Tools** Use simulation to explain electronegativity, dipole moment and hydrogen bond. **Exploring Digital Resources** explain the existence of partial covalent character in ionic compounds with reference to Fajan's rule. **Exploring Digital Resources** Explore metallic bond in the light of the electron-sea model by using simulation. **Promoting Socio-cultural, Economic, Environmental**

explain the shapes of sp, sp^2 and sp^3 molecules. xix. Discuss VSEPR theory, VBT and MOT to explain the shape of molecules. xx. Explain electronegativity, dipole moment and hydrogen bond and conditions for formation of hydrogen bond by using simulation /video tutorial. xxi. Calculate the polarity of bond in different molecules to predict their ionic character. xxii. Explain the existence of partial covalent character in ionic compounds with reference to Fajan's rule. xxiii. Explain metallic bond in the light of the electron-sea model by using simulation. xxiv. Explore the historical evolution and properties of metals and their applications with the changing time. xxv. Analyse the causes and the factors determining Van der Waal's force. xxvi. Relate chemical bonds with the properties of substances and their	*covalent bond, definition of coordinate bond with some examples of coordinate molecules, properties of coordinate compounds*) 1.2.3 Shapes of Molecules and Ions Hybridisation of orbitals (*Scope: definition of hybridisation of orbitals, necessary conditions for hybridisation, types of hybridisation-sp, sp^2, sp^3).* 1.1.4 Factors influencing shapes of molecules (*Scope: explanation of type of hybridisation, VSEPR theory, VBT and MOT*) 1.1.5 Shapes of certain molecules (*Scope: explanation of shapes and bond angles in molecules and ions with up to six electron pairs surrounding central atom e.g. BF_3, CH_4, NH_4^+, SF_6, NH_3, H_2O, CO_2, etc. formula for predicting shapes of molecules and their bond angles for other molecules and ions*) 1.1.6 Polar Molecules (*Scope: definition of electronegativity, polarity in covalent bonds, partial ionic character in covalent bond*) 1.1.7 Dipole Moment (*Scope: definition of dipole moment, applications of dipole moment in determining the symmetry of the molecules, the polarity of the bonds and percentage of ionic character*) 1.1.8 Partial Covalent Character in Ionic Compound (*Scope: explanation of partial covalent character in ionic compounds and Fajan's rule*). 1.1.9 Hydrogen Bond (*Scope: definition of hydrogen bond, conditions required for the formation of hydrogen bond,*	molecules. **Engaging in Argument From Evidence** Discuss hybridisation, VSEPR theory, VBT and MOT to explain the shape of molecules. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Calculate the polarity of bond in different molecules to predict their ionic character. **Analyzing and Interpreting Data** Analyse the necessary conditions for formation of hydrogen bond **Constructing Explanations and Designing Solutions** Explain the information collected through the investigation. **Analyzing and Interpreting Data** Relate the significance of hydrogen bond to support different forms of life on the Earth. **Engaging in Argument From Evidence**	**and Human Values** apply the knowledge of properties of metals to design a roof for houses in the locality.

application in material science and significance in life. xxvii. Compare the physical properties of molecules based on strength of Van der Waal's forces.	*types of hydrogen bond with examples, some consequences of hydrogen bonding*). 1.1.10 Metallic Bonding (*Scope: explanation of metallic bond using electron-sea model, properties of metals based on electron-sea model*) 1.1.11 *Van der Waal's forces* (*Scope: definition of Van der Waal's forces, causes of Van der Waal's forces, dipole-dipole interaction, ion-dipole interaction, London forces, factors determining Van der Waal's forces*)	Predict the properties of metals in relation to metallic bond. **Analyzing and Interpreting Data** Analyse and interpret the causes and the factors determining van der Waal's force.	

Table 8: *Learning Objectives and Dimension for Materials and Change, class XI*

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	**Society and Technology**
i. Study the members of different classes of organic compounds to explain homologous series and functional group. ii. Write structural formula of organic compounds and apply IUPAC rules to name them. iii. Explain isomerism in organic compounds using relevant videos or simulation.	2. Materials and Change 2.1. Introduction to Organic Chemistry 2.1.1. Functional Groups (Scope: definition of functional group, names and structures of functional groups) 2.1.2 Homologous Series *(Scope: characteristics of homologous series)* 2.1.3 Nomenclature of	**Analyzing and Interpreting Data** Study the members of different classes of organic compounds to explain homologous series and functional group. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name the different classes of organic compounds. **Developing and Using Models** Construct structural formulas from the IUPAC names of the compounds. **Developing and Using Models**	**Exploring Digital Resources** Explore different types of isomerism existing in organic compounds by using relevant videos or simulation. **Exploring**

iv. Construct 2D/3D structures of different structural and stereo isomers of organic compounds. v. Analyse the significance of structural and stereo isomers in the agrochemical and pharmaceutical industries. vi. Investigate types of organic reactions such as substitution reaction, addition reaction, elimination reaction and rearrangement reaction with relevant examples. vii. Explain the concept of nucleophiles and electrophiles using relevant video or simulation. viii. Compare mechanism of free radical reaction and mechanism of polar reaction. ix. Explain electron displacement effect with reference to inductive effect in organic compounds. x. Differentiate between SN^1 and SN^2 and E^1 and E^2 reactions based on their reaction mechanisms.	Different Classes of Organic Compounds *(Scope: types of nomenclature, common system, IUPAC rule, explanation and examples, General rules for naming organic compounds, nomenclature for branched chain alkanes, nomenclature for unsaturated hydrocarbons, nomenclature for compounds containing one functional group, multiple bonds and substituents, nomenclature for polyfunctional compounds, nomenclature for aromatic compounds, writing structural formulae from the IUPAC name of the compounds).* *2.1.4. Isomerism (Scope: types of isomerism, structural isomerism: chain isomerism, position isomerism, functional isomerism, metamerism, tautomerism, Stereoisomerism: geometry and optical isomerism)*	Construct 2D/3D structures of different structural isomers of organic compounds. **Analyzing and Interpreting Data** Analyse the significance of structural isomers in the agrochemical industries and other areas of life. **Asking Questions and Defining Problems** Ask questions on the type of organic reactions **Planning and Carrying Out Investigations** Carry out investigation on the types of organic reactions. **Analyzing and Interpreting Data** Analyse and interpret the data collected through the investigation **Constructing Explanations and Designing solutions** Construct explanations based on the data interpreted**.** **Evaluating, and Communicating Information** Share the explanation to the class through different media **Constructing Explanations and Designing Solutions** Compare mechanism of free radical reaction and mechanism of polar reaction. **Engaging in Argument From Evidence** Differentiate between SN^1 and SN^2 and E^1 and E^2 reactions based on their reaction mechanisms. **Engaging in Argument From Evidence** Classify hydrocarbons on the basis of structure. **Developing and Using Models** Construct general formula of alkanes, alkenes and alkynes based on their homologous series.	**Digital Resources** Explore the concept of nucleophiles and electrophiles using relevant video or simulation. **Exploring Digital Resources** Explain different terms associated with polymerisation and its classification using relevant sources. **Exploring Digital Resources** Explain addition polymers with relevant examples using relevant sources. **Promoting Socio-cultural, Economic, Environmental**

xi. Classify hydrocarbons based on structure. xii. Construct general formula of alkanes, alkenes and alkynes based on their homologous series. xiii. Compare 2D/3D molecular structures to explain different types of isomerism existing in alkanes, alkenes and alkynes. xiv. Investigate the properties of alkanes, alkenes and alkynes to relate their properties to daily life. xv. Design an experiment to demonstrate the laboratory preparation of acetylene. xvi. Research on the extraction of hydrocarbons from local plants that may be used as fuel. xvii. Apply the knowledge of hydrocarbon combustion to formulate a fuel that is eco-friendly. xviii. Discuss / debate on the policies/resolutions adopted in national and international climate change conferences or summit such as COP26,	*2.1.4 Types of Organic Reactions* *(Scope: definition of substitution reaction, addition reaction, elimination reaction and rearrangement reaction with examples, nucleophiles and electrophiles: definition of nucleophilic reagents or nucleophiles, electrophilic reagents or electrophiles with examples, Mechanism of a free-radical reaction: Explanation of steps of free-radical mechanism using example of chlorination of alkane, Mechanism of a polar reaction: Explanation of steps of SN1, SN2, E1 and E2 reaction mechanism, Electron displacement effect (Inductive effect)).* 2.2 Hydrocarbons 2.2.1 Hydrocarbons *(Scope: Classification of hydrocarbons into cyclic, acyclic, aliphatic and aromatic).* 2.2.2 Alkanes *(Scope: structural isomerism in alkanes,*	**Engaging in Argument From Evidence** Compare 2D/3D molecular structures to explain different types of isomerism existing in alkanes, alkenes and alkynes. **Asking Questions and Defining Problems** Ask questions on the properties of hydrocarbons to relate to daily life. **Planning and Carrying Out Investigations** Carry out an investigation on the properties of hydrocarbons **Analyzing and Interpreting Data** Analyse the data collected through the investigation **Constructing Explanations and Designing Solutions** Construct the explanation on the properties of hydrocarbons and its significance in day to day life **Obtaining, Evaluating, and Communicating Information** Share the explanation through different media. **Asking Questions and Defining Problems** Ask question on extraction of hydrocarbons from local plants that may solve future energy problems. **Planning and Carrying Out Investigations** Carry out research to extract hydrocarbons from local plants that may solve future energy problems. **Analyzing and Interpreting Data** Analyse the data collected through the research **Constructing Explanations and Designing Solutions** Construct explanations and solution through the data analysed. **Obtaining, Evaluating, and Communicating Information** Share the explanation and solution through	**and Human Values** Design a polymer that has a commercial value based on the knowledge of polymer and polymerisation **Exploring Digital Resources** Explain the general mechanism of electrophilic substitution reaction in benzene with relevant examples using illustration. **Exploring Digital Resources** Explain Friedel Craft's alkylation and effect of substituent on orientation and reactivity of benzene. **Promoting Socio-cultural,**

UN conference on climate change, etc. xix. Explain addition polymers with examples using relevant sources. xx. Explain different terms associated with polymerisation and its classification using relevant sources. xxi. Design space suits / fire fighter's gears / scuba diver's suit / bulletproof vest etc., using the knowledge of polymers. xxii. Design a polymer that has a commercial value based on the knowledge of polymer and polymerization. xxiii. Discuss the recent advancement in polymer science. xxiv. Apply IUPAC rules to name alcohols. xxv. Distinguish primary, secondary and tertiary alcohols xxvi. Investigate the chemical properties of alcohol with relevant examples. xxvii. Formulate a chemical combination for a particular brand of alcoholic beverage using	*preparations, physical and chemical properties (oxidation and halogenation), uses and impacts).* 2.2.3 Alkenes *(Scope: isomerism in alkenes, cis- and trans- isomerism in relation to E and Z configuration, preparations, physical properties, chemical properties (electrophilic addition reactions with Br2, H2SO4 and HCl with mechanism, use of Markownikoff's rule in prediction of products in addition reactions), uses and impacts).* 2.2.4 Alkynes *(Scope: isomerism in alkynes, preparations, physical properties, chemical properties (electrophilic addition reaction with H2, Br2 and HCl with mechanism), uses and impacts).* 2.2.5 Polymerisation *(Scope: Classification: Condensation and Addition polymers: Preparation, properties,*	different media. **Asking Questions and Defining Problems** Ask questions to design an automobile engine that can promote complete burning of hydrocarbon. **Planning and Carrying Out Investigations** Plan to design an engine. **Analyzing and Interpreting Data** Analyse the design of the engine **Constructing Explanations and Designing Solutions** Construct explanations and solution through the design. **Obtaining, Evaluating, and Communicating Information** Share the design and solution through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name alcohols. **Engaging in Argument From Evidence** Distinguish primary, secondary and tertiary alcohols **Analyzing and Interpreting Data** Investigate the chemical properties of alcohol with relevant examples. **Asking Questions and Defining Problems** Ask questions on formulating a chemical combination for a particular brand of alcoholic beverage using the knowledge of properties of alcohol, quantitative and qualitative analysis. **Planning and Carrying Out Investigations** Plan and carry out an investigation to formulate an alcohol. **Analyzing and Interpreting Data** Analyse and interpret the data collected from the investigation.	**Economic, Environmental and Human Values** Write a report on the health risk associated with benzene. **Promoting Socio-cultural, Economic, Environmental and Human Values** Relate the significance of phenol to health and medicine.

the knowledge of properties of alcohol and quantitative and qualitative analysis. xxviii. Critique on the national and international policies on use of alcohol related to youth, culture, environment, health and economy. xxix. Construct 2D/3D model of benzene molecule to explain its structure using ChemDraw or any other image editing software. xxx. Explain the general mechanism of electrophilic substitution reaction in benzene with relevant examples using illustration. xxxi. Explain Friedel Craft's alkylation, acylation and effect of substituent on orientation and reactivity of benzene. xxxii. Apply IUPAC rules to name benzene and its derivatives. xxxiii. Design an experiment to explain the preparation of phenol. xxxiv. Design an experiment to explain the reactions of phenol with dilute and	*uses and impacts (Polyethene, PTFE, PVC, Polystyrene, Melamine and Bakelite)).* **2.3 Alcohols** *(Scope; nomenclature of alcohols, primary, secondary and tertiary alcohols, structure of alcohols, oxidation of alcohols, dehydration of alcohol in the presence of acid catalyst, uses and implications of alcohol).* **2.4 Aromatic Compounds** *2.4.1 Benzene* *(Scope: structure and bonding: Kekule's structure, drawbacks of Kekule's structure, molecular orbital structure, evidence in support of molecular orbital structure, electrophilic substitution reaction of arenes, General mechanism of electrophilic substitution, reaction of arenes with concentrated nitric acid in the presence of sulphuric acid, reaction of arenes with a halogen, Friedel-Crafts alkylation and*	**Constructing Explanations and Designing Solutions** Construct an explanation and solution through the data interpreted. **Obtaining, Evaluating, and Communicating Information** Share the information through different media. **Developing and Using Models** Construct a 2D/3D model of a benzene molecule to explain its structure. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name phenol and its derivatives. **Developing and Using Models** Design an experiment to explain the preparation of phenol. **Analyzing and Interpreting Data** Analyse the data collected through the design. **Constructing Explanations and Designing Solutions** Construct an explanation on preparation of phenol **Obtaining, Evaluating, and Communicating Information** Share the experimental design to the class. **Developing and Using Models** Design an experiment to explain the reaction of phenol dilute and concentrated nitric acids, and Kolbe's reaction. **Analyzing and Interpreting Data** Analyse the data collected through the design. **Constructing Explanations and Designing Solutions** Construct an explanation on reactions of phenol	

concentrated nitric acids, and Kolbe's reaction. xxxv. Relate the significance of benzene and phenol to health and medicine. xxxvi. Write a report on the health risk associated with benzene and phenol. xxxvii. Carry out qualitative analysis to identify aromatic compounds in some local plants that have commercial values.	*acylation, importance of Friedel-Crafts reaction in organic synthesis such as manufacture of polystyrene, effects of substituents on orientation and reactivity of benzene ,uses and implications)* **2.4.2 Phenol** *(Scope: nomenclature, structure, general methods of preparation, industrial preparation, , reactions with dilute and concentrated nitric acid, Kolbe's reaction ,uses and implications)*	dilute and concentrated nitric acids, and Kolbe's reaction **Obtaining, Evaluating, and Communicating Information** Share the experimental design to the class. **Asking Questions and Defining Problems** Qualitative analysis to identify aromatic compounds in local plants that have medicinal values. **Planning and Carrying Out Investigations** Visit your locality to find out plants that have medicinal values for qualitative analysis. **Analyzing and Interpreting Data** Study the plant and carry out analysis to identify aromatic compounds. **Constructing Explanations and Designing Solutions** Construct the explanation on qualitative analysis of aromatic compounds present in local plants. **Obtaining, Evaluating, and Communicating Information** Share the explanation through different media.	

Table 9: *Learning Objectives and Dimensions for Patterns in Chemistry, class XI*

Learning Objectives	Core Concepts (Chapter/Topic/Theme	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Classify elements as s-block, p-block, d-block and f-block elements	3.1. Periodic Table 3.1.1 Classification of Elements *(Scope: classification of*	**Engaging in Argument From Evidence** Use electronic configuration to classify elements as s- block, p-block, d-block and f-block elements. **Using Mathematics, Information and Computer**	**Exploring Digital Resources** Discuss the

using electronic configuration. ii. Predict the period, group and block for elements using mathematical formula. iii. Interpret the given mathematical data to analyse the variation of atomic radii, ionisation energy and electronegativity of elements in the periodic table. iv. Discuss the factors affecting ionisation energy of elements by using relevant sources. v. Justify the variation in melting and boiling points of elements in the second period and third period. vi. Explain the periodic properties of elements using online interactive periodic table. vii. Create an interactive periodic table by applying the knowledge of periodic properties of elements. viii. Predict the properties of elements that are yet to be discovered by applying the knowledge	*elements as s, p, d and f block elements, prediction of period, group and block for elements based on electronic configuration)* 3.1.2 Periodic properties *(Scope: atomic radius: covalent radius, Van der Waals' radius, metallic radius, Variation of atomic radii, comparison of the ionic and atomic radii, Ionization enthalpy: definition of first ionisation energy and successive ionisation energies, variation of ionisation energy in the periodic table, factors on which ionisation energy depends, electronegativity: variation of electronegativity in period and group, melting point and boiling point: trends in melting and boiling points of elements in the second period and third period)* **3.2. Oxidation Number** 3.2.1 Redox reactions and oxidation number *(Scope: electronic concept*	**Technology, and Computational Thinking** Predict the period, group and block for elements using formulas. **Analyzing and Interpreting Data** Interpret the given mathematical data to analyse the variation of atomic radii and ionisation energy of elements in the periodic table. **Engaging in Argument From Evidence** Justify the variation in melting and boiling points of elements in the second period and third period. **Analyzing and Interpreting Data** Predict the properties of elements that are yet to be discovered by applying the knowledge of periodic trends of elements. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to identify reducing and oxidising agents. **Planning and Carrying Out Investigations** Plan to design an experiment. **Analyzing and Interpreting Data** Analyse the design of the experiment. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the design of the experiment. **Obtaining, Evaluating, and Communicating Information** Share the design of the experiment to the class through different media. **Asking Questions and Defining Problems** Ask questions and define problems to design a simulation to explain the reversible reactions **Planning and Carrying Out Investigations** Plan to design a simulation.. **Analyzing and Interpreting Data**	factors affecting ionisation energy of elements by using relevant sources. **Carrying out STEM Activities** Apply the knowledge of periodic table to create an interactive periodic table using multimedia. **Exploring Digital Resources** Watch a video on the concept of oxidation number and the steps to calculate oxidation number. **Exploring Digital Resources** Explore examples and characteristics of physical changes in equilibrium by observing the natural phenomena in the surrounding.

of periodic trends of elements and propose their position in the periodic table. ix. Formulate a nano-compound that may be used in the field of technology, industries and medicine. x. Calculate the oxidation number of elements, compounds and ions. xi. Design and carryout an experiment to identify reducing and oxidising agents. xii. Predict the feasibility of reaction based on redox reaction. xiii. Explore the applications of redox reactions in daily life. xiv. Explain reversible reactions by designing the simulation / video. xv. Explore examples and characteristics of physical changes in equilibrium by observing the natural phenomena in the surrounding. xvi. Demonstrate the features of chemical	*of oxidation and reduction: explanation of electronic concept of oxidation and reduction, Redox reactions: explanation of redox reactions with examples, definition of oxidising agent and reducing agent based on electronic concept, identification of oxidising and reducing agents in redox reactions, rules for oxidation number: definition of oxidation number, rules for assigning oxidation numbers to atoms in elements, compounds and ions, oxidation number and nomenclature, definition of oxidation and reduction in terms of oxidation number and applications).* **3.3. Chemical Equilibria** 3.3.1 Concept and laws of chemical equilibrium *(Scope: reversible reactions, Explanation of reversible reactions with examples, Equilibria involving physical changes: Examples of*	Analyse the design of the simulation.. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the design of the simulation. **Obtaining, Evaluating, and Communicating Information** Share the design of the simulation to the class through different media. **Asking Questions and Defining Problems** Ask questions and define problems to design a simulation to demonstrate the features of chemical equilibrium. **Planning and Carrying Out Investigations** Plan to design a simulation. **Analyzing and Interpreting Data** Analyse the design of the simulation. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the design of the simulation. **Obtaining, Evaluating, and Communicating Information** Share the design of the simulation to the class through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Deduce expression for law of chemical equilibrium and equilibrium constant from law of mass action by using mathematical tool. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Solve numerical problems by applying the expression of equilibrium constant or law of equilibrium. **Asking Questions and Defining Problems** Ask questions and define problems to design an	

equilibrium by designing a simulation/video. xvii. Deduce mathematical expression for law of chemical equilibrium and equilibrium constant from law of mass action. xviii. Solve numerical problems by applying the expression of equilibrium constant or law of equilibrium. xix. Design and carryout an experiment to verify Le Chatelier's principle. xx. Design a model of a chemical process for an industry to optimise the product and save time using the knowledge of chemical equilibrium. xxi. Analyse the biological significance of chemical equilibrium. xxii. Determine the phase, components and degree of freedom of the system using Gibbs' phase rule. xxiii. Compare true equilibrium and metastable equilibrium with examples.	*physical changes in equilibrium, general characteristics of equilibria involving Physical Processes, Equilibria in chemical process: Dynamic equilibrium: Explanation of dynamic nature ofchemical reaction in equilibrium, Concept of chemical equilibrium: Explanation of concept of chemical equilibrium using graph and examples, main features of chemical equilibrium, Law of chemical equilibrium from law of mass action: Deduction of expression for law of chemical equilibrium from law of mass action, deduction of expressions for equilibrium constant 'KC' and 'Kp' for homogenous and heterogeneous reactions, relation between KC and Kp, units and calculations of KC and Kp, Le Chatelier's principle: Effects of change in concentration, pressure and temperature on the position of*	experiment to demonstrate Le Chatelier's principle. **Planning and Carrying Out Investigations** Plan to design an experiment to demonstrate Le Chatelier's principle. **Analyzing and Interpreting Data** Analyse the design of the experiment to demonstrate Le Chatelier's principle. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on experiment on Le Chatelier's principle **Obtaining, Evaluating, and Communicating Information** Share the design of the experiment to the class through different media. **Asking Questions and Defining Problems** Ask questions and define problems to design a chemical process for industry to optimise the product and save time using the knowledge of chemical equilibrium. **Planning and Carrying Out Investigations** Plan to design an experiment. **Analyzing and Interpreting Data** Analyse the design of the experiment. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the design of the experiment. **Obtaining, Evaluating, and Communicating Information** Share the design of the experiment to the class through different media. **Analyzing and Interpreting Data** Analyse the biological significance of chemical equilibrium. **Analyzing and Interpreting Data**	

xxiv. Explain the phase diagram of the water system by constructing a model. xxv. Analyse the relationship between vapour pressure and boiling point of a substance. xxvi. Interpret Raoult's law to explain the lowering of vapour pressure due to the presence of non-volatile solute. xxvii. Construct a model of a cooking system for domestic use based on the principles of Raoult's law. xxviii. Design an experiment to investigate the properties of ideal and non-ideal solutions. xxix. Interpret graphs to explain positive and negative deviations from an ideal solution in terms of intermolecular forces. xxx. Construct vapour pressure and	*equilibrium in homogeneous reactions and applications).* **3.4. Phase Equilibria** 3.4.1 Phase and phase Diagram *(Scope: Explanation of the terms phase, components and degree of freedom with examples, Equilibrium: Definition of true equilibrium and metastable equilibrium with examples, Phase diagram: Explanation of phase diagram, definition and representation of invariant system, univariant system and bivariant system in phase diagram, Phase diagram of water system: Interpretation of phase diagram of water system)* *3.4.2 Vapour Pressure, Law of Vapour Pressure and Law of Partial Pressure.* *(Scope:Vapour pressure of a liquid: Definition of vapour pressure of liquid, Raoult's law: Statements and expressions of Raoult's law for dilute*	Determine the phase, components and degree of freedom of the system using Gibbs' phase rule. **Engaging in Argument From Evidence** Compare true equilibrium and metastable equilibrium using examples. **Developing and Using Models** Explain the phase diagram of the water system by constructing a model. **Analyzing and Interpreting Data** Analyse the relationship between vapour pressure and boiling point. **Analyzing and Interpreting Data** Interpret Raoult's law to explain the lowering of vapour pressure due to the presence of non-volatile solute. **Developing and Using Models** Construct a model of a cooking system for domestic use based on the principles of Raoult's law. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate the properties of ideal and non- ideal solutions. **Planning and Carrying Out Investigations** Plan to design an experiment. **Analyzing and Interpreting Data** Analyse the design of the experiment. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the design of the experiment. **Obtaining, Evaluating, and Communicating Information** Share the design of the experiment to the class through different media. **Analyzing and Interpreting Data**	

composition curves based on the concept of Raoult's law and Dalton's law of partial pressures. xxxi. Design and carry out an experiment to investigate the properties of azeotropes. xxxii. Relate the knowledge of vapour pressure and boiling point to explain fractional distillation. xxxiii. Apply the knowledge of fractional distillation to construct a physical model of fractionating column that may be used in the industries.	*solutions of non-volatile solutes, expression for relative lowering of vapour pressure, numerical problems, Dalton's law of partial pressure: Statement and expression of Dalton's law of partial pressure).* 3.4.3 Ideal and non-ideal solutions *(Scope: Explanation of ideal and non-ideal solutions using vapour pressure-composition curves, explanation of negative and positive deviations from ideal solution, Azeotropes: Definition of azeotropes, explanation of types of azeotropes with examples, Fractional distillation: Explanation of principle of fractional distillation for ideal solution) and applications).*	Interpret graphs to explain positive and negative deviations from an ideal solution in terms of intermolecular forces. **Developing and Using Models** Construct vapour pressure and composition curves based on the concept of Raoult's law and Dalton's law of partial pressures. **Asking Questions and Defining Problems** Ask questions and define problems to experiment to investigate the properties of azeotropes **Planning and Carrying Out Investigations** Plan to design an experiment to investigate the properties of azeotropes. **Analyzing and Interpreting Data** Analyse the design to investigate the properties of azeotropes.. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the experiment to investigate the properties of azeotropes. **Obtaining, Evaluating, and Communicating Information** Share the design of the experiment to investigate the properties of azeotropes. **Analyzing and Interpreting Data** Relate the knowledge of vapour pressure and boiling point to explain fractional distillation. **Developing and Using Models** Apply the knowledge of fractional distillation to construct a physical model of fractionating column that may be used in the local industries.	

Class-wise Competency (Class XII)

By the end of class XII, a learner should be able to:

1. Classifying Materials

- apply the concept of ionic equilibria in relation to industries, environment, agriculture, food products and human health.
- relate the knowledge of Nuclear Chemistry to evaluate the application and impact of nuclear materials with reference to medicine, defence, engineering and source of energy.
- apply the knowledge of chemical kinetics to evaluate its significance in the field of industry, cosmology, geology, biology, engineering etc.
- relate the concept of thermodynamics to heat, work and interconversion of energy in understanding the physical and chemical processes taking place in the universe.

3. Material and Change

- apply the knowledge of organic compounds and their interconversion to relate their importance and impact in daily life.
- narrate the nutritional value of amino acids to practice healthy dietary habit.

3. Patterns in Chemistry.

- Relate the principle of colligative properties to day-to-day applications in improving the quality of life.
- Apply the knowledge of coordination chemistry to enhance the production in industries and understand the functioning of biological systems.
- Apply analytical techniques for qualitative and quantitative analysis in industries, research, space and forensic science.

Table 10: *Learning Objectives and Dimension for Materials and Change, class XII*

Learning Objectives		Process/Essential Skills	
	Core Concepts	Scientific Methods and Engineering	Society and Technology

i. Write structural formula of carbonyl compounds and apply IUPAC rules to name them. ii. Design an experiment to carry out the preparation of aldehydes and ketones. iii. Design experiments to investigate the physical and chemical properties of aldehydes and ketones.	**2. Materials and Change** **2.1. Carbonyl Compounds** 2.1.1. Nomenclature of carbonyl compounds *(Scope: common naming system and IUPAC system of aldehydes (formaldehyde, acetaldehyde, benzaldehyde) and ketones (acetone)*). 2.1.2. Preparation and Properties of Carbonyl Compounds *(Scope: preparation of aldehydes: formaldehyde from methanol, acetaldehyde from ethanol, benzaldehyde from toluene,*	**Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name carbonyl compounds. **Asking Questions and Defining Problems** Ask questions and define problems on preparation of aldehydes and ketones.. **Planning and Carrying Out Investigations** Plan and carry out the experiment on preparation of aldehyde and ketones. **Analyzing and Interpreting Data** Analyse and confirm the product obtained. **Constructing Explanations and Designing Solutions** Construct explanations from the experiment on preparation of aldehyde and ketones. **Obtaining, Evaluating, and Communicating Information** Share the information through discussion in the class	**Exploring Digital Resources** Explore properties and uses of carbonyl compounds using relevant sources. **Exploring Digital Resources** Explore uses of carboxylic acids using relevant sources.

iv. Design 3D model of any carbonyl compounds using ICT or any other materials. v. Explore the uses of aldehydes and ketones using relevant sources. vi. Research to extract chemical substances containing aldehydes from local plants that can be used as preservatives, insecticides, perfumes and vaccines. vii. Analyze the presence of formaldehyde in dry fish, vegetables and other products and find its impact on health. viii. Write the structural formula and apply IUPAC rules to name carboxylic acids.	*Physical properties of aldehydes: Physical state, colour, odour, solubility, melting points and boiling points, polar nature of carbonyl group, dipole moment of aldehyde, Chemical properties of aldehydes: Oxidation of aldehydes with acidified $K_2Cr_2O_7$, Tollen's reagent and Fehling's solution, reduction of aldehydes with $NaBH_4$, addition reaction of aldehydes with HCN, Cannizzaro reaction (formaldehyde and benzaldehyde), Iodoform test for aldehydes, uses of aldehydes, preparation of ketones: acetone from isopropyl alcohol, physical properties of ketones: Physical state, colour, odour, solubility, melting points and boiling points, polar nature of carbonyl group, dipole moment of ketones, chemical properties of ketones: reduction of ketones with $NaBH_4$,*	**Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate the physical and chemical properties of aldehydes and ketones. **Planning and Carrying Out Investigations** Plan to carry out investigation on the physical and chemical properties of the aldehydes and ketones. **Analyzing and Interpreting Data** Analyse and interpret the experimental design. **Constructing Explanations and Designing Solutions** Construct an explanation based on the design of the experiment. **Obtaining, Evaluating, and Communicating Information** Share the information to the class using different media. **Asking Questions and Defining Problems** Ask questions and define problems to extract insecticide from local plants that contain aldehydes. **Planning and Carrying Out Investigations** Plan and carry out the research to extract insecticide from local plants that contain aldehyde. **Analyzing and Interpreting Data** Analyse the data collected from the research. **Constructing Explanations and Designing Solutions** Construct explanations from the data analysed and design a solution based on the research on insecticide. **Obtaining, Evaluating, and Communicating Information** Share the information through different media.	**Exploring Digital Resources** explore the uses of carboxylic derivatives through relevant sources. **Promoting Socio-cultural, Economic, Environmental and Human Values** Design a prototype to produce biofuel from local organic waste that may solve energy problems in the locality. **Promoting Socio-cultural, Economic, Environmental and Human Values**

ix. Explore and design an experiment to prepare carboxylic acids. x. Correlate the variation in physical properties of carboxylic acids with their structure. xi. Compare the relative strength of different carboxylic acids. xii. Design and carry out an experiment to extract vinegar from fruits that contain acetic acid and explore its uses. xiii. Write structural formula and apply IUPAC rules to name derivatives of carboxylic acid. xiv. Design an experiment to prepare derivatives of carboxylic acids. xv. Design an experiment to investigate the physical and chemical properties	*addition reaction of ketones with HCN, Iodoform test for ketones, uses of ketone compounds*). **2.2. Carboxylic Acids** 2.2.1. Nomenclature of carboxylic acids *(Scope: common naming system and IUPAC system (formic acid, acetic acid, benzoic acid and oxalic acid).* 2.2.2.Preparation and Properties of carboxylic acids *(scope: preparation of formic acid from methanol, preparation of acetic acid from ethanol, preparation of oxalic acid from cane sugar, preparation of benzoic acid from benzyl alcohol, physical properties of carboxylic acid: physical state, colour, odour, solubility in water due to*	**Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name carboxylic acids. **Asking Questions and Defining Problems** Ask questions to design an experiment to demonstrate the preparation of carboxylic acids. **Planning and Carrying Out Investigations** Plan to design an experiment to demonstrate the preparation of carboxylic acids. **Analyzing and Interpreting Data** Analyse the experimental design to demonstrate the preparation of carboxylic acid. **Constructing Explanations and Designing Solutions** Construct an explanation from the experimental design. **Obtaining, Evaluating, and Communicating Information** Share the experimental design to the class through different media. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate the physical and chemical properties of carboxylic acid **Planning and Carrying Out Investigations** Plan to design an experiment to investigate the physical and chemical properties of carboxylic acid. **Analyzing and Interpreting Data** Analyse and interpret the experimental design. **Constructing Explanations and Designing Solutions**	Evaluate the environmental significance of biofuel. **Exploring Digital Resources** Explore the uses and the factors affecting the basic strength of amines. **Exploring Digital Resources** Examine the optical properties and amphoteric nature of amino acids in relation to its biological significance.

of derivatives of carboxylic acids. xvi. Explore the uses of carboxylic acid derivatives through relevant sources. xvii. Study the chemical composition in the different types of soap samples available in the market to compare the quality of the product. xviii. Apply the knowledge of the chemical composition and saponification to prepare a soap sample that may be used in a community. xix. Research on the quality of fats consumed by Bhutanese to assess the health risk associated with fats.	*hydrogen bonding, boiling points and melting points of carboxylic acid, chemical properties of carboxylic acid: neutralisation reaction of carboxylic acids with NaOH, Na_2CO_3 and $NaHCO_3$, esterification reaction with ethanol, uses of carboxylic acids*). **2.3. Carboxylic Acid Derivatives** 2.3.1 Acyl halides-Acetyl Chloride *(Scope: nomenclature: common naming system and IUPAC naming system of acyl halides, preparation of acetyl chloride: from glacial acetic with PCl_5 and $SOCl_2$, Physical properties of acetyl chloride: Physical state, smell, solubility and boiling point, Chemical properties of acetyl chloride: mechanism of nucleophilic addition elimination reaction, hydrolysis, alcoholysis,*	Construct an explanation based on the design of the experiment. **Obtaining, Evaluating, and Communicating Information** Share the information to the class using different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name derivatives of carboxylic acid. **Asking** **Questions and Defining Problems** Ask questions to design an experiment to demonstrate the preparation of derivatives of carboxylic acids. **Planning and Carrying Out Investigations** Plan to design an experiment to demonstrate the preparation of derivatives of carboxylic acids. **Analyzing and Interpreting Data** Analyse the experimental design to demonstrate the preparation of derivatives of carboxylic acid. **Constructing Explanations and Designing Solutions** Construct an explanation from the experimental design. **Obtaining, Evaluating, and Communicating Information** Share the experimental design to the class through different media. **Asking Questions and Defining Problems** Ask questions to investigate the physical and chemical properties of derivatives of carboxylic acids. **Planning and Carrying Out Investigations**	

xx. Design a prototype to produce biofuel from oils, fats and local organic waste that may solve energy and environmental problems. xxi. Use 2D/3D molecular models to compare aliphatic amines such as primary, secondary and tertiary amines and aromatic amines. xxii. Design an experiment to demonstrate the preparation of amines. xxiii. Design experiments to investigate the physical and chemical properties of amines. xxiv. Explore the uses and the factors affecting the basic strength of amines.	*ammonolysis, reaction with ethyl amine, uses of acetyl chloride*). 2.3.2 Esters- ethyl acetate *(Scope: common naming system and IUPAC naming system of esters, Preparation of ethyl acetate: From glacial acetic and ethanol in the presence of conc. H_2SO_4, Physical properties of ethyl acetate: Physical state, boiling point and solubility, Chemical properties of ethyl acetate: Hydrolysis in acidic and alkaline medium, saponification, uses of ethyl acetate)* 2.3.3 Fats and Oils (*Scope: definition of saturated and unsaturated fats, health risk of saturated fats, Biodiesel: Manufacture of biodiesel from reaction between carboxylic acid and methanol)* 2.3.4 Alkanamides-Acetamide	Plan to design an experiment to investigate the physical and chemical properties of derivatives of carboxylic acids. **Analyzing and Interpreting Data** Analyse the experimental design to investigate the physical and chemical properties of derivatives of carboxylic acids. **Constructing Explanations and Designing Solutions** Construct an explanation from the experimental design. **Obtaining, Evaluating, and Communicating Information** Share the experimental design to the class through different media. **Analyzing and Interpreting Data** study the chemical composition in the different types of soap samples available in the market to compare the quality of the product. **Asking Questions and Defining Problems** Ask questions to prepare a soap based on the knowledge of saponification that can be used in a community. **Planning and Carrying Out Investigations** Plan to prepare a soap using the knowledge of saponification. **Analyzing and Interpreting Data** Analyse the soap prepared. **Constructing Explanations and Designing Solutions** Construct an explanation for the soap prepared. **Obtaining, Evaluating, and Communicating Information**	

xxv. Apply the knowledge of factors affecting basic strength of amines to compare the basicity of different amines. xxvi. Outline the importance of amines in pharmaceutical industries. xxvii. Use 2D/3D molecular model of amino acid to explain the structure of amino acids. xxviii. Apply common and IUPAC naming system for amino acids. xxix. Examine the optical properties and amphoteric nature of amino acids in relation to its biological significance.	(*Scope: nomenclature: common naming system, IUPAC naming system of alkanamides, Preparation of acetamide: distillation of ammonium acetate in presence of glacial acetic acid, Physical properties of acetamide: Physical state, solubility, odour, melting and boiling points, Chemical properties of acetamide: Hydrolysis in acidic medium and alkaline medium, reduction in presence of sodium-metal and absolute alcohol, Hoffman's degradation reaction and its significance in organic synthesis, uses of acetamide)* **2.4 Amines** 2.4.1. Classification and nomenclature of Amines *(Scope: Classification of amines:aliphatic amines, aromatic amines, Nomenclature of amines:Common naming*	Advertise the soap through different media. **Asking Questions and Defining Problems** Ask questions to research the quality of fats consumed by Bhutanese and analyse the health risk associated with fats. **Planning and Carrying Out Investigations** Plan to carry out the investigation **Analyzing and Interpreting Data** Analyse the data collected through the investigation. **Constructing Explanations and Designing Solutions** Construct an explanation and design a solution based on the data analysed. **Obtaining, Evaluating, and Communicating Information** Share the information through different media. **Developing and Using Models** Use 2D/3D molecular models to compare aliphatic amines such as primary, secondary and tertiary amines and aromatic amines. **Asking Questions and Defining Problems** Ask questions to design an experiment to explain the preparation of amines. **Planning and Carrying Out Investigations** Plan to design an experiment to explain the preparation of amines. **Analyzing and Interpreting Data** Analyse and interpret the experimental design. **Constructing Explanations and Designing Solutions**	

xxx.	Research to find out amino acid deficiency symptoms among local population in connection to vegetarian diet to prepare a news report.	*amines: common naming system, IUPAC naming system).* 2.4.2. Preparation and properties of Amines *Scope: preparation of amines: Preparation of methyl amine from methyl iodide in excess of alcoholic ammonia, preparation of ethylamine from ethane nitrile, preparation of aniline from nitrobenzene, Physical properties: Physical state, colour, odour, solubility and boiling point, Chemical properties: Reaction of amines with water and acids, factors affecting basic strength of amines, basic strength among ammonia, primary aliphatic amine and primary aromatic amine, uses of amines).*	Construct an explanation based on the design of the experiment. **Obtaining, Evaluating, and Communicating Information** Share the information to the class using different media. **Constructing Explanations and Designing Solutions** Design experiments to investigate the physical and chemical properties of amines. **Analyzing and Interpreting Data** Apply the knowledge of factors affecting basic strength of amines to compare the basicity of different amines. **Constructing Explanations and Designing Solutions** Outline the importance of amines in pharmacological industries. **Developing and Using Models** Use 2D/3D molecular model of amino acid to explain the structure of amino acids. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply common and IUPAC naming system for amino acids. **Asking Questions and Defining Problems** Ask questions to carry out the investigation of the amphoteric nature of amino acids. **Planning and Carrying Out Investigations** Plan to investigate the amphoteric nature of amino acids. **Analyzing and Interpreting Data**	

	2.5 Amino Acids *(Scope: general structure and formula of amino acids, nomenclature of amino acids: common naming system, IUPAC naming system, optical properties: optical activity of amino acids, zwitter ion: definition of zwitter ion, formation of zwitter ion in neutral aqueous solution, amphoteric character of amino acids, migration of zwitter ion in acidic and basic medium, definition of isoelectric point and characteristics of isoelectric point)*	Analyse and interpret the data collected through the investigation. **Constructing Explanations and Designing Solutions** Construct an explanation based on data collected. **Obtaining, Evaluating, and Communicating Information** Share the information to the class using different media. **Asking Questions and Defining Problems** Ask questions to research on amino acid deficiency symptoms among Bhutanese population in connection to vegetarian diet. **Planning and Carrying Out Investigations** Plan to carry out the research. **Analyzing and Interpreting Data** Analyse and interpret data collected through the investigation. **Constructing Explanations and Designing Solutions** Construct an explanation based on the data analysed. **Obtaining, Evaluating, and Communicating Information** Share the information using different media.	

Table 11: *Learning Objectives and Dimensions for Patterns in Chemistry.*

Learning Objectives (KSVA)	Core Concepts (Chapter/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering	**Society and Technology**
i. Deduce the units of molarity, molality, normality and mole fraction for expressing concentration of the solution. ii. Solve numerical problems related to concentration of solutions and colligative properties. iii. Design and carry out an experiment to prepare standard solutions that can be used in the laboratory based on the principles of molarity, molality and normality. iv. Determine relative molecular mass (RMM) of solute using colligative properties. v. Formulate a car coolant, which does not freeze in winter based on the principles of colligative properties.	**3.Patterns in Chemistry** **3.1 Colligative Properties** 3.1.1 Concentration units of solution *(Scope: definition, expression and units of normality, molarity, molality and mole fraction, related numerical problems).* 3.1.2 Colligative properties of solution *(Scope: relative lowering of vapour pressure: Effect of presence of solute in a solution on vapour pressure, expression of Raoult's law, determination of RMM, related numerical*	**Analyzing and Interpreting Data** Compare molarity, molality, normality and mole fraction as different units for expressing the concentration of solutions. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Deduce units of molarity, molality, normality and mole fraction from their respective formulas. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply mathematical expressions and relevant data to solve problems related to concentration of solutions. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Establish the relationship between molarity and normality. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to prepare standard solutions that can be used in the laboratory based on the principles of molarity, molality and normality. **Planning and Carrying Out Investigations**	**Exploring Digital Resources** Explain ionic equilibrium and dissociation of electrolytes using simulation. **Exploring Digital Resources** Explore factors that affect the degree of dissociation using relevant sources. **Exploring Digital Resources** Explore Bronsted- Lowry

vi. Design a chemical process to show impact of colligative properties on taste and quality of food. vii. Explain ionic equilibrium and dissociation of electrolytes using simulation. viii. Deduce the mathematical expression for degree of dissociation. ix. Explore factors that affect the degree of dissociation. x. Derive the mathematical expression for Ostwald's dilution law to draw the relationship between degree of dissociation and concentration of solution for weak electrolytes. xi. Solve numerical problems based on Ostwald's dilution law. xii. Interpret different values of K_a and K_b of acids and bases to predict their strength. xiii. Solve numerical problems based on K_a and K_b using relevant mathematical expression and data. xiv. Explore Bronsted-Lowry concept of acid and base from relevant sources.	*problems, elevation in boiling point: effect of presence of solute in a solution on boiling point: expression, determination of RMM, related numerical problems, depression in freezing point: effect of presence of solute in a solution on freezing point, expression, determination of RMM by Beckmann's method, related numerical problems, osmotic pressure: effect of presence of solute in a solution on osmotic pressure, expression, determination of RMM, related numerical problems, Van't Hoff Factor)* **3.2 Acid-base Equilibria** 3.2.1 Ionic equilibria and degree of dissociation	Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the experiment designed **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Asking Questions and Defining Problems** Ask questions and define problems to investigate the industrial importance and application of concentration units of solutions by interviewing the chemist in AWP or any other relevant industry in Bhutan. **Planning and Carrying Out Investigations** Plan to carry out the investigation. **Analyzing and Interpreting Data** Analyse the data collected through the interview. **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the data collected. **Obtaining, Evaluating, and Communicating Information** Share the findings to the class. **Asking Questions and Defining Problems**	concept of acid and base. **Exploring Digital Resources** Explore the characteristics of pH indicators to predict their suitability for different types of acid base titrations. **Digital Resources** Explore electrode potential and different parts of an electrochemical cell. **Exploring Digital Resources** Explain the construction and working of SHE as a reference

xv. Draw illustrations of chemical equations to explain conjugate acid-base pairs. xvi. Convert mathematical expression of ionic product of water (K_w) into a statement. xvii. Derive the mathematical expression for pH and pOH from their statements. xviii. Use mathematical expressions and the data to solve numerical problems based on pH and pOH. xix. Demonstrate the body's natural buffer system using acid and base. xx. Apply the knowledge of volumetric analysis and neutralisation reaction to design an experiment to compare the effectiveness of two or more samples of antacids. xxi. Explore the characteristics of pH indicators to predict their suitability for different types of acid base titrations. Design an experiment to investigate buffer action of buffer solutions.	*(Scope: dissociation of electrolytes in aqueous solution, degree of dissociation: definition, factors, derivation and statement of Ostwald's dilution law, calculations)* 3.2.2. Acid- Base concept and Strength of acid and base *(Scope: acid-base concept: Bronsted-Lowry concept of acid and base: explanation of conjugate acid-base pairs with examples: Lewis concept of acids and bases: explanation of Lewis concept with examples, strength of acid and base: ionisation constant of acid 'K_a' and base 'K_b', significance of K_a and K_b, calculations).* 3.2.3 Ionic Product of Water (Scope: *pH, pOH, expression and numerical*	Ask questions and define problems to design an experiment to investigate four types of colligative properties. **Planning and Carrying Out Investigations** Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the experiment designed **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply mathematical expressions and the data to calculate the relative molecular masses of non-volatile solutes based on four colligative properties. **Constructing Explanations and Designing Solutions** Formulate a car coolant which does not freeze in winter based on the principles of colligative properties **Asking Questions and Defining Problems** Ask questions and define problems to design a chemical process to show impact of colligative properties on taste and quality of food.and normality. **Planning and Carrying Out Investigations**	electrode by using simulation. **Exploring Digital Resources** Investigate the rate of reaction in relation to rate equation and rate constant by using simulation. **Exploring Digital Resources** Explore characteristics of rate constant using relevant sources. **Exploring Digital Resources** Explore zero, first and second order of reaction and the units of rate constant using graphs and

xxiii. Apply the knowledge of buffers to formulate different combinations of chemicals for preparing a buffer, which may be used as a dialysis solution. xxiv. Analyse the importance of acid, base, and buffer in relation to environment, agriculture, human health and food industries. xxv. Explain electrode potential and different parts of an electrochemical cell after exploring from relevant sources. xxvi. Explore the working of the electrochemical cell by designing a galvanic cell which can provide energy to run a wall clock, light LED bulb, etc. xxvii. Represent oxidation half-cell, reduction half-cell and net cell reaction for the galvanic cell. xxviii. Conduct an experiment to investigate factors affecting the electrode potential. xxix. Explain the construction and working of SHE as a reference electrode by using simulation/video.	*problems, pH indicators*). 3.2.4. Neutralization and Buffer solution *(Scope: strong acid vs. strong base, weak acid vs. strong base, strong acid vs. weak base, weak acid vs. weak base, Buffer solution: preparation of buffer solution, types of buffer solution, buffer action, applications of buffer)* **3.3 Redox Equilibria** 3.3.1 Electrochemical cell *(Scope: construction of Daniel cell, flow of electrons and mechanism of current production, oxidation half-cell reaction, reduction half-cell reaction, net cell reaction, types of electrode potential, factors affecting electrode potential*, *uses, impact on health and environment)* 3.3.2 Electrochemical series and e.m.f of the cell	Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the experiment designed **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Deduce the mathematical expression of degree of dissociation. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Derive the mathematical expression for Ostwald's dilution Law to draw the relationship between degree of dissociation and concentration of solution for weak electrolytes. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Solve numerical problems based on Ostwald's dilution law using mathematical expression and the data. **Analyzing and Interpreting Data** Interpret different values of K_a and K_b of acids and bases to predict their strength.	relevant mathematical data. **Exploring Digital Resources** Explain the rate determining step in a multi-step chemical reaction by using analogy. **Promoting Socio-cultural, Economic, Environmental and Human Values** Write the historical narratives of the discovery of radioactive substances and its impact on human life, society and environment.

xxx. Calculate e.m.f of a galvanic cell at standard conditions using mathematical expression and the data. xxxi. Compare the e.m.f. values of metals in electrochemical series to design a container that may be used to store metal salt solutions in the laboratory. xxxii. Apply Nernst equation in relation to the standard e.m.f. value to calculate the e.m.f. of galvanic cell at non-standard conditions. xxxiii. Evaluate use of electrochemical cell in an electric car in terms of energy efficiency, renewability and environmental impact. xxxiv. Investigate the rate of reaction in relation to rate equation and rate constant by using simulation. xxxv. Explore characteristics of rate constant. xxxvi. Explain collision theory. xxxvii. Design and carry out an experiment to investigate the factors affecting the rate of reaction.	*(Scope: application of electrochemical series, construction of standard hydrogen electrode SHE/NHE, measurement of standard electrode potential using SHE, calculation of e.m.f. of a galvanic cell under standard conditions, calculation of e.m.f. of a galvanic cell under non-standard condition using Nernst equation, application of electrochemical cells in general)* **3.4 Chemical Kinetics** 3.4.1 Rate of reaction *(Scope: rate law equation, definition and units of rate constant, characteristics of rate constant, Collision theory, factors affecting the rate of reaction (nature of reactants, concentration of reactants, surface area with*	**Using Mathematics, Information and Computer Technology, and Computational Thinking** Solve numerical problems based on K_a and K_b using relevant mathematical expression and data. **Developing and Using Models** Draw illustrations of chemical equations to explain conjugate acid-base pairs **Using Mathematics, Information and Computer Technology, and Computational Thinking** Convert mathematical expression of ionic product of water (K_w) into a statement. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Derive the mathematical expression for pH and pOH from their statements. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Use mathematical expressions and the data to solve numerical problems based on pH and pOH. **Analyzing and Interpreting Data** Apply the knowledge of volumetric and and neutralisation to design an experiment to compare the effectiveness of two or more samples of antacids. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate buffer action of buffer solutions. **Planning and Carrying Out Investigations** Plan to carry out the experiment.	**Exploring Digital Resources** Explore the properties of radioactive rays. **Exploring Digital Resources** Explain modes of decay by using nuclear equations. **Exploring Digital Resources** Explain nuclear transmutation using simulation. **Promoting Socio-cultural, Economic, Environmental and Human Values** Evaluate the significance of

xxxviii. Classify reactions based on molecularity. xxxix. Apply the knowledge of the factors affecting the rate of reaction to design chemical processes for industry to save time and optimize product. xl. Explore zero, first and second order of reaction and the units of rate constant using graphs and relevant mathematical data. xli. Explain the rate determining step in a multi-step chemical reaction by using analogy. xlii. Determine the order of reaction and rate constant by using the mathematical expression and experimental data. xliii. Carry out Chemistry project based on chemical kinetics. xliv. Write the historical narratives of the discovery of radioactive substances, their uses and impact on health, environment and international politics.	*of reactants, catalyst, temperature, light*). 3.5.2 Molecularity and Order of Reaction (Scope: *definition and classification of molecularity with examples, order of reaction: zero, first and second order of reaction, rate vs. concentration graph for zero, first and second order, rate determining steps and reaction mechanism, units of rate constants, experimental determination of order of reaction: determination of rate equation by initial concentration method*). **3.5 Nuclear chemistry** 3.5.1 Radioactive elements: *(Scope: brief history on discovery of radioactive elements*).	**Analyzing and Interpreting Data** Analyse the experiment designed **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Analyzing and Interpreting Data** Apply the knowledge of buffers to formulate different combinations of chemicals for preparing a buffer which may be used as a dialysis solution. **Planning and Carrying Out Investigations** Plan to carry out the experiment by designing a galvanic cell which can provide enough power to run the wall clock. **Analyzing and Interpreting Data** Explore the working of the electrochemical cell **Analyzing and Interpreting Data** Represent oxidation half-cell, reduction half-cell and net cell reaction for the galvanic cell. **Asking Questions and Defining Problems** Ask questions and define problems to conduct an experiment to investigate factors affecting the electrode potential **Planning and Carrying Out Investigations** Plan to carry out the experiment.	radioactive substances with reference to energy source, medicine, research, agriculture, environment and politics. **Exploring Digital Resources** Explain open, closed and isolated systems by using relevant devices. **Exploring Digital Resources** Compare intensive and extensive systems by using analogy. **Exploring Digital Resources**

xlv. Explore the properties of radioactive rays. xlvi. Interpret the stability of different elements using serge chart. xlvii. Explain modes of radioactive decay by using nuclear equations. xlviii. Apply the knowledge of modes of decay to state group displacement law. xlix. Explain nuclear transmutation using simulation, video, etc. l. Solve numerical problems based on half-life of radioactive elements. li. Evaluate the significance of radioactive substances with reference to energy source, medicine, research, agriculture, environment and politics. lii. Argue for and against the use of nuclear weapons in the world. liii. Explain open, closed and isolated systems by using relevant devices. liv. Compare intensive and extensive properties of a system using analogy.	3.5.2 Nature of Radioactive Elements (Scope: *Brief description of n/p ratio with reference to stability of isotopes).* 3.5.3 Types and Properties of Radioactive Rays (Scope: *penetrating power, ionization energy, biological damage*). 3.5.4 Modes of Decay, Group Displacement Law and Transmutation (Scope: *equations for radioactive decay, half-life of radioactive elements, and illustration with examples of group displacement law, transmutation: nuclear reaction*). 3.5.5Tracer Elements and Their Uses (Scope: *Phosphorus 30 and 32, iodine 131, cobalt 60, sodium 24*). 3.5.6 Impacts of nuclear materials on health, environment and international politics. **3.6. Thermodynamics** 3.6.1. Basic Terms in Thermodynamics *(Scope: Types of system:*	**Analyzing and Interpreting Data** Analyse the experiment designed **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Calculate e.m.f of a galvanic cell at standard conditions using mathematical expression and the data. **Asking Questions and Defining Problems** Ask questions and define problems to conduct to design a container that may be used to store metal salt solutions in the laboratory. **Planning and Carrying Out Investigations** Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the container designed **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the container designed. **Obtaining, Evaluating, and Communicating Information**	Explain reversible, irreversible and thermodynamic processes by using analogy. **Exploring Digital Resources** Explore the limitations of the first law of thermodynamics. **Exploring Digital Resources** Explore different physical and chemical processes in the surrounding to identify spontaneous and non-spontaneous processes. **Exploring Digital Resources**

lv. Explain reversible, irreversible and thermodynamic processes using simulation, videos, analogy etc. lvi. Derive the equation for change in internal energy. lvii. calculate heat and work done of a system using mathematical expression and the given data. lviii. Convert the statement of the first law of thermodynamics into mathematical expression. lix. Explore the limitations of the first law of thermodynamics. lx. Design an experiment to investigate enthalpy change in a chemical reaction. lxi. Establish the relationship between enthalpy and internal energy using relevant mathematical expression. lxii. Calculate enthalpy and internal energy for chemical reactions using mathematical expression and the data. lxiii. Explore different physical and chemical processes in the surrounding to identify spontaneous and non-spontaneous processes.	**3.6 Thermodynamics** 3.6.1 Basic Terms in Thermodynamics (Scope: *types of system: Open system, closed system, isolated system, Macroscopic properties of a system: Intensive and extensive systems, Types of processes: Reversible and irreversible processes, thermodynamic processes- isothermal, adiabatic, isobaric, isochoric, cyclic processes*). 3.6.2 First Law of Thermodynamics (Scope: *statement, mathematical form of the law, limitations, Internal Energy: Definition, internal energy change, Heat and work: Positive and negative heat, work done in isothermal reversible and irreversible processes, Enthalpy: Definition, enthalpy change in chemical reaction, relationship between*	Share the experiment to the class through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply Nernst equation in relation to the standard e.m.f value to calculate the e.m.f. of galvanic cell at non-standard conditions. **Analyzing and Interpreting Data** Evaluate use of electrochemical cell in an electric car in terms of energy efficiency, renewability and environmental impact. **Asking Questions and Defining Problems** Ask questions and define problems to conduct to design an electrochemical cell using lemons to light a torch bulb **Planning and Carrying Out Investigations** Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the electrochemical cell designed. **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the electrochemical cell designed. **Obtaining, Evaluating, and Communicating Information** Share the design to the class through different media. **Analyzing and Interpreting Data**	Explain entropy in relation to its significance in nature by using simulation or video. **Exploring Digital Resources** Explore the statements of the second law of thermodynamics. **Exploring Digital Resources** Explore the characteristics of transition elements using relevant resources. **Exploring Digital Resources** Classify ligands on the basis of charge and mode

lxiv. Explore the statements of the second law of thermodynamics. lxv. Explain entropy in relation to its significance in nature by using simulation or video. lxvi. Solve numerical problems using the expression of Gibb's free energy. lxvii. Design a fast defroster using the principles of thermodynamics that can be used in the kitchen. lxviii. Justify the position of transition elements in the periodic table. lxix. Explore the characteristics of transition elements. lxx. Classify ligands on the basis of charge and mode of attachment. lxxi. Apply knowledge of Werner's theory to determine the primary and secondary valencies of coordination compounds. lxxii. Construct 2D/3D models of coordination compounds to explain the structure of coordination compounds based on Werner's theory. lxxiii. Apply IUPAC rules to name coordination complexes and write their formula.	*enthalpy and internal energy, numerical problems*). 3.6.3 Entropy (Scope: *definition of entropy, change in entropy in reversible process, spontaneous and non-spontaneous processes: definition of spontaneous and non-spontaneous processes with examples, factors that determine the feasibility, or spontaneity of process*). 3.6.4 Second Law of Thermodynamics (Scope: *statements of the law, Gibb's free energy and numerical problems*). **3.7 Coordination chemistry** 3.7.1 Transition Elements and Characteristics (*Scope: position of transition elements in periodic table, series of transition elements, electronic configuration, characteristics of*	Identify different chemical reactions to classify molecularity of reactions using relevant resources. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate the factors affecting the rate of reaction. **Planning and Carrying Out Investigations** Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the experiment designed. **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Constructing Explanations and Designing Solutions** Apply the knowledge of the factors affecting the rate of reaction to design chemical processes for industry to save time and optimize products. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Determine the order of reaction and rate constant by using the mathematical expression and experimental data. **Analyzing and Interpreting Data**	of attachment using relevant sources. **Exploring Digital Resources** Examine different colours exhibited by coordination compounds using relevant resources. **Exploring Digital Resources** Explore the working principle, instrumentation and use of TLC, HPLC, mass spectrometry, IR spectroscopy and NMR spectroscopy using relevant resources.

lxxiv. Explain the colours exhibited by coordination compounds based on crystal field splitting. lxxv. Evaluate the importance of coordination compounds in industries and biological systems. lxxvi. Construct 2D/3D models of haemoglobin, chlorophyll, cis-platin, etc to relate the importance of coordination complexes. lxxvii. Create a new hypothetical 2D/3D model of a coordination complex that may have some applications in life.	*characteristics of transition elements: variable oxidation states, formation of coloured ions, formation of complex compounds, catalytic properties*). 3.7.2 Terms in Coordination Compounds (Scope: *definition of central atom or ion, ligands, coordination spheres or coordination entity, ionic spheres, coordination number, oxidation number, charge of the complex, chelation, denticity, Types of ligands: Classification on the basis of charge, classification on the basis of mode of attachment*). 3.7.3 Werner's Coordination Theory (*Scope: postulates of Werner's theory)* 3.7.4 Nomenclature of Coordination Compounds *(Scope: Rules for writing*	Verify experimentally any order of reactions using the resources available in the laboratory. **Analyzing and Interpreting Data** Interpret the stability curve to explain radioactive disintegration of radioactive elements. **Analyzing and Interpreting Dat**a Apply the knowledge of modes of decay to state group displacement law. **Engaging in Argument From Evidence** Argue for and against the use of nuclear weapons in the world. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Derive the equation for change in internal energy by using the statement of internal energy. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply mathematical expressions and data to calculate heat and work done in a system. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Convert the statement of the first law of thermodynamics into mathematical expressions. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to investigate enthalpy change in a chemical reaction. **Planning and Carrying Out Investigations**	**Promoting Socio-cultural, Economic, Environmental and Human Values** interview a forensic expert in JDWNRH or RBP headquarter to explore the type of analytical technique used in investigating the crime.

lxxviii. Explore the definition and basic steps in analytical techniques. lxxix. Design an experiment to conduct a chemical analysis of a sample of beverage available in the market. lxxx. Explore the working principle, instrumentation and use of TLC, HPLC, mass spectrometry, IR spectroscopy and NMR spectroscopy using relevant resources. lxxxi. Analyse the importance of NMR in the medical field. lxxxii. Interpret mass spectrum and the fragmentation pattern of a molecular ion and daughter ions. lxxxiii. Determine the molecular mass of an organic molecule from its molecular ion peak in a mass spectrum.	*the formula of complex ion or compound, rules for writing the IUPAC name and formula of coordination complexes*). 3.7.5 Colour Exhibited by Coordination Compounds (Scope: *factors on which colour depends-nature of metal ion and nature of ligands, explanation of colour of complexes using crystal field splitting*). 3.7.6 Uses of Transition Metal Ion Complexes (Scope: *catalyst, medicine, reagents, biological importance*). **3.8 Analytical Techniques** 3.8.1 Introduction to analytical chemistry (*Scope: Definition and basic steps in analytical chemistry).* *3.8.2* Thin Layer Chromatography (TLC)	Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the experiment designed. **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Establish the relationship between enthalpy and internal energy using relevant mathematical expressions. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Calculate enthalpy and internal energy for chemical reactions using mathematical expression and the data. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Solve numericals using the expression of Gibb's free energy. **Asking Questions and Defining Problems** Ask questions and define problems to design a thermos flask using the principle of thermodynamics. **Planning and Carrying Out Investigations** Plan to design a thermos flask.	

lxxxiv. Analyse the presence of aromatic compounds present in the extracts of local plants. lxxxv. Interpret concept of equivalent and non-equivalent proton, chemical shift, spin-spin coupling and (n+1) rule from NMR spectrum. lxxxvi. Interpret NMR spectra of aliphatic hydrocarbons lxxxvii. Interview a forensic expert in JDWNRH or RBP headquarter or Pharmaceutical Institutes to explore the type of analytical techniques used.	(Scope: *principle, R_f value, instrumentation and applications*). 3.8.3 High Performance Liquid Chromatography (HPLC) (*Scope: principle, instrumentation-components of basic HPLC system and applications*). 3.8.4 Spectroscopy (*Scope: mass spectrometry: Principle, instrumentation, interpret mass spectrum, and applications, Infrared (IR) Spectroscopy: principle, instrumentation, interpret IR spectrum and applications, Nuclear magnetic resonance (NMR) spectroscopy: principle, equivalent and non-equivalent proton, chemical shift, spin-spin coupling, (n+1) rule, instrumentation, interpret NMR spectra of aliphatic*	**Analyzing and Interpreting Data** Analyse the thermos flask designed. **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the thermos flask designed. **Obtaining, Evaluating, and Communicating Information** Share the thermos flask to the class **Analyzing and Interpreting Data** Justify the position of transition elements in the periodic table. **Analyzing and Interpreting Data** Apply knowledge of Werner's coordination theory to determine the primary valency and secondary valency of coordination compounds. **Developing and Using Models** Construct 2D/3D models of molecules of coordination compounds to explain the structure of coordination compounds based on Werner's coordination theory. **Using Mathematics, Information and Computer Technology, and Computational Thinking** Apply IUPAC rules to name coordination compounds **Analyzing and Interpreting Data** Evaluate the importance of transition metal/coordination compounds in chemical industries. **Developing and Using Models**	

	interpret NMR spectra of aliphatic hydrocarbons and applications).	Construct 2D/3D models of haemoglobin to relate the importance of coordination complexes in biological systems. **Asking Questions and Defining Problems** Ask questions and define problems to design an experiment to conduct a chemical analysis of a sample of beverage available in the market. **Planning and Carrying Out Investigations** Plan to carry out the experiment. **Analyzing and Interpreting Data** Analyse the experiment designed. **Constructing Explanations and Designing Solutions** Construct explanations and design solution based on the experiment. **Obtaining, Evaluating, and Communicating Information** Share the experiment to the class through different media. **Analyzing and Interpreting Data** Analyse the importance of NMR in the medical field using relevant resources. **Analyzing and Interpreting Data** Interpret mass spectra and the fragmentation pattern of a molecular ion and daughter ions. **Analyzing and Interpreting Data** Determine the molecular mass of an organic molecule from its molecular ion peak in a mass spectrum. **Asking Questions and Defining Problems**	

		Ask questions and define problems to investigate the presence of aromatic compounds in local plants. **Planning and Carrying Out Investigations** Plan to carry out the investigation **Analyzing and Interpreting Data** Analyse the data collected through the investigation. **Constructing Explanations and Designing Solutions** Construct explanations and design solutions based on the data analysed from the investigation. **Obtaining, Evaluating, and Communicating Information** Share the information through the school journal/national journal/international journal).. **Analyzing and Interpreting Data** Interprete concept of equivalent and non-equivalent proton, chemical shift, spin-spin coupling and (n+1) rule from NMR spectrum. **Analyzing and Interpreting Data** Interpret NMR spectra of aliphatic hydrocarbons	

3 SECTION D: Physics (Physical Processes)

12. 1 Key Stage 4 (IX-X)

Competency-based Standard

By the end of key stage 4 (class X), learners should be able to:

1. **Newtonian Mechanics**
    1.1. Investigate the concept of force through Newton's laws of motion and use equations of motion and expression F=ma to solve problems related to real life experiences.
    1.2. Exhibit the clear understanding of theoretical and practical concepts of work, energy, power and moment to relate the concepts in real life applications.
    1.3. Apply the scientific principles and concepts to examine the importance of sustainable and efficient energy use innovations for energy conservation and security.
    1.4. Examine the stability of the body through its centre of gravity and describe its significance and application in everyday activities.
    1.5. Study the motion of falling objects through scientific experimentation and become aware of its potential danger to adopt a cautious attitude of precautions and safety.
2. **Fluid Mechanics and Thermal Physics**
    2.1. Exhibit the understanding of fluid pressure and Pascal's law and apply the concept to design (conceptual or working model) infrastructures and hydraulic machines.
    2.2. Verify Archimedes principle and recognize its applications to find the volume of objects, in floatation and to design devices and machines.
    2.3. Apply the scientific concepts to design a model of devices and infrastructures to minimize heat loss through different modes of heat transfer.
    2.4. Explore applications of different temperature scales and investigate the quantity of heat in different materials to make a right choice of materials for different purposes.
    2.5. Experiment and explain the principle of calorimetry to verify the law of conservation of energy in an isolated system.
3. **Electricity and Magnetism**
    3.1. Investigate electric current and verify Ohm's law through an experiment to construct the relationship among basic electrical quantities such as potential difference, current and resistance.
    3.2. Explain and apply the concepts of heating effect of current and electric power in different electrical appliances to identify the right choice of appliances for specific purposes.
    3.3. Investigate to substantiate that an electric current can produce a magnetic field and a changing magnetic field can produce an electric current to understand their applications in many electronic devices.

4. Waves and Optics

4.1. Apply the concept of refraction and total internal reflection to design simple optical devices that can solve the problem related to illumination and communication.

4.2. Illustrate the displacement time graph for transverse and longitudinal waves (digitally or physically) to construct relationships between wavelength and frequency that determines the communication system.

4.3. Examine the properties of electromagnetic (EM) waves and their applications in daily lives to appreciate the advantages of modern communication systems.

4.4. Integrate scientific and technical information to support the claim that digitized signals are a more reliable way to encode and transmit information than analog signals.

5. Atomic, Nuclear and Space Physics

5.1. Represent nuclide notation to apply its concept in radioactivity and recognise its application and safety measures.

5.2. Describe the characteristics and environment of the moon to explore the possibilities of settlement on the moon.

5.3. Explore the role of gravitation in the evolution of the universe (stars, solar system, planets) and mankind's quest, achievement, and advancement in space exploration.

5.4. Gather evidence to enhance the conceptual understanding of space exploration, space technology and their purposes and design basic astronomical instruments.

Class-wise Competency (Class IX)

By the end of class IX, learners should be able to:

1. Newtonian Mechanics

- Analyse and communicate the inferences of motion graphs by using mathematics and Computer Assisted Instruction (CAI) tools and apps to comprehend the nature of motion through graphical representation.
- Use natural phenomena and modern technology to construct concepts on effects of forces in opposite directions and relate them to everyday life.
- Investigate the concept of momentum experimentally and solve numerical problems using equations of linear motions related to real life situations.
- Experiment the laws of motion and use the concept to explain the applications of these laws on real-life situations.
- Carry out scientific investigation to substantiate the mathematical relationship among the net force, mass, and acceleration to predict the motion of an object.

2. Fluid Mechanics and Thermal Physics

- Experiment and communicate the results of fluid pressure to relate its applications in mechanical and fluid engineering.
- Elucidate phenomena based on the result of an investigation on Archimedes' principle to comprehend the applications of Archimedes' principle and principle of floatation and design any model based on Archimedes' principle and principle of floatation.

- Measure the temperature of the bodies in different scales and convert it from one scale to another scale to understand relationships among various temperature measuring scales.
- Carry out an experiment to investigate the mode of transfer of thermal energy (heat) to apply the concept in designing heat efficient devices.
- Describe and apply the conceptual understanding of thermal expansion of matter in designing devices like thermometers and infrastructures.

3. Electricity and magnetism

- Interpret electric current using interactive simulation to generate concepts of electrical variables that affect each other.
- Analyze the graph of alternating current and direct current to recognize the power supplied by different sources.
- Design and construct d.c. motor to appreciate their applications in various electrical devices.

4. Waves and Optics

- Design and use models to describe the laws of refraction through various materials to relate its applications in daily use.
- Design any working or conceptual model of an optical instrument using the concept of total internal reflection to comprehend its application in various fields.
- Differentiate between transverse and longitudinal waves by using simulations or physical tools and construct the relationship between frequency and wavelength to explain the nature of waves.
- Communicate scientific and technical information about the properties of waves (reflection and refraction) and appreciate the applications of waves in communication, medicines, and entertainment.

5. Atomic, Nuclear, and Space Physics

- Design a model or use technological tools to comprehend the structures of atom and nucleus to represent elements using nuclide notation.
- Explore different types of telescopes and components to comprehend its application as an astronomical instrument.
- Gather evidence related to advancement in moon exploration to describe physical and chemical properties of the moon and explore the possibility of settling on the moon in future.
- Design physical or virtual prototype of any one of the items necessary for human survival on the Moon.

Table 1. *Learning Objectives and Dimensions for Newtonian Mechanics, class IX*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Illustrate distance-time graph and velocity-time graph manually and using CAI tools. ii. Describe the effects of balanced and unbalanced force to determine that state of a body. iii. Investigate variables that describe the momentum. iv. Apply three equations of linear motion to solve simple numerical problems related to real life experiences. v. Apply the concept of Newton's first law of motion to design a simple model that explains the benefits of wearing a seat belt. vi. Investigate to support the claim that Newton's second law of motion describes the mathematical relationship among	**1. Newtonian Mechanics** 1.1. **Force and Acceleration** 1.1.1 Graphical Representation of distance-time graph and velocity-time graph *(Scope: representation and interpretation of speed, velocity and acceleration from distance time graph and velocity time graph)* 1.1.2 Balanced and Unbalanced Force *(Scope: resultant force due to balanced and unbalanced force to determine the state of a body).* 1.1.3 Momentum of a Body *(Scope: explanation, mathematical expression, simple numerical problem, and applications).* 1.1.4 Equations of Linear Motion *(Scope: linear motion equations and simple numerical problems)*	**Asking Questions and Defining Problems** -How mass and acceleration influences force? - How Newton's laws are applied to real life situations? **Planning and Carrying out Investigations** - Conduct experiments to construct relationships in Newton's second law of motion, and to demonstrate the effect of mass and velocity on momentum. -Carry out practical demonstrations to collect data to illustrate motion graphs. -Investigate the applications of Newton's Laws of Motion **Analyzing and Interpreting Data** -Analyse data obtained from investigation to interpret the relation among force, mass and acceleration -Plot the graph by CAI tools and analyse data to interpret the motion of a body (speed, velocity and acceleration) -Analyze data on mass and velocity to interpret the magnitude of momentum. **Constructing Explanation and Designing Solutions** -Construct and explain the mathematical relationship among force, mass and acceleration, -Construct and explain mathematical relationships among momentum, velocity and mass. **Using Mathematics and Computational Thinking** -Apply three equations of linear motion to solve simple numerical problems.	**Exploring Digital Resources** - Use mobile apps (e.g. Physics at school) to study distance-time and velocity-time graphs. - Use CAI tools to plot and analyse the data for motion. - Use simulations or mobile apps to learn the concept of balanced and unbalanced force and Newton's third law of motion. **Using Physical Tools** - Use graph papers to plot motion graphs - Use relevant materials to carry out various experiments on Newton's laws and construct models based on the applications of laws.

the net force, mass, and acceleration. vii. Design a model to demonstrate and relate the concept of Newton's third of motion to real life situations.	1.1.5 Newton's First Law of Motion. *(Scope: inertia of rest and motion, and applications)* 1.1.6 Newton's Second Law of Motion *(Scope: relation among force, mass and acceleration, simple numerical problems)* 1.1.7 Newton's Third Law of Motion. *(Scope: qualitative explanation and applications)*	- Use mathematical relationships from momentum and Newton's second law of motion to solve numerical problems. **Engaging in Argument From Evidence** - Initiate an argument that draws conceptual understanding of Newton's laws and relate it to the philosophy of cause and effect. **Developing and Using Models** -Construct a simple rocket to demonstrate Newton's third law. -Design a simple model to demonstrate the benefits of seat belts. -Design and construct a boat propelled by a simple DC motor to demonstrate Newton's third law of motion. **Obtaining, Evaluating and Communicating Information** - Explore applications of Newton's laws in daily experiences and share the findings with justification.	**Carrying out STEM Activities** -Design and construct a boat propelled by a simple DC motor to demonstrate Newton's third law of motion. **Promoting Socio-cultural, Economic, Environment and Human Values** - Relate Newton's law to the philosophy of cause of effect.

Table 2. *Learning Objectives and Dimensions for Fluid Mechanics and Thermal Physics, class IX*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	**Society and Technology**
i. Carry out an experiment to verify the laws of liquid pressure and derive mathematical expression to relate its application in daily life. ii. Evaluate the variation of atmospheric	**2. Fluid Mechanics and Thermal Physics** **2.1 Pressure in Fluid** 2.1.1 Pressure inside a Liquid *(Scope: laws of liquid pressure, derivation of mathematical expression, and applications in daily life).* 2.1.2 Atmospheric Pressure and Weather Forecasting *(Scope:*	**Asking Questions and Defining Problems** -How liquid pressure is affected by factors like depth, density and acceleration due to gravity? - What are the real life applications of Archimedes' principle? **Planning and Carrying out experiment** -Carry out an experiment to verify the laws of liquid pressure and Archimedes' principle. **Analyzing and Interpreting Data**	**Exploring Digital Resources** - Use digital resources to gather information on the concept of fluid pressure, Archimedes' principle and its applications. -Use interactive simulations to

pressure to forecast weather. iii. Verify Archimedes' principle to compute buoyant force, relative density and volume of irregular shaped objects through experimentation or simulation. iv. Design a device to explain the principle of floatation and its application in real life situations. v. Measure and convert the temperature of bodies from one scale to another scale. vi. Conduct an experiment to detect the flow of thermal energy and explain the concept of thermal equilibrium. vii. Design a device to minimize the transfer of thermal energy to explain the concept of thermal insulation. viii. Describe thermal expansion and relate its application in the engineering field.	*concept on barometer, types of barometer, and their use in weather forecasting)* **2.2 Buoyant Force** 2.2.1 Upthrust. *(Scope: derivation and calculation of upthrust*) 2.2.2 Archimedes' Principle *(Scope: verification of Archimedes' principle, calculation of relative density and its applications)* 2.2.3. Floating Bodies *(Scope: conditions and forces on floating body)* 2.2.4 Applications of the Principle of Floatation in Everyday Life. ***2.3* Heat and Temperature** 2.3.1 Measurement of Temperature *(Scope: temperature scales; Celsius, Fahrenheit and Kelvin scales, conversion of temperature from one scale to another, absolute zero).* 2.3.2 Thermal Energy *(Scope: explain the term thermal energy, modes of thermal energy transfer, and applications of thermal equilibrium)*	-Analyze data to construct the correlation between liquid pressure, depth and density of the liquid. -Analyze data to construct the correlation between liquid pressure, depth and density of the liquid using the mathematics model or expression and show the value of liquid pressure as different depth, density etc **Constructing explanation and designing solutions** - Explain liquid pressure and its application in construction of infrastructure based on evidence collected during the experiment and computation of the data. - Design a conceptual model that integrates the concept of thermal insulation in energy efficient houses. **Obtaining, evaluating and communicating information** -Read the information individually or in group about the weather forecast, evaluate the information and share the information to the class. -Gather information on the concept of heat transfer and evaluate its applications in real life situations. **Developing and using models** - Design a suit to float in water with the concept of the principle of floatation. Or use their model to explain how models work based on the principle learnt. - Design a device or a model structure that reduces the transfer of energy. **Engaging in argument from evidence**	demonstrate the liquid pressure and Archimedes' principles. **Using Physical Tools** **-** Use a manometer to study the laws of liquid pressure. - Use relevant materials (tools) to carry out experiments on liquid pressure and Archimedes' principle, and to design models based on the principle of floatation. -Use a simple barometer to forecast weather. **Carrying out STEM Activities** -Create or use simulation or animation to understand modes of transfer of heat. - Design models to demonstrate applications of Archimedes' principle and principle of floatation. **Promoting Socio-cultural, Economic,**

	2.3.3 Thermal Insulation *(Scope: applications of thermal insulation)* 2.3.4 Thermal Expansion of Matter. *(Scope: types of thermal expansion and its applications, anomalous expansion of water and its effects).*	-Organise a session to argue how humans float or sink in the water. - Engage in a debate about how to survive by floating on liquid during an emergency, with or without devices using the evidence from the attributes required for the floatation. **Using mathematics and computational thinking** -Solve simple numerical problems based on liquid pressure and buoyancy. - convert temperature for various scales for specific purposes.	**Environment, and Human Values** -Design and exhibit urban water supply models. - Use the concept of thermal insulation in designing apartments to improve the insulation. - Use the concept of anomalous expansion of water to prevent bursting of pipes during cold seasons.

Table 3. *Learning Objectives and Dimensions for Electricity and Magnetism, class IX*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Interpret electric current in terms of flow of charge using interactive simulation to elucidate the understanding of flow of current. ii. Analyze the graph of alternating current and direct current using simulation or an oscilloscope.	**3. Electricity and magnetism** **3.1 Electric Charge** 3.1.1 Electric Current *(Scope: electric current in terms of the flow of charge carried by free electrons in metals, measurement of electric current, and related numerical problems)* **3.2 Magnetic Effect of Current** 3.2.1 Alternating Current and Direct Current (a.c. and d.c.)	**Asking Questions and Defining Problems** - How does magnetic effect of current help to operate a d.c. motor? **Planning and Carrying out experiment** -Investigate force on a current carrying conductor placed in a magnetic field. **Analyzing and Interpreting Data.**	**Exploring Digital Resources** - Use digital resources to gather information on the concept of current, magnetisation and its applications. -Use related video on working on a d.c. motor. -Attend an online quiz related to a particular concept. **Using Physical Tools** -Use Barlow's wheel to study the magnetic effect of current. -Use an oscilloscope in understanding the direct and alternating current. **Carrying out STEM Activities**

iii. Design a simple direct current (d.c.) motor by applying the concept of magnetic effect of current.	*(Scope: a.c. and d.c. with graphical representations)* 3.2.2 Force on a Current Carrying Conductor placed in a Magnetic Field. *(Scope: Lorentz force, construction, working, and applications of d.c. motor)*	-Interpret the graph of alternating current and direct current. **Constructing Explanation and Designing Solutions** - Illustrate conceptual understanding on the working of d.c. motor. **Developing and using models** -Design a simple direct current motot to demonstrate the force experienced by a current carrying conductor placed in a magnetic field. -Use simulation to study the pattern of current.	-Simulate d.c and a.c current through animation, 3D visualization software and mobile apps. - Design a simple d.c. motor to comprehend its working and applications in various electrical appliances. **Promoting Socio-cultural, Economic, Environment and Human Values** -Use d.c motors to design smart household appliances. - Appreciate the multiple uses of electricity and its contribution to the environment, economic, and social development.

Table 4. *Learning Objectives and Dimensions for Waves and Optics, class IX*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Carry out an experiment to comprehend the laws of refraction using a ray box or glass slab. ii. Apply the concept of refraction to construct an optical instrument. iii. Explain the concept of total internal reflection	**4. Waves and Optics** **4.1 Ray optics** 4.1.1 Refraction of Light *(Scope: refraction of light through a glass slab, laws of refraction, refractive index)* 4.1.2 Total Internal Reflection *(Scope: explanation, natural phenomena and applications)* **4.2 Waves**	**Asking Questions and Defining Problems** -How is the refractive index related to the bending of light? -How waves enable communication? **Planning and Carrying out experiment** -Conduct an experiment to verify laws of refraction and determine the refractive index of a glass slab. **Analyzing and Interpreting Data** - Draw inference based on experiments to determine refractive index.	**Exploring Digital Resources** **-**Explore relevant online videos to study the mechanism of the refraction process. **Using Physical Tools** -Use glass slab to study refraction of light. - Use slinky/helical springs to demonstrate

using any simulation and CAI tools to comprehend its application in various purposes. iv. Describe the properties and terms related to transverse and longitudinal waves using simulations or available materials. v. Explore the application of waves in daily application using CAI tools.	4.2.1 Types of Waves *(Scope: transverse and longitudinal*) 4.2.2 Properties of Waves *(Scope: terms used in waves, reflection and refraction of sound and light waves*) 4.2.3 Uses of waves *(Scope: Ultrasound, SONAR, RADAR)*	**Developing and using models** -Use models to demonstrate the nature of waves. -Develop a working model applying the knowledge of total internal reflection. **Obtaining, evaluating and communicating information** -Explore and explain the natural phenomena due to total internal reflection. -Communicate how waves are used in different devices for use in daily activities. **Using Mathematics and Computational Thinking** -Calculate refractive index of glass slab using the data obtained.	the nature of transverse and longitudinal waves. **Carrying out STEM Activities** -Create animations to demonstrate refraction of light. -Design an experimental setup to demonstrate total internal reflection in the stream of water with the help of a laser. **Promoting Socio-cultural, Economic, Environment and Human Values**. - Appreciate the applications of waves to enhance communication and medical purposes.

Table 5. *Learning Objectives and Dimensions for Atomic, Nuclear, and Space Physics, class IX*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Describe the composition of the nucleus, in terms of protons and neutrons and represent radioactive elements using nuclide notation.	**5. Atomic, Nuclear, and Space Physics** **5.1 Nuclear Atom** 5.1.1 The Nuclear Atom *(Scope: nuclear composition, protons and neutrons, proton number, nucleon number, nuclide notation).*	**Asking questions and defining problems** - Is there a possibility for humans to settle on the moon? **Planning and carrying out investigation** -Justify through scientific evidence of conditions required for the Human survival on the Moon. **Developing and using models**	**Exploring Digital Resources** -Use digital resources to gather scientific and technical information to explore the Moon and understand atomic structure.

ii. Explain the components and basic operation of different types of telescopes and design a prototype of a telescope. iii. Explore evidence related to advancement in moon exploration. iv. Describe composition, positions, and sizes of the Moon relative to the Earth. v. Explore the requirements for human survival on the Moon. vi. Design physical or virtual prototype of any one of the items necessary for human survival on the Moon.	**5.2 Astronomical Instruments** *(Scope: concept, components, types and construction of telescope)* **5.3 The Moon** 5.3.1 Advancement of Moon Exploration (*Scope: history of the moon exploration, current developments, future possibilities)* 5.3.2 Physical and Chemical Properties of the Moon and its Environment (*Scope: position, size, composition, impact of Moon's environment on human health, and survival on the Moon)*	- Use a model or simulation to comprehend the atomic and nuclear composition. - Design a Telescope to understand its working in space exploration -Design physical/virtual prototype of any one of the items necessary for human survival on the Moon. **Analyzing and interpreting data** - Analyse the information gathered about the Moon to interpret the advancement and future possibility of survival. **Constructing explanation and designing solutions** -Design a prototype of the item necessary for human survival on the moon. **Engaging in argument from evidence** -Debate on possibilities of life on the moon. **Obtaining, evaluating and communicating information** - Initiate debate on ideas presented about the possibility of life concerning the composition of the moon.	**Using Physical Tools** -Use telescopes to understand space technology. **Carrying out STEM Activities** - Design a model (physical or conceptual) of the moon with its composition suitable for human survival. **Promoting Socio-cultural, Economic, Environment, and Human Values.** - Draw inferences from lunar phases and relate its consequences in various natural and cultural settings. -Explore the composition of the moon suitable for human survival.

Class-wise Competency (Class X)

By the end of class X, learners should be able to:

1. Newtonian mechanics

- Locate the centre of gravity experimentally to determine the stability of the body and relate its significance in everyday experiences.
- Determine the resultant force and moment to comprehend the concepts of equilibrium to apply the effect in principle of moment.
- Construct and present arguments using evidence to support the claim that the force on falling objects changes with velocity.
- Establish relationships among energy, work, and power to relate with daily applications and solve related numerical problems.
- Demonstrate the understanding of the law of conservation of energy using various examples and appreciate its applications in real life phenomena.
- Describe the efficient methods of energy consumption and generation to attain energy sustainability and make evidence based decisions for power generation to minimise its negative impact on environment, society, economy and culture in the global and local context.

2. Fluid Mechanics and Thermal Physics

- Experiment to deduce mathematical relationship between factors affecting pressure due to solid and fluid to apply its concept in daily life.
- Investigate and design a functional prototype to elucidate the application of Pascal's law in various hydraulic machines.
- Explain the exchange of heat between the system and surrounding to design a calorimeter to verify the principle of calorimetry.
- Analyse and compare the specific heat capacity of substances to make the right choice of materials for specific purposes such as high specific heat capacity material as coolant and low specific heat capacity material as utensils.
- Illustrate the latent heat of fusion and vaporization through experimentation and relate concept to the natural phenomena.

3. Electricity and Magnetism

- Deduce the relationship among potential difference, current and resistance to verify Ohm's law and analyse I-V graphs for different types of conductors to relate its uses in electronic gadgets.
- Demonstrate the understanding of Faraday's laws of electromagnetic induction through simulation or model and apply the concept to design and explain the working of an a.c generator.
- Design and experiment on working of step up and step down transformers based on electromagnetic induction to explore its application in power transmission and various electrical appliances.
- Explain the concept of heating effect of current and electric power to relate its applications in daily use of electrical appliances.

4. Waves and Optics

- Examine the scientific and technical information of electromagnetic waves and their applications to comprehend the applications of waves in communication, medicines and entertainment.

- Gather evidence to comprehend communication using different waves over short and long distances to compare their effectiveness in communication for specific purposes.
- Interpret the ways of transmitting information using digital signals and analogue signals integrating scientific and technical information to claim that digital signals are more reliable and effective than analogue signals.

5. Atomic, Nuclear, and Space Physics

- Explain the concept of radioactivity with its properties to understand their applications and safety precautions while working with radiations.
- Demonstrate understanding of the universal law of gravitation and its role in the formation of the universe with the help of model or simulation.
- Communicate scientific and technical information about the formation of the universe, stars, solar system, and planets to understand the universe and its evolution.
- Use the information and communication technologies to enhance the conceptual understanding of space exploration, space technology and their purposes.

Table 6. *Learning Objectives and Dimensions for Newtonian Mechanics, class X*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Investigate the location of the center of gravity to relate with stability of bodies. ii. Demonstrate three types of equilibrium to relate with real life application. iii. Examine the effect of resultant force to comprehend the conditions for equilibrium. iv. Explore the various application of couple in daily life.	**1. Newtonian Mechanics** **1.1 Gravitational Force** 1.1.1. Centre of Gravity (C.G) and Stability of Bodies *(Scope: location of C.G, relation of position of C.G and area of base of support with stability)* 1.1.2. Equilibrium *(Scope: definition and application of stable, unstable, and neutral equilibrium)* **1.2 Moment of Force**	**Asking Questions and Defining Problems** -How does the center of gravity determine the stability of the body? -How is energy conserved when it is converted from one form to another form? -Which source of energy has minimal impact on the environment? **Planning and Carrying out Investigations**	**Exploring Digital Resources** -Use interactive simulations to deduce the mathematical expression and study the conversation of energy. -Use Mathematics and Computer Assisted Instruction (CAI) tools and mobile apps to investigate the motion of falling objects.

v. Deduce the mathematical expression for the principle of moments through an interactive simulation or an experiment. vi. Examine the motion of falling objects to explain that force changes with change in velocity. vii. Examine the concept of work done to calculate power and efficiency of different machines. viii. Describe transformation of energy between potential and kinetic energy to demonstrate the energy conservation using simulations or a prototype. ix. Analyse various methods of using energy efficiently in daily life. x. Design an energy efficient structure based on efficient ways of using energy (conceptual or physical) xi. Discuss on various methods of power generation to provide evidence-based ideas to generate power with minimum negative impact on the environment, economy and culture.	1.2.1 Forces and Equilibrium *(Scope: resultant force and conditions for equilibrium).* 1.2.2 Couple *(Scope: definition, mathematical expression, application, and numerical problems)* 1.2.3 Principle of Moments *(Scope: principle, mathematical expression, and numerical problems)* **1.3 Falling Objects** 1.3.1 Forces on Falling Objects *(Scope: free fall, drag force, terminal velocity)* **1.4 Work and Energy** 1.4.1 Work and Power *(Scope: work done, work done against gravity, power and efficiency)* 1.4.2 Energy *(Scope: potential energy, kinetic energy, law of conservation of energy)* 1.4.3 Energy Conservation *(Scope: efficient ways to use energy)* 1.4.4 Impact of Power Generation on the Environment. *(Scope: hydroelectricity, solar energy, bioenergy, wind energy, nuclear energy and its impact on environment).*	-Carry out an experiment to determine the centre of gravity of irregular shape. -Verify the factors affecting the stability of a body. - Verify principle of moment experimentally. **Developing and Using Models** -Develop a prototype to explain the concept of energy transformation in conservation of energy. -Design an energy efficient structure integrating efficient ways of using energy. **Analyzing and Interpreting Data** - Analyse the data collected from experiments to interpret the concept of stability and principle of moment. **Using Mathematics and Computational Thinking** - Use mathematical relationships for principle of moment, work done and power, and energy to solve numerical problems. **Constructing Explanation and Designing Solutions** - Develop a prototype to explain the concept of conservation of energy. **Obtaining, Evaluating and Communicating Information** - Explore and evaluate the impacts of power generation on the	-Explore information on conservation of energy and impacts of power generation on the environment using various digital resources. **Using Physical Tools** -Use devices from daily life to explore the effect of couples. **Carrying out STEM Activities** - Develop a prototype to demonstrate the concept of energy transformation. -Design an energy efficient structure using the concept of energy efficiency. **Promoting Socio-cultural, Economic, Environment, and Human Values** -Apply the knowledge of energy conservation in real life. - Promote the use of technology to attain energy efficiency.

		environment and create awareness to the larger audience.	

Table 7. *Learning Objectives and Dimensions for Fluid Mechanics and Thermal Physics, class X*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Design an experiment to explain the factors affecting the magnitude of pressure due to solid. ii. Devise an experiment to establish mathematical expression of factors affecting fluid pressure. iii. Verify Pascal's law through an experiment (simulation or practical) to relate its application in hydraulic machines. iv. Develop a structure or model of any hydraulic machine based on the principle of transmission of liquid pressure. v. Conduct an experiment to compare specific heat	**2. Fluid Mechanics and Thermal Physics** **2.1 Thrust on a Surface Area** *2.1.1* Pressure. *(Scope: magnitude of pressure due to solid and fluid, mathematical relation, numerical problems and its applications)* **2.2 Transmission of Pressure in the Liquid** 2.2.1 Pascal's Law *(Scope: description, application, and numerical problems)* **2.3 Thermal Physics** 2.3.1 Specific Heat Capacity *(Scope: concept of heat capacity, compare specific heat capacity of different substances and its*	**Asking Questions and Defining Problems** -How does fluid transmit pressure in hydraulic machines? -What causes heating and cooling of objects? **Developing and Using Models** -Use Pascal's syringe to demonstrate the Pascal's law. -Design a calorimeter to validate the principle of calorimetry. - Use models of any hydraulic machines to demonstrate transmission of pressure through confined liquid. **Planning and Carrying out Investigations** -Design an experimental demonstration to explain the factors affecting the magnitude of pressure due to solid and fluid. - Perform an experiment to demonstrate the flow of heat and compare specific heat capacities of different liquids. - Carry out an experiment to verify the principle of calorimetry. **Analyzing and Interpreting Data** - Analyse the factors affecting pressures based on data from demonstration.	**Exploring Digital Resources** -Use simulation in verifying pascals' law. - Use videos to learn about working of hydraulic machines. - Use digital tools, apps or multimedia to explain the measurement of heat. **Using Physical Tools** - Use a pascal syringe in demonstrating Pascal's law. - Use calorimeter in verifying principle of calorimetry. - Use available materials to develop a model using the principle of transmission of liquid pressure. **Carrying out STEM Activities** **-** Design calorimeter to measure the quantity of heat lost and gained.

capacity of different substances to select the substances for specific purposes. vi. Design a calorimeter and carryout experiment to validate the principle of calorimetry. vii. Interpret the principle of calorimetry and use calorimetric data to calculate heat exchange. viii. Illustrate the latent heat of fusion and vaporization through experimentation to relate its application to natural phenomena.	*application, numerical problems)* *2.3.2* Calorimeters and Calorimetry *(Scope: calorimeters, principle of calorimetry and its applications, and numerical problems)* 2.3.3 Latent Heat *(Scope: latent heat of fusion, explain latent heat of vaporization and its effects)*	- Analyse and interpret the data from the experiment on specific heat capacity to apply in real world situations. **Using Mathematics and Computational Thinking** - Compute pressure problems using equations to find the magnitude of pressure due to solid and fluid. - Calculate heat gained or lost using the principle of calorimetry. -Use the programming language or animation to create the simulation to explain about latent heat. **Constructing Explanation and Designing Solutions** - Design a force multiplying device applying Pascal's law to make the work easier. **Obtaining, Evaluating and Communicating Information** - Explain the applications of Pascal's law in working of different hydraulic machines. - Analyze the calorimetric data obtained from an experiment performed to verify the principle of calorimetry.	- Develop a prototype of a hydraulic machine to demonstrate the applications of Pascal's law. **Promoting Socio-cultural, Economic, Environment, and Human Values**. -Design any strong structure using the concept of P=F/A. - Impart values on use of hydraulic machines for the ease and convenience of daily activities. -Apply the knowledge of calorimetry in real life situations to show the conservation of energy. - Apply the concept of specific heat and latent heat to various applications.

Table 8. *Learning Objectives and Dimensions for Electricity and Magnetism, class X*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explore the concept of electric current, potential difference and resistance using appropriate analogy/CAI	**3. Electricity and Magnetism** 3.1 Electric Circuit *(Scope: flow of electric current, potential*	**Asking Questions and Defining Problems** - What is the working principle of a.c. generator? - How are potential differences and current related?	**Exploring Digital Resources** - Use appropriate analogy/computer assisted tools/simulation to analyze

tools/simulation/mobile apps. ii. Devise an experiment or use simulation to construct a relationship amongst current, potential difference, and resistance. iii. Interpret the graph of ohmic and non-ohmic conductors to comprehend its application in various electrical devices. iv. Describe the heating effect of electric current and its application in a range of devices to calculate its electric power. v. Carry out an experiment or use simulation to demonstrate Faraday's laws and explore their applications in real life situations. vi. Develop a model/simulation/animation to illustrate the working of a.c generator employing relevant programming language/interactive presentation tools. vii. Design a conceptual model of transformer with high efficiency, state applications and basic	*difference, resistance and resistors, factors affecting resistance, potential drop)* 3.2 Ohm's law *(Scope: law, verification, Ohmic and non-ohmic conductor, calculations)* 3.3 Heating Effect of Current *(Scope: applications, electric power, and numerical problems)* 3.4 Electromagnetic Induction *(Scope: Faraday's laws, a.c generator, working of a.c generator, factors affecting the magnitude of induced emf, types of transformers, applications, and numerical problems)*	**Developing and Using Models** - Construct the model to demonstrate electromagnetic induction. **Planning and Carrying out Investigations** - Conduct an experiment to establish the relationship between current, voltage, and resistance. - Design an experiment to comprehend Faraday's laws. **Analyzing and Interpreting Data** - Analyze the relation between electric current and potential difference. - Interpret the graph of ohmic and non-ohmic conductors and apply its concept to various electrical devices. -Analyze and deduce Faraday's laws from the experiment. **Using Mathematics and Computational Thinking** - Use Ohm's law equation to compute current, voltage and resistance. - Mathematically explain the rate at which energy is consumed by different household appliances. - Compute transformer ratio. **Constructing Explanation and Designing Solutions** - Design a conceptual transformer with higher efficiency to comprehend its application. **Obtaining, Evaluating and Communicating Information** - Communicate information regarding the working model constructed to explain the concept of electromagnetic induction.	the relation between potential difference and current. -Use simulation to comprehend Faraday's Laws. - Use digital resources to explore the construction and working of a.c. generator. **Using Physical Tools** - Use electrical devices (ammeter, voltmeter, resistor, wire, key, cell etc) to develop simple electrical circuit and to verify Ohm's law. **Carrying out STEM Activities** - Develop a simulation/animation to understand about a.c. generator. -Design a model of a micro hydropower station. **Promoting Socio-cultural, Economic, Environment, and Human Values** - Explain the rate at which energy is being consumed by different electrical appliances. - Relate the concept of the heating effect of electric

calculations on transformation ratio.		- Explore and explain applications of heating effect of current in daily use of electrical appliances.	current to save the environment, and promote the health and wellbeing of mankind.

Table 9. *Learning Objectives and Dimensions for Wave and Optics, class X*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Describe scientific properties of electromagnetic waves and their application. ii. Demonstrate understanding of applications of electromagnetic waves for communication over long and short distances. iii. Design a device or use model to explain the communicate over short and long distances using electromagnetic waves. iv. Perform an experimental verification to show that sound waves obey the laws of reflection. v. Interpret the ways of transmitting information using digital signals and analogue signals.	**4. Wave and Optics** **4.1 Types of Electromagnetic Waves** *(Scope: types of electromagnetic waves based on frequency and wavelength, applications, and safety measures)* **4.2 Communication through Waves** (Scope: *communication over short and long distances, communication through sound waves, analogue and digital signals)*	**Asking Questions and Defining Problems** - How are waves used for various communication purposes? **Developing and Using Models** -Demonstrate short range communication using a self-designed device or available devices. **Planning and Carrying out Investigations** - Investigate the reflection of sound waves. **Analyzing and Interpreting Data** - Analyse and interpret the uses of electromagnetic waves in industrial and medical purposes. **Constructing Explanation and Designing Solutions** - Design a device or conceptual model that is used to communicate over short and long distances using electromagnetic waves. **Obtaining, Evaluating and Communicating Information** - Obtain information regarding harmful effects of waves and communicate about the safety measures.	**Exploring Digital Resources** -Use digital resources to gather scientific and technical information on electromagnetic waves and their applications. - Use simulations/GIF files/mobile apps to interpret the scientific properties of electromagnetic waves. **Using Physical Tools** - Use of electronic devices and other available materials demonstrate concept and design models. **Carrying out STEM Activities** - Set up a mini radio station in the school (model or working) based on information gathered.

			Promoting Socio-cultural, Economic, Environment, and Human Values. -Enhance communication and general wellbeing of mankind.

Table 10. *Learning Objectives and Dimensions for Atomic, Nuclear, and Space Physics, class X*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explore the characteristics of α, β and γ particles and identify their emission using a simulation or CAI tools. ii. Explain applications and safety precautions related to radioactive substances. iii. Explain the law of universal gravitation using interactive simulation. iv. Communicate scientific and technical information about evolution of the universe, solar system, planets, and stars. v. Describe various types of space exploration and spacecrafts used to enhance understanding of space exploration.	**5.1 Nuclear atom** 5.1.1 Radioactivity *(Scope: detection and properties of α,β,γ radiation, radioactive decay and its applications, safety precautions)* **5.2. Space Exploration** 5.2.1. The Universe *(Scope: Newton's law of universal gravitation and its role, the origin and evolution of the universe: Solar system, galaxies, stars, planets).* 5.2.2. Space Explorer *(Scope: human space exploration, rovers, spacecrafts)*	**Asking Questions and Defining Problems** -What is the role of gravity in the formation of the universe? - What are the means of exploring space to find the possibility of life elsewhere? **Planning and Carrying out Investigations** -Use simulation or conceptual model to investigate the alpha, beta and gamma emission. **Developing and using models** -Develop a model of star formation illustrating important processes. **Analyzing and Interpreting Data** - Analyse the possibility of human survival on other planets. **Constructing Explanation and Designing Solutions** -Design a prototype of spacecrafts to explore the universe.	**Exploring Digital Resources** -Explore and study virtual illustrations of gravity and its role in the formation of the universe. -Use digital resources to gather scientific and technical information on the evolution of the universe, space exploration, and life elsewhere. **Using Physical Tools** - Use available materials to design models or prototypes. - Use programming language to create simulation or animation to simulate the alpha and beta emission. **Carrying out STEM Activities**

vi. Design a prototype of spacecrafts to explore the universe. vii. Explore the possibility of human survival beyond Earth.	5.2.3. Purpose of Space Exploration *(Scope: evidence of life elsewhere - Mars)*	**Obtaining, Evaluating and Communicating Information** -Explore the possibility of human survival beyond Earth. **Using Mathematics and Computational Thinking** -Calculate the mass number and atomic number of substances after alpha, beta, and gamma emission. - Use mathematical expressions of the universal law of gravitation to solve numerical problems. **Engaging in Argument from Evidence** - Collect information and scientific evidence to back up your claim about life on other planets.	**-** Use programming language to create simulation or animation to simulate the alpha, beta, and gamma emission. - Design prototype (conceptual or physical) of a space explorer. **Promoting Socio-cultural, Economic, Environment, and Human Values**. - Comprehend and communicate on the positive use of radioactivity. - Appreciate the continuous evolution of the universe and relate it to different philosophical assumptions.

12.2 Key Stage 5 (XI-XII)

Competency-based Standard

By the end of key stage 5 (class XII), learners should be able to:

1. **Newtonian Mechanics**

1.1. *Vectors*

- Exhibit the understanding of scalar and vector to represent physical quantities, resolve vector quantities using interactive tools and apply the concept of resultant vectors in daily life experiences.

1.2. *Motion along a straight line and plane*

- Examine the motion of an object in terms of its position, velocity and acceleration (with respect to a frame of reference) as functions of time to solve numerical problems related to real life situations.
- Describe the shape of the path taken by projectile motion launched at different angles is independent of horizontal and vertical motion and apply the concept to solve numerical problems relating to everyday applications.

1.3. *Dynamics – forces in action*

- Construct relationships among force, mass and acceleration (F=ma) and momentum, mass and velocity (p=mv) using Newton's laws of motion.

1.4.Mechanical Properties of Solids

- Determine elastic behavior of solids through experimentation to study its applications in the engineering fields.

1.5. *Oscillation*

- Interpret oscillatory motion using graphs and equations to solve numerical problems of oscillatory motion.

2. Fluid Mechanics and Thermal Physics

2.1 Investigate the properties and energy possessed by a fluid to comprehend the practical applications of fluid mechanics.

2.2 Explain PV diagram to show that internal energy is state variable and recognise its applications in batteries, air compression technology, and environmental conservation.

3. Electricity and magnetism

3.1 Magnetism

- Investigate and explain the force experienced by a current carrying conductor placed in a magnetic field based on the concept of magnetic flux to exhibit a understanding of electromagnetism.

3.2 Electromagnetism

- Design and conduct an experiment to describe the force experienced by a moving charge (Lorentz force) and a current carrying conductor placed in a magnetic field to understand the working of electrical devices that use motors.

3.3 Electricity

- Experiment and describe the net effect of interaction of charges (Coulomb's Law) and net effect of voltage and current through complex circuits (Kirchhoff's law and principle of wheatstone bridge).
- Examine the heating effect of a conductor due to electric current to determine the power rating of electrical appliances and calculate the costs of running various electrical appliances.
- Identify the resistors based on colour coding and investigate effectiveness of parallel and series connection to make the right choice for household wiring and safety precaution.
- Investigate Faraday's and Lenz's law to understand the induced e.m.f in simple generators, self and mutual inductance to describe the working of transformers.
- Compare the temperature dependence of resistivity of conductors, semiconductors, thermistors, and superconductors to apply the concept of conservation of energy in electrical devices.
- Study semiconductors to understand its application in sensors and thin film technology.
- Examine a.c circuit, explain sinusoidal variation of voltage and current, and solve numerical problems.

3.4 Capacitor

- Experiment and examine the behaviour of a capacitor during charging and discharging through a capacitor to determine the effective capacitance when capacitors are connected in series or parallel and apply the concept in electronics.

4. Waves and optics

4.1 Ray optics

- Develop conceptual understanding of formation of images by different optical systems, total internal reflection and its application in medical technology, telecommunications and natural phenomena and verify these concepts through simulations or practical experiments.

4.2 Waves

- Explain the concept, properties and mode of propagation of electromagnetic waves and examine its applications in communication systems and medical fields.
- Explore information to support the claim that digital signals are a more reliable way to encode and transmit information than analog signals.
- Describe the concept of interference and diffraction using Huygens' principle and superposition of waves to understand its applications in various fields.

5. Atomic, Nuclear and Space Physics

5.1 Nuclear and particle physics

- Explore applications of atomic and nuclear phenomena such as nanotechnology, radiation therapy, diagnostic imaging and nuclear power (purpose).

5.2 Quantum physics

- Explain the concept of photoelectric effect simulation to comprehend the particle nature of light and its application in the solar industry.

5.3 Space physics

- Explain the principle of stationing/launching satellites and Kepler's laws of planetary motion to describe the motion of planets and satellites.
- Assess the emerging satellite technologies and rocketry to make best use of their applications in the area of remote sensing.
- Identify the rocket parameters using interactive simulation to deploy satellites for the particular purposes undergoing different stages of rocket launch.
- Suggest ways to remove satellite debris in the space to reduce hazards of the space environment inline with the GNH philosophy.

Class-wise Competency (Class XI)

1. Newtonian Mechanics

- Explain scalars and vectors to solve numerical problems and relate its applications to real life situations.
- Carry out an experiment to investigate motion of an object in terms of position, velocity and acceleration with respect to time and apply mathematical relations to solve the problem numerically and graphically.

- Analyse the projectile motion, including the resolution of vertical and horizontal components of acceleration, velocity, and displacement using interactive simulation to relate its applications in games, military, and Physical Processes in motion.
- Verify Newton's laws of motion to apply their concept in everyday experiences.
- Examine the law of conservation of momentum and circular motion using relevant tools (simulations, apps, or physical tools) to relate its significance in daily life.
- Interpret the concept of elastic properties of materials using Hooke’s law to make the right choice of material for the construction of different infrastructures.
- Investigate the transformation of energy experimentally to describe the conservation of mechanical energy.

2. Fluid Mechanics and Thermal Physics

- Explain the concept of internal energy and its relation with heat and work using simulations or physical tools to comprehend the concept of conservation of energy.
- Describe the internal energy to comprehend thermodynamic processes and technological implications in daily life.

3. Electricity and Magnetism

- Conduct an experiment to demonstrate Lorentz force and determine the direction of current, magnetic field and force using appropriate rules to apply the concept in construction of electric motors.
- Explain magnetic flux and its density to determine the field strength and its applications.
- Illustrate the pattern of motion of a charged particle in a uniform magnetic field using 3D interactive simulation to comprehend its application in electronics.
- Identify the colour bands of the resistor to specify the actual value of resistance used in the electrical circuits.
- Explain electrical power and electrical energy consumption to calculate the electric bill.
- Investigate the effectiveness of parallel and series connections of resistors to make a professional judgment for household circuiting based on evidence.

4. Waves and Optics

- Investigate the properties of waves using simulation to comprehend the significance of waves in daily life.
- Explain the concept of total internal reflection and to describe its application in communication, medical technology and natural phenomena.
- Explain the electromagnetic waves (EM), its modes of propagation, basic terminologies to comprehend the modern communication systems.
- Interpret analogue and digital signals to substantiate the advantages of digital signals in modern communication.
- Describe polarization of EM waves to understand its applications in the plastic industry, movie industry and seismology.

5 Atomic, Nuclear and Space Physics

- Describe the atomic masses and composition of nucleus to explain nuclear force using interactive simulation to determine the advantages and disadvantages of the nuclear force.
- Investigate spectral series of hydrogen atom to study the emission spectrum using interactive simulation to show that all materials, when hot, will emit light.
- Investigate the phenomenon of radioactivity using the nuclear equation of decay reaction and discuss the benefits and risks involved.
- Describe the universal law of gravitation to determine the acceleration due to gravity on Earth, escape velocity, and explain centripetal force and gravitational force that keeps celestial bodies in orbit.
- Explore information on satellite technologies to make the best use of their applications in the area of remote sensing.

Table 11. *Learning Objectives and Dimensions for Newtonian Mechanics, class XI*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Carry out an experiment to explain rest and motion, position and path length of an object. ii. Interpret instantaneous values of speed, velocity and acceleration using graphs or Computer Assisted Instruction (CAI). iii. Derive kinematic equations using graphical methods for uniform motion. iv. Interpret the differences between scalars and vectors	**1.1 Motion in a Straight Line** **1.1.1** Rest and Motion *(Scope: Rest and Motion, Position, and Path length)* **1.1.2** Instantaneous Velocity (*Scope: instantaneous speed and acceleration using velocity-time graph).* **1.1.3** Kinematic Equations *(Scope: derivation using Graphical method, solve numerical problems*). **1.2. Motion in a Plane** 1.2.1. Scalars and Vectors *(Scope: addition and subtraction of vectors by graphical method, resolution of vectors, phasor).*	**Asking Questions and Defining Problems** -What are the advantages and disadvantages of elastic behaviour of materials? **Planning and Carrying out Investigations** -Conduct an experiment to interpret position,velocity and acceleration graphically. -Carry out an experiment to verify Newton's second law. -Design and conduct experiments to verify law of	**Exploring Digital Resources** - Use mobile apps (e.g. physics at school) to study motion graphs. -Use simulations to examine the projectile motion. -Use simulations or mobile apps to deepen the understanding of conservation of

to perform addition and subtraction of vectors using interactive simulation. v. Derive and verify the parallelogram law of vector addition. vi. Examine the projectile motion using mobile apps or interactive simulations and relate its applications in everyday experiences. vii. Design an experiment to verify Newton's laws of motion and demonstrate the applications of Newton's laws and impulse in real life situations. viii. Conduct an experiment to verify the law of conservation of momentum using simulation/physical tools. ix. Conduct an investigation to exhibit that force varies with mass, velocity and radius to equate centripetal force and weight. x. Carry out an experiment to verify Hooke's law and explore the applications of materials in the engineering field based on their mechanical properties. xi. Compare the density of a glass slab and a wire using	1.2.2. Parallelogram Law of Vector addition *(Scope: derivation, solve numerical problems to find the resultant vectors)* 1.2.3. Projectile Motion *(Scope:derivation, terms related to projectile motion, application in daily life).* **1.3. Laws of Motion** 1.3.1. Law of Inertia. *(Scope: Newton's first, second (F = ma), third law and its applications in daily life, calculate the impulse due to a force and impulse-momentum theorem.)* 1.3.2. Conservation of Momentum *(Scope: elastic and inelastic collision).* 1.3.3. Circular Motion *(Scope: uniform circular motion, centripetal force, centripetal acceleration, average speed, period and frequency of rotation).* **1.4. Mechanical Properties of Solids** 1.4.1. Elastic Behaviour of Solids. *(Scope: elastic* behaviour *of solids, types of stress and strain, stress and strain curve,calculate stress and strain, Hooke's law, work done by a spring force, Young's modulus and applications of elastic* behaviour *of materials).* *1.4.2.* Density of Objects *(Scope: compare the densities of different materials, least count, zero error)* **1.5. Work, Energy** 1.5.1. Work *(Scope: commutative properties of scalar products, graphical explanation of work done, calculate work*	conservation of momentum and Hooke's law. -Design and conduct an experiment to verify parallelogram law of vector addition. - **Analyzing and Interpreting Data** -Use the data to interpret Newton's second law. -Analyze the data to verify the Hooke's law. -study the data obtained to verify parallelogram law of vector addition. **Constructing Explanation and Designing Solutions** -Construct an explanation on conservation of momentum. **Using Mathematics and Computational Thinking** -Apply kinematic equations to solve numerical problems. **Engaging in Argument From Evidence** -Construct scientific arguments on advantages and disadvantages of elastic behaviour of solids. **Developing and Using Models** -Design a model to enhance the understanding of Newton's third law of motion.	momentum and projectile motion. **Using Physical Tools** -use vernier callipers screw gauge to measure density of an object. -Use Gravesand's apparatus to verify Parallelogram law of vector addition **Carrying out STEM Activities** -Design and construct a model car from available materials to demonstrate Newton's law of motion. -Improvise Gravesand's apparatus to verify parallelogram law of vector addition. **Promoting Socio-cultural, Economic Environment, and Human Values**

vernier callipers and screw gauge. xii. Carry out an activity to interpret the force-displacement graph and relate work done in terms of scalar product of vectors to verify work done by gravitational force using simulation. xiii. Investigate the transformation of energy experimentally to describe the conservation of mechanical energy.	*done using scalar product of vectors, work done by gravitational force).* 1.5.2. Conservation of Mechanical Energy. *(Scope: kinetic energy (K.E), calculation of K.E for moving bodies using final expression, concept of potential energy (P.E), calculation of P.E near the Earth's surface, law of conservation of mechanical energy using equations of potential energy and kinetic energy, and its calculation from work done).*	-Construct a Gravesand's apparatus study vector addition. **Obtaining, Evaluating and Communicating Information** -Explain and demonstrate the application of Newton's laws in rocket launch.	- Design a working model that works based on Newton's law and contributes to the betterment of society.

Table 12. *Learning Objectives and Dimensions for Fluid Mechanics and Thermal Physics, class XI*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering	**Society and Technology**
i. Conduct an experiment to explain work done on the system and work done by the system to comprehend the thermodynamic processes. ii. Interpret the relation between internal energy and temperature to understand the motion of the gas molecules and plot PV diagram	**2.1 Thermal Physics** 2.1.1 Heat, Internal Energy and Work *(Scope: internal energy and its relation with heat and work, first law of thermodynamics (pressure-volume (PV) diagram), thermodynamic processes, equation and its calculations, internal energy at absolute zero temperature).*	**Asking Questions and Defining Problems** -how temperature affects the motion of a gas molecule? **Planning and carrying out investigation** -Design an experiment to explain work done on the system and by the system. **Constructing explanation and designing solutions** -Construct an explanation on how internal energy and temperature are related. **Using Mathematics and Computational Thinking** -Solve numerical problems related to internal energy and temperature. **Engaging in Argument From Evidence**	**Exploring Digital Resources** -Use simulations/mobile apps to understand the relation between internal energy and the temperature. **Using Physical Tools** - Use thermometers to interpret the concept of heat and internal energy. **Carrying out STEM Activities** -Use interactive simulation to demonstrate the concept of internal energy and temperature.

using interactive simulation.		-engage in scientific debate on conservation of heat energy. **Developing and Using Models** -Use models such as thermos flasks to explain how heat is retained and insulated. **Obtaining, Evaluating and Communicating Information** -Evaluate the need of thermal reservoirs for people living in cold places of Bhutan.	**-Promoting Socio-cultural, Economic, Environment and Human Values** -Appreciate the conservation of the environment, and improvement of economic value through infrastructure built based on green technology (thermal insulation).

Table 13. *Learning Objectives and Dimensions for Electricity and Magnetism, class XI*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	**Society and Technology**
i. Design an experiment to demonstrate Lorentz force and determine direction of force, current and magnetic field using right hand rule. ii. Explain the magnetic flux and its density to determine the magnetic field strength. iii. Illustrate the motion of a charged particle placed in a uniform magnetic field using 3D interactive simulation. iv. Obtain the resistance value of carbon resistor using colour coding and verify the value of resistance using	**3.1 Magnetic Fields** **3.1.1** Magnetic Force and Field (*Scope: Lorentz force, magnetic force on a current carrying conductor in a magnetic field, magnetic field pattern due to a long straight current carrying conductor*). **3.1.2** Magnetic Flux (*Scope: magnetic flux, flux density and numerical problems*). **3.1.3** Motion of a Charged Particle in a Uniform Magnetic Field (*Scope: motion of a charged particle in a uniform magnetic field*). **3.2 Electric Circuits** 3.2.1 Resistivity of Various Materials (Scope: resistor colour codes)	**Asking questions and defining problems** -Which electrical circuit is effective for household wiring? Parallel or series? **Planning and carrying out investigation** -Carry out an experiment to demonstrate Lorentz force. -Conduct a comparative study to investigate which connection (series or parallel) is better for household circuits. **Developing and using models** -develop and use a working model to demonstrate series and parallel connections. **Analyzing and interpreting data** -analyze the direction of the force experienced by a conductor when the direction of current is reversed.	**Exploring Digital Resources** -Use interactive simulations to demonstrate the motion of charge particles in uniform magnetic fields. **Using Physical Tools** - Use magnet, conductor and mercury to conduct experiments to verify Lorentz force. **-**Use ammeter, voltmeter, connecting wires and bulbs to demonstrate the connections.

multimeter and mobile application. v. Explain electrical power and electrical energy consumption to calculate the electric bill. vi. Investigate the voltage drop across the dry cell to determine the efficiency of a dry cell. vii. Experiment with the equivalent resistance of resistors in series and parallel combinations to make a professional decision based on investigative evidence for residential circuitry.	3.2.2 Electrical Energy and Power (*Scope: calculate electrical energy, power in electric circuits and electric bill based on the consumption of the electrical energy*). 3.2.3 Internal Resistance of a Cell *(Scope: internal resistance, voltage drop)* 3.2.4 Series and Parallel Circuits (*Scope: series and parallel combination of resistors in electrical circuits, and calculate the effective resistance and effective conductance of electric ircuits, principle of wheatstone bridge)*	-Analyze the effectiveness of two methods of connections. -calculate and analyze the consumption of the monthly electric bill. -examine the resistor value using colour codes. **Constructing explanation and designing solutions** -Construct explanatory concept of Lorentz force based on the information gathered from the experiment. **Obtaining, evaluating and communicating information** - Evaluate the effectiveness of two methods of connections. -assess voltage drop across the dry cell due to internal resistance. **Using Mathematics and Computational Thinking** -Use mathematical expression of electrical energy to calculate electric bill. -calculate magnetic flux using mathematical expression. **Engaging in argument from evidence** -Engage students to debate on selecting a particular type of electrical connection in household wiring.	-use resistors and multimeter to determine the resistor value. **Carrying out STEM Activities** -Use multimeter and mobile app to verify the resistance of carbon resistors. -Construct a circuit model to demonstrate series and parallel connections. **Promoting Socio-cultural, Economic, Environment and Human Values** -Apply the knowledge of parallel connection in household wiring effectively. -keep track of electrical energy consumption and use the electrical energy efficiently.

Table 14. *Learning Objectives and Dimensions for Waves and Optics, class XI*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology

i. Carry out an experiment to demonstrate Snell's law and examine its application in designing optical instruments. ii. Study how the angle of incidence and angle of minimum deviation determine the refractive index of a given prism. iii. Explain the concept of total internal reflection and relate its applications in communication and natural phenomena (rainbow). iv. Determine the focal length of a concave mirror based on its radius of curvature v. Explain the concept of waves and the characteristics of transverse and longitudinal waves using simulations and solve numerical problems related to waves. vi. Design a model to explain electromagnetic waves and its application in modern communication systems.	**4.1 Optics** 4.1.1 **Snell's Law** *(Scope: reflection, refraction, calculation of refractive index using Snell's law).* *5.1.*Refractive index *(Scope:, angle of incidence, angle of deviation, angle of refraction, angle of emergence, angle of prism)* 5.2.Total Internal Reflection (*Scope: formation of rainbow, optical fibres, construction and working of optical fibre: acceptance angle (final expression) and its application in medical technology and communication*). *5.3.*Radius of curvature and focal length of concave mirror *(Scope:spherometer, least count, focal length, relation between focal length and radius of curvature)* 5.4.**Waves** 4.2.1. Characteristics of Transverse and Longitudinal Waves (*Scope: wave motion and types of waves, calculation of wavelength, frequency, velocity, displacement, amplitude, period and phase, differences between transverse and longitudinal waves along with graphical representations*).	**Asking questions and defining problems** -Which mode of digital transmission (wireless or wired) is preferred in modern communication systems? -Under what circumstances can we observe a rainbow? **Planning and carrying out investigation** -conduct an experiment to verify Snell's law. -carry out an experiment to determine the focal length of a concave mirror. **Developing and using models** -Use a model of radio communication to explain the application of EM waves. -use sunglasses to explain polarization. **Analyzing and interpreting data** -analyze the variables obtained from experiment and verify Snell's law. **Constructing explanation and designing solutions** -Construct an explanation on how ground wave propagation is used in communication over short distances. -apply scientific information gathered to construct an explanation on advantages of digital signals over analogue signals in modern communication systems. -explain how the angle of incidence determines the refractive index of a	**Exploring Digital Resources** -Use interactive simulations to understand three different modes of propagation of EM waves. -Use simulations /multimedia to interpret the superiority of digital signal over analogue signal in modern communication systems. **Using Physical Tools** -Use glass blocks, optical pins and drawing boards to conduct experiments to verify Snell's law. –Use spherometer and concave mirror to determine the focal length. **Carrying out STEM Activities** -Use multimedia to comprehend the different applications of polarized EM waves. - Construct a model to illuminate the house based on the concept of refraction and reflection. -Design a model of radio communication to

vii. Explain modes of propagation of electromagnetic (EM) waves to understand the concept of maximum line-of-sight and calculate maximum line-of-sight. viii. Examine the advantages of digital signals over analogue signals in modern communication systems through the use of multimedia. ix. Explain the concept of polarization of EM waves using simulation and multimedia and explore its applications.	5.5.**Electromagnetic Waves** 4.3.1. Electromagnetic Waves (*Scope: electromagnetic waves, its applications in communication, elements of a communication system and basic terminologies used in communication systems*). 4.3.2. Propagation of Electromagnetic Waves (*Scope: the propagation of electromagnetic waves and calculation of maximum line-of-sight to get digital signals).* 4.3.3. Analogue Signal and Digital Signal (*Scope: differences between analogue and digital signals and sampling of analogue signals to get digital signals, advantages of digital signals in modern communication*). 4.3.4. Polarization of Electromagnetic Waves (*Scope: polarization of electromagnetic waves and its applications in plastic, movie industry and seismology*).	prism based on the evidence collected from the experiment. **Obtaining, evaluating and communicating information** -evaluate the information gathered from the simulation and discuss how electromagnetic (EM) waves propagate. -evaluate the information obtained from multimedia to explain advantages of digital signals in modern communication. **Using Mathematics and Computational Thinking** -solve numerical problems based on Snell's law to compare the refractive index of different optically transparent media. -organize data in graphs to calculate frequency, time period, wavelength, and velocity. **Engaging in argument from evidence** -Engage in a debate on helpful and harmful effects of electromagnetic waves in communication.	enhance the understanding of applications of EM waves. **Promoting Socio-cultural, Economic, Environment, and Human Values** -conserve environment by designing a green technology based on concept of refraction and reflection - use the knowledge of wireless communication technology to reduce expenditure and resources used for wiring. -Promote the values of saving energy using the knowledge of optical illumination for socio economic development. -use modern communication systems to promote preservation of our culture.

Table 15. *Learning Objectives and Dimensions for Atomic, Nuclear and Space Physics, class XI*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology

i. Investigate a spectral series of hydrogen atom using interactive simulations or any apps. ii. Explain the concept of half-life decay of radioactive nuclei using water analogy to comprehend radioactivity. iii. Investigate the phenomenon of radioactivity using the concept of half-life and the nuclear decay equation to assess the benefits and risks involved. iv. Describe the effect of gravitational force on centripetal force to comprehend the motion of satellites in the orbit. v. Describe different types of Satellites vi. Explain the applications of satellite technology for various purposes.	**5.1 Atoms** 5.1.1 **Atomic Spectra** (*Scope: discrete energy level, transition between energy level, atomic spectra and spectral series of hydrogen atom, Rydberg's formula and its usage in determining wavelength of spectral lines*). **5.2 Nuclei** 5.2.1 **Radioactivity** *(Scope: isotope, stability, radioactivity, law of radioactive decay, final expression with decay constant, half-life and calculation, decay curves, nuclear decay equations, applications of radioactivity, safety)* **5.3 Space Technology** 5.3.1 Universal Law of Gravitation (Scope: *acceleration due to gravity of the Earth, orbital velocity, centripetal force)* 5.3.2 Satellites *(Scope: types of satellites based on their orbit and payload)* 5.3.3 Space Technology Applications *(Scope: communications, Earth observation, disaster management, weather*	**Asking questions and defining problems** -How does nuclear radiation impact the environment? -How can we use carbon dating to find out the age of materials? -how can atomic spectra be used to identify elements? -What keeps the satellite stay in orbit? **Planning and carrying out investigation** -plan and carry out a project to investigate the factors affecting climate in Bhutan. -Experiment to investigate the types of satellite data through data analysis tools. **Developing and using models** -Design a model of satellite based on the information gathered about payload and orbital mechanics. -**Analyzing and interpreting data** -Analyze and interpret the data obtained from remote sensing data archive and suggest measures to combat climate change. -**Constructing explanation and designing solutions** -Construct an explanation on various applications of radioactivity in medical science. -apply scientific ideas to review an explanation about the universal law of gravitation. **Obtaining, evaluating and communicating information** -Evaluate the benefits and risks of nuclear radiation for health and environment. -analyze the information from remote sensing data archive to inform the findings to the relevant authorities and general public through online social platforms.	**Exploring Digital Resources** -Use multimedia to interpret the concept of nuclear stability. - Use video to explain the types of satellites. -Use satellite image source, online and offline software to processing data. **Using Physical Tools** -use burette, stop clock in water analogy to explain the concept of half-life decay of radioactive nuclei. **Carrying out STEM Activities** -Design a model of satellite based on the information gathered about payload and orbital mechanics. **Promoting Socio-cultural, Economic,**

vii. Analyse satellite data to study local and global phenomena such as global warming, natural disaster, land use, etc.	*forecast, education, health, navigation, agriculture, etc.)* 5.3.4 Satellite Data Analysis *(Scope: satellite data analysis, remote sensing).*	**Using Mathematics and Computational Thinking** -describe the spectral lines by calculating wavelength using Rydberg's formula. -organize the data and plot the decay curve to calculate half-life. **Engaging in argument from evidence** -critique satellite technology in bhutan by citing relevant evidence and providing scientific questions. -Engage in a debate on advantages and disadvantages of having our own satellite stationed in space.	**Environment, and Human Values** - Advocate on applications of nuclear radiation. -analyze the information from remote sensing data archive to address local and global challenges (weather and climate).

Class-wise Competency (Class XII)

1. Newtonian Mechanics

- Conduct an experiment to interpret the concept of simple harmonic motion graphically using interactive simulation and study its application in amusement parks, open space gyms, earthquake seismometers etc.
- Explain the concept of resonance through an experiment to create awareness about the effect of seismic waves on infrastructures and design a conceptual model of earthquake resistant infrastructures.

2. Fluid Mechanics and Thermal Physics

- Conduct an experiment on surface tension to comprehend the movement of liquids in capillary tubes and flow of liquids through porous surfaces and apply the concept to separate water from mixtures or purify water of microscopic impurities.
- Design an experiment to measure the viscosity of the fluids to comprehend behaviour of flow of fluid.
- Validate the Bernoulli's equation using interactive simulations or models to explore the various applications in sizing the pipe, flow sensors, ejectors, pitot tube etc.

3. Electricity and Magnetism

- Examine force of attraction and repulsion between charges using any interactive simulations or apps to explain Coulomb's law.
- Interpret electric field, its strength and express electric flux for uniform and non-uniform electric field using simulations or apps to relate its applications in our life.

- Construct a model of capacitor to explain its function as energy storage used in electronic devices.
- Design an experiment to verify Faraday's laws of electromagnetic induction and apply the concept to design a working or conceptual model of a generator.
- Explain the concept of self and mutual inductance and design a model (conceptual or working) to comprehend the working mechanism of a transformer.
- Investigate the temperature dependence of resistivity of conductors, semiconductors, thermistors, and superconductors to identify appropriate materials for various applications.
- Explain the distribution of voltage and current within the circuit and solve circuit network problems using the concept of Kirchhoff's law.
- Explain a.c. circuit using interactive simulation or apps to describe the occurrence of electrical resonance.

4. Waves and Optics

- Conduct an experiment to study the behaviour of light when it strikes on different optical media and use the concept to design optical instruments.
- Investigate and sketch image formation for different optical media using interactive simulation to comprehend the significance of optical media in optical instruments.
- Verify Huygens' principle using appropriate light sources to explain the wave nature of light.
- Illustrate interference and diffraction graphically and use the concept to study the stellar spectra and relate the concept in the field of optical communication.
- Explain the particle nature of light and the photoelectric effect (Einstein's photoelectric equation) using interactive simulations/multimedia to relate its working in solar panel.

5. Atomic, Nuclear and Space Physics

- Examine the interior components of atoms and explain the behaviour and properties of each component to explain the standard model.
- Study the concept of nanotechnology and recognise its significance and influence in our society.
- Study nuclear energy as an alternative source of energy in future to assess the pros and cons of nuclear energy.
- Identify the rocket parameters using interactive simulation to comprehend the process of rocket launch and satellite deployment.
- Examine the methods of satellite disposal and suggest ways to minimize the accumulation of defunct satellites in space.

Table 16. *Learning Objectives and Dimensions for Newtonian Mechanics, class XII*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explain periodic motion and oscillatory motion and relate with Simple Harmonic Motion (SHM) graphically using interactive simulation. ii. Use algebraic or computational representations to claim that total energy in SHM is conserved. iii. Determine the value of acceleration due to gravity of a place to provide scientific evidence that a simple pendulum executes SHM. iv. Experimentally investigate the concept of resonance using a tuning fork.	**1. Newtonian Mechanics** **1.1. Oscillations** 1.1.1. Periodic and Oscillatory Motions. *(Scope: Periodic and Oscillatory motions, simple harmonic motion, time period and frequency of periodic motion and displacement of periodic motion and its calculation, relation between simple harmonic motion and uniform circular motion.)* 1.1.2. Velocity and Acceleration in Simple Harmonic Motion. *(Scope: velocity and acceleration in simple harmonic motion.)* 1.1.3. Energy in Simple Harmonic Motion. *(Scope: energy in Simple Harmonic Motion (SHM), Hooke's law, slope and intercept from graph, least count of stopclock)* 1.1.4. System Executing Simple Harmonic Motion: Simple Pendulum. *(Scope: simple pendulum, acceleration due to*	**Asking questions and defining problems** -What is the relation between simple harmonic motion and uniform circular motion? -Why do soldiers break steps while marching over a bridge? **Planning and carrying out investigation** - Conduct experiments to show SHM using a simple pendulum and spring with slotted weights. - Conduct an experiment on resonance using a tuning fork. **-Analysing and interpreting data** -Analyse data obtained from various experiments such as simple pendulum, spring constant and resonance and apply it to calculate unknown variables. **-Constructing explanation and designing solutions** -Explain how earthquake waves cause resonance that leads to destruction of human properties and design a conceptual model of earthquake resistant infrastructures. **Obtaining, evaluating and communicating information** -Evaluate the applications of resonance in daily life. **Using Mathematics and Computational Thinking**	**Exploring Digital Resources** -Use simulations to explain periodic and simple harmonic motion. **Using Physical Tools** - Use a simple pendulum and mass-spring system to interpret and demonstrate the concept of simple harmonic motion. -Use sonometer and tuning fork to demonstrate the concept of resonance. **Carrying out STEM Activities** **-**Design a model of earthquake resistant infrastructures. -Design experiment to use mass-spring system to comprehend the concept of force constant and time period.

	gravity, time period, least count of vernier caliper and stopclock, conceptual relationship between effective length and time period, slope from graph) 1.1.5. Forced Oscillations and Resonance *(Scope: free, forced oscillation and resonance, condition for resonance in forced oscillations, frequency of tuning fork, tension of wire, resonance, sonometer)*	-Employ mathematical representations to support the claim that total mechanical energy is conserved in SHM. **Engaging in argument from evidence** **-**Engage debate construction of earthquake resistant infrastructures in the locality based on seismological data. - Discuss how the time period is affected by the effective length of a simple pendulum. **Developing and using models** -design an earthquake resistant model and sonometer to demonstrate the concept of resonance. -use a mass-spring system (model) to comprehend the concept of force constant and time period.	**Promoting Socio-cultural, Economic, and Human Values** -Create awareness on the importance of building earthquake resistant infrastructures.

Table 17. *Learning Objectives and Dimensions for Fluid Mechanics and Thermal Physics, class XII*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Carry out an experiment on surface tension of liquid from capillary rise method to comprehend its importance in everyday phenomena. ii. Design an experiment to measure the viscosity of the fluids and explain its applications in our daily life.	**2.1 Fluid Mechanics** 2.1.1 Surface Tension. *(Scope: Motion of bodies in a uniform gravitational field with fluid resistance, graphs and only final expressions, molecular theory for surface tension, applications of surface tension, cause and effect of surface tension in liquids, angle of contact, movement of liquids in capillary tubes using ideas of surface tension, travelling*	**Asking Questions and Defining Problems** **-**How is surface tension related to viscosity? -How Bernoulli's equation is applied in the engineering field? - Will it be possible for animals and plants to survive without surface tension? **Planning and Carrying out Investigations** -Carry out an experiment to investigate surface tension and its importance in everyday phenomena. **Developing and Using Models**	**Exploring Digital Resources** -Use interactive simulations to verify Bernoulli's equation. -Use interactive simulations/multimedia to explain real and ideal gases. **Using Physical Tools** -Use a travelling microscope to determine the surface

iii. Verify Bernoulli's equation using interactive simulations or models. iv. Differentiate between real and ideal gases using multimedia. v. Explain kinetic theory of an ideal gas and solve numerical problems.	*microscope, least count of travelling microscope, flow of liquids through porous media using capillary action.)* 2.1.2 Viscosity of Fluids. *(Scope: viscosity of fluids, streamline, laminar and turbulent flow, equation of continuity - principle of continuity in any steady state process, Bernoulli's principle and its application).* **2.2 Kinetic Theory of Gas** 2.2.1 Kinetic Theory of Ideal Gas *(Scope: real and ideal gas, postulates and consequences of the kinetic theory of gases, pressure of an ideal gas, kinetic interpretation of temperature and final expression of average, rms and most probable speed of gas molecule)*.	-Use a travelling microscope to determine the surface tension of water from the capillary rise method. **Analyzing and Interpreting Data** -Analyze the data of viscosity of liquid to understand its applications. **Using Mathematics and Computational Thinking** -Solve numerical problems related to capillary rise and the kinetic theory of ideal gas. **Constructing Explanation and Designing Solutions** -Explain the importance of viscosity of different fluids and its applications. **Engaging in Argument From Evidence** -Engage in a debate on the importance of surface tension of liquid. **Obtaining, Evaluating and Communicating Information** - Communicate kinetic theory of ideal gas.	tension of water from capillary rise method. **Carrying out STEM Activities** - Use simulations to explain the concept of Bernoulli's Principle. **Promoting Socio-cultural, Economic, and Human Values** -Understand and apply Bernoulli's principle to resize water pipes when watering gardens.

Table 18. *Learning Objectives and Dimensions for Electricity and Magnetism, class XII*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
i. Explain the basic properties of electric charge and verify Coulomb's law using interactive simulations. ii. Relate electric field, and electric flux and determine the strength of	**3. Electricity and magnetism** **3.1 Electricity** 3.1.1 Electric Charge. (*Scope: basic properties, Coulomb's law, forces due to multiple charges*). 3.1.2 Electric Field. *(Scope: electric field and electric field intensity, physical significance of electric field, electric field lines and their*	**Asking Questions and Defining Problems** -Why do people feel dizzy when they place their head inside a strong magnetic field? **Planning and Carrying out Investigations**	**Exploring Digital Resources** -Use interactive simulations/multimedia to explain electric field, electric flux and strength of the charge of an object.

the charge of an object using relevant mathematical expressions. iii. Construct a simple model of a capacitor to explain the working and its applications in electronic devices. iv. Explain the concept of combination of capacitors in series and parallel. v. Explain magnetic flux and terms related to it and solve numerical problems. vi. Define magnetic moment and compare the magnetic moment of two bar magnets to comprehend the magnetic field strength. vii. Design an experiment to verify Faraday's laws and relate Lenz's law to explain the working of a.c. generator. viii. Comprehend self and mutual induction to explain the concept of a transformer using simulations/multimedia ix. Classify substances into conductors, insulators and semiconductors and	*properties, similarities and differences between electric field and gravitational field, electric flux, electric field strength due to a point charge, electric field strength between two charged parallel plates, charged particle moving in a uniform electric field).* **3.2 Capacitors** 3.2.1 Capacitors and Capacitance. *(Scope: capacitors and capacitance, unit of capacitance, q = CV and effect of dielectric on capacitance, energy stored in capacitors (analytical and graphical), charging and discharging of capacitor (final expression and graphs))*. 3.2.2 Combination of Capacitors. *(Scope: series and parallel combinations of capacitors).* **3.3 Electromagnetic Induction** 3.3.1. Magnetic Flux. *(Scope: terms and final expressions of: magnetic circuit, permeability, magnetic field strength, magneto-motive force, reluctance, permeance, and flux in magnetic circuit).* 3.3.2. Magnetic moment of a bar magnet *(Scope: magnetic moment, tangent law, deflection magnetometer - Tan A position)* 3.3.3. The Experiments of Faraday and Henry. *(Scope: experiments of Faraday and Henry, Faraday's laws of electromagnetic induction, Lenz's law, energy conservation, and a.c. generator).* 3.3.4. Inductance. *(Scope: inductance, self induction and mutual induction, coefficient of self induction, coefficient of mutual induction, transformer).* **3.4 Electric Circuit**	-Conduct an experiment to determine the strength of charge of an object. -Construct a simple model of a generator. -Conduct experiments on emf of dry cell and specific resistance to examine Kirchhoff's law. **Developing and Using Models** -Use a digital model to verify the application of a potential divider. **Analysing and Interpreting Data** -Compare the temperature dependence of resistivity of conductors, semiconductors, thermistors, and superconductors. - Analyse the application of potential dividers using interactive simulations. **Using Mathematics and Computational Thinking** -Use expression of Coulomb's law to determine the electrostatic force between two charges. -Integrate the concept of transformer into adapter	**Using Physical Tools** -Use magnet and wire to develop models to demonstrate Faraday's , Henry's and Lenz's law. **Carrying out STEM Activities** - Use simulations to explain Faraday's law. **Promoting Socio-cultural, Economic, and Human Values** -Appreciate the importance of an a.c. generator in improving the human livelihood and reducing the environmental impact as a result of energy generated by using an a.c. generator.

evaluate their dependence on temperature. x. Explain semiconductors and its importance in designing electronic devices. xi. Conduct an experiment to verify Kirchhoff's laws. xii. Design a model based on the application of potential dividers using interactive simulations. xiii. Determine emf of a dry cell by changing the resistance. xiv. Determine specific resistance of the given wire by changing the resistance of the resistance box. xv. Explain the sinusoidal variation of voltage and current in an a.c. circuit using interactive simulation/multimedia. xvi. Apply graphical and mathematical methods to analyse the maximum current in the LCR circuit.	3.4.1 Classification of Substances. *(Scope: classification of substances into conductors, insulators and semiconductors based on the energy bands, effect of temperature on the resistivity of conductors, semiconductors, thermistor and superconductors, potential applications of Room Temperature Superconductors (RTS)).* 3.4.2 Semiconductors. *(Scope: types of semiconductor).* 3.4.3. DC Circuits. *(Scope: d.c. circuits, Kirchhoff's laws, applications of potential divider in light sensor, temperature sensor, and audio volume controls).* 3.4.4 Electromotive force of a dry cell. *(Scope: electromotive force (emf) of a dry cell, null point, least count, resistance per unit length, slope from graph).* 3.4.5 Specific resistance *(Scope: principle of wheatstone bridge, specific resistance of resistor, least count).* 3.4.6 AC Circuits. *(Scope: a.c. circuit, root mean square (RMS) value of a.c., sinusoidal variation of voltage and current when ac voltage is applied to resistor, inductor and capacitor in an a.c. circuit (final expressions)).* 3.4.7 AC Voltage Applied to a Series LCR Circuit. *(Scope: phasor diagram solution, analytical solution and resonance).*	using interactive simulation by changing the variables. -Use the mathematical expression to calculate the electric flux. **Constructing Explanation and Designing Solutions** -Construct a model of capacitor to show that it stores charge. **Obtaining, Evaluating and Communicating Information** -Evaluate the advantages and disadvantages of superconductors. **Engaging in Argument From Evidence** -Discuss the importance of a.c. generator based on scientific information.	

Table 19. *Learning Objectives and Dimensions for Waves and Optics, class XII*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology

i. Conduct an experiment to comprehend the behaviour of light when it strikes on spherical mirrors using interactive simulation and sketch ray diagrams. ii. Verify the focal length of a given convex lens by u-v and displacement method. iii. Determine the focal length of concave and convex lenses based on the concept of combination of lenses. iv. Perform an experiment to compare the refractive index of two liquids and verify the law of refraction. v. Verify Huygens' principle to comprehend refraction and reflection of plane waves using interactive simulations. vi. Investigate Young's experiment to understand superposition and interference of light waves using interactive simulation. vii. Explain the phenomena of diffraction of light and	**4. Waves and Optics** **4.1.Ray Optics** 4.1.1. Reflection of Light by Spherical Mirrors. *(Scope:reflection of light by spherical mirrors, cartesian sign convention, magnification, mirror equation (final expressions)).* 4.1.2. Refraction through Spherical Surfaces.*(Scope: Cartesian sign convention, linear (transverse) magnification, refraction by lenses, converging and diverging lenses, derivation and application of lens equation (final expression), focal length of lens using u-v and displacement method (range and least count of optical bench, slope from graph) mathematical expression of magnification, power of a lens, focal length by combination of lenses).* 4.1.3. Refractive Index *(Scope: law of refraction, real depth, apparent depth, traveling microscope, least count)* **4.2.Wave Optics** 4.2.1 Wavefront and Huygens' Principle. *(Scope: wavefront, types of wavefronts and Huygens' principle).* 4.2.2. Refraction and Reflection of Plane Waves using Huygens Principle. *(Scope: derivation)* 4.2.3. Superposition of Waves. *(Scope: superposition of waves, interference, coherence and incoherence, path difference and phase difference).*	**Asking Questions and Defining Problems** -What happens to the nature of images formed when light strikes on optical systems? -How does the refractive index of a liquid vary with change in real and apparent depth? -How can focal lengths of concave or convex lenses be determined by combining them with a convex lens? -What is the difference in intensity of light produced by interference and diffraction? **Planning and Carrying out Investigations** - Conduct an experiment to comprehend the refraction of light by spherical lens. -Conduct investigation to verify Einstein's photoelectric effect using multimedia/simulation. -Analyze how the position of an object affects the nature of the image formed when light strikes on optical systems using simulation. **Developing and Using Models** - Conduct an experiment to determine the focal length of a given lens using various methods (u-v, displacement, combination of lenses). -Use various simulations to explain behaviour of light when it strikes on optical systems, Huygens' principle, interference, diffraction and Einstein's photoelectric effect.	**Exploring Digital Resources** -Use interactive simulations to comprehend Hugyens' principle, Young's experiment and explain interferences of light using simulations,mobile apps, multimedia, etc. **Using Physical Tools** - Use lenses to interpret refraction of light. **Carrying out STEM Activities** - Use multimedia to explain Huygens' principle. **Promoting Socio-cultural, Economic, and Human Values** -Design a model to trap light energy as an alternative to

compare its intensity to that of interference. viii. Discuss the photon model of electromagnetic radiation and calculate energy of photon in eV. ix. Verify Einstein's photoelectric effect to comprehend the particle nature of light using multimedia/simulation. x. Explain the wave nature of light through the de Broglie wave equation using multimedia.	4.2.4. Interference and Young's Experiment. *(Scope: conditions for constructive and destructive interference, locating the fringes and intensity in double-slit interference).* 4.2.5 Diffraction. *(Scope: diffraction of light, diffraction by single slit: locating minima, use of diffraction in the spectral analysis of the light from the star).* **4.3. Quantum physics** 4.3.1. Particle Nature of Light: The photon. *(Scope: energy of photon and unit conversion in eV, photon model of electromagnetic radiation).* 4.3.2. Electron Emission and Photoelectric Effect. *(Scope: electron emission, experimental study of photoelectric effect, significance of the terms work function, stopping potential and threshold frequency, wave theory of light).* 4.3.3. Einstein's Photoelectric Equation: Energy Quantum of Radiation. *(Scope: photoelectric equation, numerical problems, and conservation of energy).* 4.3.4. Wave Nature of Matter. *(Scope: de Broglie matter waves, mathematical expressions and numerical problems).*	**Analysing and Interpreting Data** -Analyse the data to calculate focal length of a given mirror and lens. **Using Mathematics and Computational Thinking** -Solve numerical problems using equations related to the dual nature of light. -Use slope from graph to determine the focal length of concave and convex lenses based on the concept of combination of lenses. -Use interactive simulation to investigate Huygen's principle by comparing intensity of light after interference and diffraction. **Constructing Explanation and Designing Solutions** -Construct an explanation on the dual nature of light. **Obtaining, Evaluating and Communicating Information** -Communicate applications of light in designing optical devices like eyeglasses, camera, television, etc. **Engaging in Argument From Evidence /** -Organise a debate on the dual nature of light.	other natural resources.

Table 20. *Learning Objectives and Dimensions for Atomic, Nuclear, and Space Physics, class XII*

	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills

Learning Objectives (KSVA)		Scientific Methods and Engineering Practices	Society and Technology
i. Explain the interior components of atoms, its behaviour and properties using interactive simulation or video. ii. Describe particles and antiparticles to comprehend the concept of annihilation. iii. Explain the concept of nanotechnology and its real-world applications. iv. Explain mass defect and binding energy per nucleon and solve numerical problems. v. Interpret the curve of average binding energy per nucleon against nucleon number. vi. Evaluate the useful and destructive applications of nuclear fission. vii. Compare and contrast nuclear fission and nuclear fusion. viii. Explain satellite development processes to develop a model of an artificial satellite. ix. Explain the concept of rocket launch technology. x. Explain earth segment subsystems to investigate	**5. Atomic, Nuclear, and Space Physics** **5.1. Particle Physics** 5.1.1. Standard Model. *(Scope: elementary particles and four fundamental forces)* 5.1.2. Particles and Antiparticles. *(Scope: particles and antiparticles, annihilation of particles).* 5.1.3. Classification of Particles. *(Scope: classification of particles, quarks and leptons, properties of quarks, conservation laws regulating particles,change of quarks during β^+ and β^- decay).* 5.1.4. Nanotechnology *(Scope: nanotechnology, applications and future implications).* **5.2. Nuclear Energy** 5.2.1. Nuclear Energy *(Scope: nuclear energy, mass defect, binding energy, nuclear stability, thermal neutrons).* 5.2.2. Nuclear Fission: The basic process. *(Scope: nuclear fission, nuclear chain reaction-controlled and uncontrolled, nuclear fission reactor, peaceful and destructive applications of nuclear fission).* 5.2.3. Nuclear Fusion: The basic process. *(Scope: nuclear fusion, thermonuclear fusion in the Sun and other stars-CNO Cycle and P-P cycle, controlled thermonuclear fusion, advantages of nuclear fusion as a potential energy source over nuclear fission).*	**Asking Questions and Defining Problems** -Identify the key areas of research in the field of nanotechnology and its real-world applications. -Describe the processes of satellite development. -Explore the various systems and subsystems within a satellite. **Planning and Carrying out Investigations** Investigate the concept of nanotechnology and recognise its significance and influence in our society. -Investigate the methods of satellite tracking and operation from a ground station, satellite disposal or space debris management. **Developing and Using Models** Develop and use a model of an artificial satellite (conceptual or practical). **Analysing and Interpreting Data**	**Exploring Digital Resources** -Use simulations to study the interior components of atoms and it's properties. **Using Physical Tools** -Demonstrate the understanding of satellite development processes by developing a model of an artificial satellite (conceptual or practical). **Carrying out STEM Activities** -Design a model of a simple rocket to enrich students' understanding of rocket technology. **Promoting Socio-cultural, Economic,**

transmission and reception of signals from satellites and describe space segment subsystems to comprehend how satellites are stationed in a particular orbit. xi. Identify the elements of the space environment to minimize space hazards. xii. Study the space laws and regulations to create awareness that all nations have equal opportunity and accountability to explore space.	**5.3. Space Science and Technology: Satellite Development** 5.3.1. Processes of Satellite Development. *(Scope: mission definition review, preliminary design review, critical design review, safety review).* 5.3.2.Orbital Mechanics and Satellite Launch. *(Scope: Kepler's laws, rocket technology).* 5.3.3. Satellite Subsystems and Satellite Tracking or Operation. *(Scope: command and data-handling subsystem (CDHS), electrical power system (EPS), environmental control and life-support subsystem (ECLSS), onboard computer (OBC), structures and mechanics, satellite ground station, satellite tracking, satellite operation).* 5.3.4. The Space Environment. *(Scope: major hazards of the space environment, living and working in space).* 5.3.5. Satellite Disposal. *(Scope: end of life of a satellite, disposal, space debris management).* 5.3.6. Space Law and Regulations. *(Scope: international space treaties, registration convention, frequency regulations, international governing bodies such as international telecommunications union (ITU), united nations office for outer space affairs (UNOOSA)).*	-Interpret the curve of average binding energy per nucleon against the nucleon number. -Interpret the concept of nuclear fission using interactive simulation. -Analyze existing international and national space law and regulations. **Using Mathematics and Computational Thinking** -Solve numerical problems involving mass defect and binding energy. **-Constructing Explanation and Designing Solutions** -Examine the peaceful and destructive applications of nuclear fission. **Engaging in Argument From Evidence** -Argue on advantages and disadvantages of nuclear energy.	**Environment, and Human Values** -Design a model that demonstrates the peaceful application of nuclear energy. -Design a model that demonstrates the sustainable usage of space resources by space debris management. -Become aware on space laws and regulations.

SECTION E:ENVIRONMENTAL SCIENCE

4 SECTION E: Environmental Science

13. 1 Key Stage 4 (IX-X)

Competency-based Standard

By the end of key stage 4 (class X), a learner should be able to:

1. Systems in Nature

1.1. Exhibit understanding of the ecosystem and identify the effects of human activities on natural processes and inter-relationship in maintaining a balanced ecosystem in nature.

1.2. Analyse diverse factors that influence the ecosystem equilibrium and stability to understand the health of an ecosystem and communicate through the representations of flow charts and mathematical calculations.

2. Environmental Issues and Concerns

2.1. Use the understanding of the provisions of natural resources and the ecological footprint, develop an argument on how the human lifestyle is related to resource consumption to stimulate behaviour change of people for the sustainable well-being of people and the environment.

2.2. Demonstrate concerns towards the environment by exploring the transformation of human's dependence on natural resources with the change of their lifestyle, and exhibit behavioural change in consumption and waste generation patterns.

2.3. Evaluate the causes and impacts of pollution on humans and nature, and suggest preventive measures to reduce the ever-increasing pollution issues in the environment.

2.4. Design mitigation strategies and plans to manage and reduce the risk of disaster to save life, properties and the natural world.

3. Natural Resource Management

3.1. Illustrate conservation strategies and practice skills based on the issues and challenges towards mitigating the threats to biodiversity and the wellbeing of all life forms.

3.2. Explore ideas and processes of managing watersheds for the socio-economic benefits of the community, and suggest measures to conserve water resources.

3.3. Explain and design strategies for sustainable use of land resources and waste management for socio-economic development, and prevent land pollution for the wellbeing of people and the health of the environment.

3.4. Evaluate energy security of Bhutan and other few countries in the light of energy resources and consumption patterns and their effects on the life of people to inform the decision on the design and use of diverse strategies to conserve energy.

4. Sustainable Development

4.1. Analyse the diverse perspectives of development and evaluate the significance of social, economic and the environmental dimensions to identify ways and means towards achieving the sustainable development goals.

4.2. Recognise and promote sustainable development as a holistic developmental paradigm through the analysis of sustainable development initiatives.

Class-wise Competency (Class IX)

By the end of class IX, learners should be able to:

1. Systems in Nature

1.1. Ecosystem Organisation and Types

- Justify the ecological niche of an organism with the knowledge of the ecosystem and interactions among the components to understand how the health of an ecosystem is maintained.

1.2. Biogeographical Zones and Biomes

- Interpret the biogeographical zones and biomes of Bhutan by obtaining, evaluating, and communicating information from global to local context to understand the significance of biomes to the world.

1.3. Interdependence in Nature: Organism Interaction

- Identify the significant roles of living organisms in sustaining a healthy ecosystem, and construct a flowchart to explain the mechanism of balance in nature.

1.4. Homeostasis

- Analyse the roles of external and internal factors responsible for maintaining a balanced ecosystem and ecological resilience in nature, and generate big ideas that emerged from the analysis.

2. Environmental Issues and Concerns

2.1. Classification of Natural Resources

- Evaluate the significance of natural resources for people through the understanding of classifications and provisions of natural resources to help people live in harmony with nature.

2.2. Natural Resources and Human Societies- The Changing Relations

- Analyse the changing trends of resource utilisation with evolution of human societies to recognize how the behaviour of humans affect the environment and peoples' livelihood.

2.3. Natural Resources Degradation

- Identify natural and anthropogenic causes of natural resources degradation to analyse its impacts on humans and the environment.

2.4. Pollutants and Pollution

- Generate innovative ideas to address the pollution issues in the community through the design and construction of model, and conduct advocacy programs in the locality.

2.5. Disaster and Environment

- Carryout disaster risk assessment in the school or a community, and provide evidence-based recommendations for reducing hazard, risk and vulnerability.

3. Natural Resource Management

3.1. Levels of Biodiversity

- Demonstrate the skills of using techniques in measuring the species diversity to evaluate the status of biodiversity in an area.

3.2. Biodiversity and its Importance

- Analyse the importance of socio-economic, cultural and ecological benefits of biodiversity to recognize the need to conserve the biodiversity.

3.3. Watersheds

- Discuss the significance of watersheds on socio-economic development, and recognise human actions as one of the chief factors to degradation of watersheds.

3.4. Watershed Management

- Apply the principles of watershed management to suggest an appropriate watershed management plan that can cater to the needs of a community.

3.5. Energy Resources and Consumption

- Classify the types of energy resources, energy consumption and energy supply, and design ways of managing energy resources for long-term sustenance in the community.

4. Sustainable Development

4.1. Concepts and Practises of Sustainable Development

- Analyse the developmental activities based on the dimensions of sustainable development, and understand ways to achieve social equity, environmental conservation, and economic progress.

4.2. Developmental Perspective of Bhutan - The Gross National Happiness (GNH)

- Relate how the four pillars and nine domains of Gross National Happiness contribute to the unique approach of Bhutan's development, and recognize GNH as the middle path development philosophy.

Table 1: *Learning Objectives and Contents_ Environmental Science, Class IX*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Themes)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
• Describe the components of the ecosystem in sustaining a healthy ecosystem. • Construct a model to explain ecosystem organisation and its types. • Justify the ecological niche of organisms in sustaining a healthy ecosystem.	**1.1 Ecosystem Organisation and Types** **Scope:** This topic introduces the concept of ecosystem and its organisation (habitat, population, community and species). It focuses on the importance of the ecological niche of organisms in an ecosystem.	**Developing and using models** • Develop a model to demonstrate the organisation of an ecosystem and its types. • Explore the environment to find the interrelationship amongst components in an ecosystem. Infer the ecological niche of the organisms.	**Use of physical tools** • Use models and drawing tools to develop the model.
• Explain the major biomes of the world based on climate and predominant flora and fauna. • Examine the biogeographical zones and biomes of Bhutan based on climate and predominant vegetation.	**1.2. Biogeographical zones and Biomes** **Scope:** This topic begins with the identification of eight Biogeographical zones and ten Biomes and their salient features. It also includes examination of biogeographical zones and biomes of Bhutan using the knowledge of biomes of the world.	**Obtaining, evaluating, and communicating information** • Obtain, evaluate and communicate information from various sources about the biomes of the world in relation to its climate and predominant flora and fauna. • Comparing similarities and differences between biomes and geographical zones assists in examining the biogeographical zones and biomes of Bhutan.	**Using Digital Resources** • Use digital resources to obtain information on major biomes of the world and their features and compare them to that of Bhutan.

• Explain various interactions among biotic components and between biotic and abiotic components in an ecosystem. • Discuss the roles of interactions amongst different organisms in sustaining a healthy ecosystem.	**1.3. Interdependence in Nature: Organism Interaction** **Scope:** This topic focuses on understanding different interactions among biotic components and between biotic and abiotic components with the help of different examples. The interactions include food chains, food webs, competition, predation and symbiotic relationships such as commensalism, mutualism and parasitism.	**Obtaining, evaluating, and communicating information** • Carry out the activity to evaluate ecological interactions and the roles they play in sustaining a healthy ecosystem.	**Using Digital Resources** • Use animation tools to illustrate the ecological interactions and prepare presentations about their findings on various ecological interactions.
• Analyse the roles of external and internal factors responsible for changes in the ecosystem and its role in maintaining homeostasis in nature. • Construct a flowchart to explain the mechanism of homeostasis in nature. • Justify ecological resilience as the means to maintain a stable ecosystem.	**1.4 Homeostasis** **Scope:** This topic explains the roles of external and internal factors to maintain homeostasis in an ecosystem. It also deals with the significance of ecological resilience in maintaining homeostasis in an ecosystem.	**Constructing Explanations and Designing solution** • Comparing the roles of external and internal factors responsible for changes in the ecosystem and how they help in maintaining homeostasis in nature. **Exploration & Evaluation** • Obtain information from various sources about ecological resilience and evaluate it as a means to maintain a stable ecosystem	**Using Digital Resources** • Use drawing tools to construct the flowchart in determining the mechanism of balance in nature. • Based on the flow chart, suggest interventions in maintaining a stable ecosystem and communicate the idea. **Deriving Correlation** • Correlate ecological resilience and balance in nature to assess the status of ecosystems in the local community.

• Classify natural resources based on origin, development process, availability and utility. • Evaluate the significance of natural resources in the locality.	**2.1. Classification of Natural Resources** **Scope:** This topic discusses the classification of natural resources based on origin, development process, availability and utility (biotic and abiotic, potential and actual, renewable and non-renewable, exhaustible and inexhaustible, conventional and non-conventional, ubiquitous and localised resources). It also evaluates the significance of natural resources in their local community.	**Obtaining, evaluating, and communicating information** • Obtain information from various sources about the classification of natural resources and evaluate its classification based on their origin or source, development process, availability and their uses.	**Using Digital Resources** • Illustrate the classification in a diagrammatic form). • The knowledge on natural resources and its classification can help prevent the depletion of natural resources available in the local community.
• Draw a timeline to represent the changing trends in utilisation of natural resources with the changing human societies. • Justify change in pattern of utilisation of natural resources among human societies.	**2.2. Natural Resources and Human Societies- The Changing Relations** **Scope:** This topic emphasises on the major changes in the resource use patterns due to transformation of human societies from hunter-gatherer to agricultural societies and to industrial societies.	**Engaging in argument from evidence** • Evaluate the claims, evidence, and reasoning behind explanations on the changing relationship between natural resources and human societies.	**Using Digital Resources** • Explore different literature on the changing relations between the natural resources and human societies on the internet and represent the information in timeline.
• Plan and carry out a case study to analyse the causes and impacts of natural resources degradation. • Design ways to reduce the natural resources degradation for sustenance of resources.	**2.3. Natural Resources Degradation** **Scope:** It includes the identification of natural and anthropogenic causes of natural resource degradation and discusses its impacts; degradation of land, deforestation and loss of biodiversity. It also explores and designs ways to reduce natural resources degradation.	**Planning and carrying out an investigation.** • Obtain information from various sources on natural resources degradation. • Design a worksheet, visit the community and collect data to observe and analyse the causes and impacts of natural degradation. • Based on the finding, design effective ways to reduce degradation of natural resources.	**Using Digital Resources** • Use MS Office and others to plot graphs and create figures to disseminate the results appropriately. • Share the findings and the ways to reduce degradation with the community for sustainable use of resources.

• Classify forms of pollutants in the school and the community based on their physical, chemical, and biological properties • Justify that pollution impacts the socio economic and physical environment and the wellbeing of people. • Construct models towards addressing the issues of pollution using innovative ideas from a variety of sources.	**2.4. Pollutants and Pollution** **Scope:** This topic clarifies the forms of pollutants - Point-source and Nonpoint source, Primary and Secondary pollutants. It also describes pollution types (air, water and land), its causes, effects and measures to control pollution.	**Constructing Explanation and Designing Solution** • Obtain information on pollution, pollutants, and type of pollutants and impact of pollution. • Carry out a field visit around the school campus or a community to conduct pollutant hunting. • Design and construct a model which can be used to control pollution.	**Serving human values and influence value formation** • Use the internet to obtain information. Study the effectiveness of the model and share with the community to address pollution problems. • Design and carry out advocacy on pollution and its impact on the lives of the people in the community.
• Explain the relationship among the hazard, vulnerability, risk, disaster and the response capacity. • Illustrate disaster risk assessment of a school or a community using standard tools to assess their preparedness. • Analyse the data to generate necessary recommendations to improve the preparedness and reduce the risk from hazards.	**2.5. Disaster and Environment** **Scope:** This topic introduces the types of disaster. It explains the concepts of hazard, vulnerability, risk, disaster and response capacity. It explores natural and anthropogenic causes of disasters and their impacts. Further, it also includes hazard preparedness.	**Constructing Explanation and Designing Solution.** • Obtain information from various sources on disaster. • Evaluate the causes of disaster through a field visit to the locality which has experienced disaster in the past. • State relationship between hazard, vulnerability, risk, disaster, and response capacity and deduce ways to reduce disaster in the community. • Carry out a survey using standard tools to assess preparedness. • Analyse and interpret the data and make necessary recommendations to improve preparedness.	**Influence Value Formation** • Derive insights from the past disasters that have occurred in the community. • Share ways to reduce disaster in the community. • Use a self-rating tool for assessing preparedness and share recommendations with the community or school to make informed decisions
• Describe the elements of biodiversity. • Identify different levels of biodiversity to draw the relationship among the	**3.1. Levels of biodiversity** **Scope:** This topic covers concepts of diversity levels - genetic, species and ecosystem diversity.	**Analysing and Interpreting data** • Obtain information for various sources and carry out field visits. • Study different ecosystems and	**Using Physical Tools** • Use excel sheet to record and analyse the data gathered.

levels.		record all types of species observed and categorise them into three levels of biodiversity.	• Communicate the findings among classmates.
• Explain the socio-economic, cultural and ecological benefits of biodiversity to infer its significance to the wellbeing of people. • Evaluate the status of biodiversity in Bhutan to understand its health in the real time.	**3.2. Biodiversity and its Importance** **Scope:** This topic covers socio-economic, cultural and ecological importance of biodiversity. It also discusses Forest ecosystem, Agricultural ecosystem, and Wildlife diversity	**Obtaining, evaluating, and communicating information** • Using various resources (Discovery learning), read and analyse importance of biodiversity in terms of socio-economic, cultural and ecological importance) • Construct a concept map (chart paper/ICT) to explain the importance of biodiversity in day-to-day life. • Gather information on the status of biodiversity in Bhutan from various sources.	**Using Digital Resources** • Use the internet or visit the library to obtain information. • Share your findings to relevant social media to heighten the awareness on the importance of biodiversity. • Make a PPT and present it to the class.
• Describe the watershed in your locality based on the six key features of watersheds. • Evaluate the importance of watershed for socio-economic wellbeing of a community. • Analyse the negative impacts of human activities on the health of watersheds.	**3.3. Watersheds** **Scope:** This topic entails us to define watersheds, identify the six key features, and discuss the importance of watersheds and explore negative impacts of human activities on watersheds.	**Constructing Explanations and Designing Solution** • Use the Google Earth apps to study Watersheds in the locality. • Demarcate a few watersheds with a marker tool and estimate the area of the watersheds and use the 'time slider' to note any changes in the watershed over the period of time. Note down the physical features of the watershed and save the work as your project work.	**Influencing Value Formation** • Share findings with the class.

• Explain the principles of watershed management. • Investigate the watershed management practices and challenges in Bhutan and in your locality to design appropriate interventions. • Design a watershed management plan that is the most suitable for your community.	**3.4. Watershed Management** **Scope:** Begin by discussing the concept of watershed management, principles of watershed management, Watershed Management Process, and designing watershed management plans for the locality.	**Obtaining, evaluating, and communicating information** • Collect information on the principles of waste management, waste management process and design, In groups, develop a watershed management plan most suitable for your community.	**Using physical tools** • Discuss with the relevant stakeholder on various watershed management practices in the locality, or browse the websites of the Ministry of Agriculture and Forests for information. Use Design Thinking method and suggest appropriate interventions.
• Classify different energy resources and evaluate the status of energy resources on the Earth. • Assess the supply and consumption patterns of the different types of energy sources in your locality. • Explore different ways of saving energy for sustainable use of energy resources. • Design any energy efficient prototype model that benefits the local community.	**3.5. Energy Resources and Consumption** **Scope:** Begin by defining energy and classify energy resources based on (nature of transaction, sources, and recovery rate); world energy supply, types of energy consumed by different countries; sector wise energy consumption.	**Obtaining, Evaluating and Communicating Information** • The learner uses various resources to gather information on classification of energy resources. **Constructing explanations and designing solutions** • Make an assessment of the quantity of different types of energy consumed at your home for a month, tabulate the data and share your findings. **Constructing explanations and designing solutions** • Investigates some of the challenges in efficient use of energy in the community. Use a design thinking strategy to develop an energy efficient prototype device.	**Using Digital Resources** • Use digital resources to understand the classification of different sources of energy **Using Digital Resources** • Use excel sheet to tabulate and analyse the data. **Influencing Value Formation** • Organise an exhibition of the models developed.

• Discuss the dimensions and goals of sustainable development to understand how the community wellbeing can be upheld. • Evaluate the consequences of developmental activities based on developmental parameters and sustainable development indicators. • Design appropriate strategies to address challenges faced in promoting sustainable development in Bhutan.	**4.1. Sustainable Development-Concept and practice** **Scope:** This topic consists of sustainable development and its dimensions, parameters, and indicators; strategies to address challenges faced in promoting sustainable development in Bhutan. Sustainable development goals. Relationship between the dimensions of sustainable development.	**Constructing explanations and designing solutions** • Explore information on sustainable development, its dimensions and parameters using library or web resources. • Make an analysis of different indicators (example, the status of GDP, GNI, GNP, and HDI of Bhutan) used to indicate the development of Bhutan. **Obtaining, evaluating, and communicating information** • Review various sustainable development initiatives in Bhutan and the challenges faced. • Design strategies to address the challenges and promote sustainable initiatives in the community.	**Using Digital Resources** • Use web resources to gather information. **Influencing Value Formation** • Use the internet or visit a library to obtain information. • Communicate finding • Share strategies to overcome challenges.
• Explain philosophy of sustainable development of Bhutan. • Relate the pillars and domains of GNH in creating just and harmonious society.	**4.2. The Gross National Happiness (GNH)** **Scope:** This topic consists of the concept of Gross National Happiness (GNH), its pillars and domains.	**Obtaining, evaluating, and communicating information** • Gather information on GNH, four pillars and nine domains using library or web sources.	**Influencing Value Formation** • Communicate finding

Class-wise Competency (Class X)

1. Systems in Nature

1.1. Biogeochemical Cycle

- Analyse the types and roles of biogeochemical cycles in regulating the nutrient flow to understand how the anthropogenic activities alter the nutrient flow in the ecosystem.

1.2. Carrying Capacity

- Explain the relationships among the factors of population, production and consumption in determining the state of a carrying capacity of a locality through mathematical calculations, and infer the consumption behaviour of people.

1.3. Ecosystem Stability

- Analyse the ecosystem based on the factors such as extrinsic, intrinsic, and species diversity to understand how they influence the ecosystem equilibrium and stability for maintaining balance in nature.

2. Environmental Issues and Concerns

2.1. People and Resource Consumption

- Evaluate one's own ecological footprint to understand how lifestyle influences resource consumption and waste generation, and infer its impact on the state of carrying capacity of the Earth.

2.2. Carrying Capacity of the Earth

- Use the knowledge and understanding of Ecological Footprint and identify its factors to justify the changing carrying capacity of the Earth.

2.3. Disaster Risk Management

- Analyse disaster mitigation processes and phases of disaster risk management to understand the significance of disaster management plans and implementation towards promoting safety of school and the community.

2.4. Greenhouse Effect

- Analyse the relationship between greenhouse effect with global warming and climate change based on available literature, and design a model to demonstrate how greenhouse effect exacerbates global warming and climate change.

2.5. Climate Change

- Analyse risks posed by climate change to the social, physical, economic, and wellbeing of people and the environment, and recognize that climate change is mostly influenced by human actions.

2.6. Initiatives on Climate Change

- Analyse the global and national initiatives on climate change mitigation and design a mitigation plan for your locality or school, and recognize the need to initiate change in actions towards climate change.

2.7. Phenology

- Justify the role of phenology as a biological indicator of climate change by making predictions based on past available data, and develop strategies or plans to minimise the causes of climate change.

3. Natural Resource Management

3.1. Measuring Biodiversity

- Analyse species of a locality to determine diversity of an area, and interpret the status of species diversity.

3.2. Biodiversity Inventory

- Investigate flora and fauna to establish biodiversity patterns of a locality.

3.3. Conservation of Biodiversity in Bhutan

- Evaluate the conservation initiatives implemented for the sustenance of biodiversity, and understand the diverse initiatives and the roles of different organisations and indigenous practices in Bhutan in conserving the biodiversity.

3.4. Land Use and Management

- Demonstrate the understanding of strategies for sustainable use of land based on the knowledge of change in land use pattern and forms of land use, and analyse the impacts on socio-economic development.

3.5. Wastes and Waste Management

- Demonstrate the understanding of waste management and waste management strategies, and suggest ways to change consumption behaviour to minimise the waste generation.

3.6. Energy Sources

- Demonstrate the understanding of various methods of energy conservation, and design technology to save energy for long-term sustenance of energy resources.

4. Sustainable Development

4.1. Sustainable Consumption and Production

- Relate consumption and production patterns with sustainable development, and model strategies to promote sustainable development.

4.2. Sustainable Development Initiatives in Bhutan

- Examine the international and national sustainable development initiatives, and identify the opportunities and challenges in the implementation in Bhutan.

Table 2: *Learning Objectives and Contents_ Environmental Science, Class X*

<table>
<tr><th rowspan="2">Learning Objectives (KSVA)</th><th rowspan="2">Core Concepts (Chapters/Topics/Themes)</th><th colspan="2">Process/Essential Skills</th></tr>
<tr><th>Scientific Methods and Engineering Practices</th><th>Society and Technology</th></tr>
<tr><td>● Explain biogeochemical cycle and its types.
● Analyse the roles of biogeochemical cycles in regulating the nutrient flow.
● Evaluate how anthropogenic activities alter the natural nutrient cycle.</td><td>1.1. Biogeochemical cycles
Scope: This topic explains Gaseous biogeochemical cycle (carbon and nitrogen cycle) and Sedimentary biogeochemical cycle (calcium and phosphorus) and how anthropogenic activities alter natural nutrient cycle.</td><td>Constructing Explanation
● Design a model to explain biogeochemical cycle and incorporate anthropogenic activities altering nutrient flow in those cycles.
● Explore measures to reduce activities that disrupt biogeochemical cycles.</td><td>Using Digital Resources
● Use the internet to search for information on biogeochemical cycle and nutrient flow.
● Communicate the findings.
Promoting Socio-cultural, Economic, and Human Values
● Share finding and measures designed to the community for sustainable use of resources.</td></tr>
</table>

● Explain carrying capacity based on population, production and consumption. ● Describe the four major limiting factors that determine the carrying capacity of an ecosystem. ● Differentiate between logistic and exponential population growth curves. ● Calculate the carrying capacity of an ecosystem. ● Justify the significance of carrying capacity for sustainable management of resources.	**1.2. Carrying Capacity** **Scope:** This topic explains about carrying capacity and its relationship with the population, production of resources and consumption. It covers concepts of exponential and logistic population growth with reference to four major limiting factors of carrying capacity - food availability, water, ecological conditions and space. It also includes the mathematical calculation of carrying capacity of a given ecosystem.	**Analysing information and using Mathematical and Computational Thinking** ● Explore and analyse the carrying capacity of an ecosystem. ● Evaluate the relationship between population, production and consumption to carrying capacity. ● Use mathematical and computational representations to support explanations on calculating carrying capacity	**Serving human values and influence value formation** ● Use the internet, visit library and discuss to obtain information on carrying capacity. ● Practice sustainable consumption behaviours in order to prevent the deterioration of carrying capacity of the locality. ● Use the knowledge to analyse one's own consumption behaviour in the context of carrying capacity
● Describe the extrinsic and intrinsic factors that influence the ecosystem equilibrium and its stability. ● Analyse the influence of ecological resistance and resilience to ecosystem stability. ● Justify that species diversity contributes towards ecosystem	**1.3. Ecosystem Stability** **Scope:** This topic discusses the extrinsic and intrinsic factors that influence the ecosystem stability and two components of ecosystem stability - resistance and resilience. It also focuses on the importance of species diversity in maintaining the stability in an ecosystem.	**Obtaining, evaluating, and communicating information** ● Explore and find out all the factors that influence ecosystems and differentiate between the influences of extrinsic and intrinsic factors on ecosystem stability. ● Develop a flowchart representing how factors affect ecosystem stability.	**Using Physical Tools** ● Use flowchart to communicate how intrinsic and extrinsic factors affect ecosystem stability.

stability.		• Analyse the relation between ecosystem stability and species diversity in maintaining the balance in nature.	
• Explain the concept of Ecological Footprint based on the factors that influence it. • Analyse the relationship between lifestyle and resource consumption. • Calculate one's own ecological footprint to interpret the resource consumption and lifestyle. • Investigate and suggest measures to reduce individual's ecological footprint.	**2.1. People and Resource Consumption** **Scope:** This topic covers the factors (social, cultural, economic, environmental, technological and political) that influence the consumption pattern which determines lifestyles. It also focuses on Ecological Footprint and its calculation to interpret the resource consumption and adopt measures to reduce Ecological Footprint.	**Engaging in argument from evidence** • Evaluate the claims, evidence, and reasoning behind currently accepted explanations on the relationship between lifestyle and resource consumption. **Using Mathematics and Computational Thinking** • Explore for a standard way to calculate ecological footprint and interpret the findings. • Design solutions to reduce ecological footprint. • Develop a presentation to communicate your findings.	**Serving human values and influence value formation** • Use the relationship between lifestyle and resource consumption to recognise one's own resource consumption. • An individual can commit to practice eco-friendly lifestyles which are healthier and ensure a sustainable future. **Exploring Digital Resources** • Use a standard tool to calculate ecological footprint. • Use the knowledge to analyse one's own resource consumption behaviour and waste generation in the context of ecological footprint. • Use the internet to explore ecological footprint and MS PowerPoint to prepare a presentation to communicate your findings.

• Explain the carrying capacity overshoot. • Analyse the changing carrying capacity of the Earth. • Relate the carrying capacity to survival of life forms.	**2.2. Carrying capacity of the Earth** **Scope:** This topic explains carrying capacity overshoot and limiting factors that influence carrying capacity of the Earth.	**Constructing explanations and designing solutions** • Explore the carrying capacity of the Earth and carrying capacity overshoot. • Explain carrying capacity overshoot with the help of a graph and deduce how the limiting factors influence carrying capacity of the Earth.	**Use of Digital Tools** • Use the internet to obtain information and a graph to explain carrying capacity overshoot. • Communicate the findings.
• Explain disaster mitigation processes. • Analyse the challenges in the disaster mitigation process to suggest measures of addressing them. • Develop a school disaster risk management plan incorporating the phases of DRM to reduce the impact of a disaster.	**2.3. Disaster Risk Management** **Scope:** This topic deliberates on disaster risk reduction management plan (DRRMP) including phases of DRM - pre-disaster, response, and post-disaster to reduce the impact of a disaster. It also covers mitigation and challenges of the mitigation process.	**Investigation and Designing Solution** • Assess and categorise the risks associated with various forms of disaster and develop a DRM plan (including a risk map) for the school. • Explore disaster mitigation, investigate some of the mitigation put in place by school or community and assess the challenges of the disaster mitigation process by interviewing school authority or community people. • Develop some additional disaster mitigation measures for the school or	**Using Digital Resources** • Incorporate the DRM phases in the DRRMP of your school for the safety of the students and staff. • Share your plan with school administration. • Explore the internet or visit a library to obtain information to address disaster mitigation and challenges. • Share mitigation measures to the school or community.

		community.	
• Explain the greenhouse effect. • Design a model to understand the consequences of the greenhouse effect. • Evaluate how our actions exacerbate the greenhouse effect.	**2.4. Greenhouse Effect** **Scope:** This topic encapsulates the relationship between greenhouse effect, global warming and climate change.	**Constructing Explanations and Designing Solution** • Explore the greenhouse effect, relate global warming by applying the scientific principles of greenhouse effect. • Construct a model of a greenhouse to demonstrate the greenhouse effect.	**Using Physical tools** • Use the greenhouse model and demonstrate its effect.
• Evaluate risks that climate change poses to agriculture, water, human health, national security, and ecosystem. • Justify that climate change is mostly influenced by human actions	**2.5. Climate Change** **Scope:** This topic explains the concept of Climate change, factors causing climate change and its impact at national and global level.	**Constructing explanations and designing solutions** • Review and evaluate the literature on the impacts of climate change. • Evaluate the status of climate change impacts in Bhutan. • Design a poster to advocate on the impact of climate change.	**Exploring Digital Resources** • Explore the internet or visit a library to glean information. • Use posters and advocate the impact of climate change.
• Analyse the national and global initiatives against climate change. • Design climate change mitigation strategies.	**2.6. Initiatives on Climate Change** **Scope:** This topic explores some of the global and national initiatives to combat and mitigate climate change such as the Earth Summit, UNFCCC, Kyoto Protocol and Paris Agreement. It further focuses on the initiatives taken at the local level.	**Obtaining, evaluating, and communicating information** • Review and evaluate Global and National initiatives. • Draw climate change mitigation measures that can be implemented at school and local level.	**Serving human values and influence value formation** • Use the internet to obtain information. • Share climate change mitigation measures to the school and community using scientific consensus to influence people with

			diverse beliefs on climate change.
• Explain phenology as the indicator of climate change • Evaluate different phenophases of plants based on past available data to explain about the changing climate.	**2.7. Phenology** **Scope:** This topic explains about the phenophases to understand climate change. It describes how to interpret the data to predict the future course of climate change and develop a strategy to minimise the causes of climate change.	**Analysing and Interpreting Data** • Obtain information on the phenology of plants and animals. • Carry out a field trip to learn different phenophases of plants and relate to the impacts of climate change.	**Influencing Value Formation** • Use the internet to obtain information about the phenophases.
• Explain the species diversity. • Carry out study on species diversity in a local ecosystem to understand the species diversity. • Assess the significance of species diversity for the wellbeing of people.	**3.1. Measuring Biodiversity** **Scope:** This topic explores the types of biodiversity. It gives more focus on measuring biodiversity with the use of tools such as Quadrat sampling and Simpson's Index of Diversity.	**Obtaining, evaluating, and communicating information** • Explore procedure and process to carry out study. • Carry out a field visit to a selected area to collect required data to study species biodiversity. • Analyse the data and interpret the finding.	**Using Physical Tools** • Use quadrat and Simpson's index of diversity to collect data and calculate species diversity respectively.
• Explain biodiversity inventory. • Maintain biodiversity inventory of an area to establish the baseline of species diversity. • Justify the importance of biodiversity inventory.	**3.2. Biodiversity Inventory** **Scope:** This topic includes flora and fauna diversity and endangered species in Bhutan, and biodiversity inventory.	**Planning and carrying out investigations** • Explore endangered plant and animal species of Bhutan. • Develop a biodiversity inventory table. • List all plants and animals found within the school	**Using Digital Resources** • Use plants and animal identification Apps. to identify and name them.

		compound in an inventory table.	
• Analyse conservation roles of relevant organisations. • Design an action plan to conserve biodiversity of a school. • Evaluate the roles of indigenous practices in biodiversity conservation.	**3.3. Conservation of Biodiversity in Bhutan** **Scope:** This topic discusses the conservation roles of relevant national and community organisations in Bhutan. It also explores the roles of indigenous practices in conservation of biodiversity.	**Obtaining, evaluating, and communicating information** • Review various conservation initiatives and practices in Bhutan, and develop proper measures to conserve biodiversity. • Visit the community and conduct a survey to evaluate various indigenous practices towards biodiversity conservation.	**Using Digital Resources** • Use digital resources to explore different biodiversity conservation measures. • Share conservation measures and models to the public through suitable medium.
• Assess the land use patterns to identify negative impact of various forms of land use and land use change on the environment. • Explain the principles of sustainable land management practices. • Design a smart land use model for sustainable use of land.	**3.4. Land Use and Management** **Scope:** This topic deals with the identification of land use patterns, land use change, impacts of various forms of land use and land use change.	**Constructing Explanations and Designing Solution** • Take a field trip to a nearby community to observe various land uses. Design a flowchart to make analysis of different land use and impacts on the environment. • Gather the national statistical data of land use (Forest, Agriculture, Pasture, Settlements, others) and analyse and develop smart land use models to curb the impacts on the environment to assess land use patterns, land use change, predict	**Influencing Value Formation** • Communicate the findings of different land use impacts on the environment. • Share smart land use models to the community.

		land use change and related environmental issues.	
• Explain waste management hierarchy based on waste types. • Segregate waste into different types based on their physical, chemical and biological properties. • Design a waste management plan to manage waste in the school.	**3.5. Wastes and Waste Management** **Scope:** This topic discusses waste with focus on solid waste, classification of solid waste on the basis of its physical, chemical and biological properties. It also discusses the importance of solid waste management and the hierarchy of solid waste management.	**Obtaining, evaluating, and communicating information** • Outdoor excursion to a nearby town or school's waste dumping site, record all types of waste and classify into different categories. **Constructing explanations and designing solutions** • Conduct literature review of various entrepreneurship ideas in managing waste. Develop an environmentally friendly waste management plan.	**Using physical tools** • Conduct an awareness program in the school on the types of waste generated in the school and the impacts it has on different life forms. **Influence value formation** • Share waste management plans with the school and the community for implementation.

• Identify potential sources of energy resources available in Bhutan and make an analysis to choose the most reliable alternative source of energy for the community. • Design energy conservation strategies that can reduce energy consumption. • Design a device which depends on alternative energy sources.	**3.7. Energy Sources** **Scope:** This topic encapsulates various sources of energy available in Bhutan, classification of energy sources into renewable and non-renewable. It also discusses various energy conservation strategies.	**Obtaining, Evaluating and Communicating Information** • Use library or web resources and find out all the energy resources to which Bhutanese people are dependent on. **Constructing explanations and designing solutions** • Visit the local community and find out the various energy conservation strategies adopted. Design a device to save energy consumption.	**Using Digital Resources** • Use digital resources to evaluate different sources of energy, and validate a potential source of energy. **Using Digital Resources** • Use social media platforms to share the plan to the school and the community for awareness generation and implementation.
• Explain the concept and dimension of sustainable development to derive its relevance to Bhutan. • Evaluate the consumption and production pattern in relation to sustainable development. • Identify sustainable consumption and production strategies initiated and implemented in Bhutan.	**4.1. Sustainable consumption and production** **Scope:** This topic introduces the concept of sustainable development and the three dimensions. It also discusses on consumption and production and relates with sustainable development. It explores how to design a model of sustainable consumption and production.	**Constructing explanations and designing solutions** • Comprehend the concept of sustainable development, sustainable consumption and production. • Develop strategies to achieve sustainable consumption and production of goods and services in the country.	**Using Digital Resources** • Use available resources to comprehend the concept of sustainable consumption and production. • Share the strategies for sustainable consumption and production in the class.

• Analyse the international and national treaties, conventions and initiatives on sustainable development for Bhutan. • Identify the challenges of implementing sustainable development initiatives in Bhutan. • Evaluate the benefits of sustainable development initiatives for the wellbeing of people.	**4.2. Sustainable development initiatives** **Scope:** This topic discusses treaties, conventions and initiatives of sustainable development (Basel convention, UNESCO World Heritage Convention, International Plant Protection Convention, Vienna Convention for the Protection of Ozone Layer, Convention on International Trade in Endangered Species of Wild Fauna and Flora, Convention on Biological Diversity (CBD), United Nations Framework Convention on Climate Change and United Nations Convention to Combat Desertification*)* and identify challenges in implementation particularly in Bhutan.	• Review various sustainable development initiatives in Bhutan and the challenges faced to achieve the outcomes of the initiatives.	**Influence value formation** • Exhibit sustainable development practices by establishing effective waste management practices in the school.

13. 2 Key Stage 5

Competency-based Standard

By the end of key stage 5 (class XII), a learner should be able to:

1. Systems in Nature

1.1. Demonstrate environmental management abilities to contribute towards evidence-based production, utilisation, and evolution of practices towards protecting the ecosystem.

1.2. Exhibit the understanding of the ecosystem, its spheres, function, and interactions of various components, and explore measures to maintaining the balance in nature.

2. Environmental Issues and Concerns

2.1. Investigate change in the consumption patterns of people in relation to the increasing pressure on our natural resources, and explore ways to bring about change in consumption behaviour in the communities.

2.2. Demonstrate the understanding of natural resources and their degradation and their impacts on human life and communicate environmental information and ideas in diverse forms to influence the mindful practice of livelihood towards living in harmony with nature.

2.3. Organise awareness campaigns and secure funds to collaborate with innovative partners, and design technologies that would enable Bhutan fight various forms of pollution.

2.4. Carry out research in various fields related to climate change, and suggest ways to control factors causing climate change towards reducing the impacts of climate change.

2.5. Plan and disseminate disaster management plans and activities for the family and the community they live in, and recognise the significance of disaster management to minimize the disastrous impacts on the society.

3. Natural Resource Management

3.1. Draw evidence from various researches on the impacts of biodiversity loss, and demonstrate the skills to collaborate with various organisations to carry out conservation initiatives.

3.2. Demonstrate the understanding of the uniqueness of Bhutan's rich natural heritage and spiritual beliefs on nature, and suggest action to safeguard the natural heritage.

3.3. Evaluate water and land resources of our country or the locality to inform the needs for adoption of effective conservation strategies for sustainable use of these resources, so that there are enough of these resources for all times to come.

3.4. Demonstrate the understanding about the clean energy, energy security and sustainable energy use, and generate innovative ideas to conserve energy with appropriate strategies for sustainable energy resources

4. Sustainable Development

4.1. Evaluate the impact of developmental activities on the environment, and suggest ways to manage the environment through the adoption of appropriate tools and techniques for the sustainable resource management.

4.2. Develop a global and national perspective of development through the lens of sustainable development and Gross National Happiness approach of development, and realise individual's roles towards sustainable living and development.

4.3. Analyse national and international developmental policies based on the principle of sustainable development, and explore ways to contribute in sustainable development activities in the community.

4.4. Demonstrate, concern, aptitude and interest to participate in the community development process to create ideas towards achieving the sustainable development goals.

Class-wise Competency (Class XI)

By the end of class XI, a learner should be able to:

1. Systems in Nature

1.1. Biomes and Ecosystems

- Explain the characteristic features of biomes and ecosystems of the Earth, and relate them to Bhutan's biomes and ecosystem.

1.2. Adaptation in Plants and Animals

- Explain adaptation and adaptive features of living things as a means of survival in the changing environment, and explore ways to protect the ecosystem and its functions.

1.3. Biogeochemical Cycles

- Analyse the types and roles of biogeochemical cycles in regulating the nutrient flow, and understand how the anthropogenic activities alter the nutrient flow in the ecosystem.

1.4. Carrying Capacity

- Evaluate the carrying capacity of the Earth in relation to resources availability and symbiotic relationship, and recognise the need for behavioural change in consumption and the lifestyle of people.

2. Environmental Issues and Concerns

2.1. Human-Ecosystem Dynamics

- Analyse coevolution and coadaptation of humans and ecosystems, and deduce appropriate strategies to reduce human activities that modify the ecosystems.

2.2. Natural Resource Degradation

- Analyse the causes and impacts of overexploitation, and generate innovative ideas for the sustainable use of natural resources.

2.3. Ecological Footprint

- Evaluate one's own ecological footprint and how lifestyle influences resource consumption and waste generation, and infer their impact on the state of carrying capacity of the Earth.

2.4. Pollution and its Types

- Investigate the types, causes, and effects of pollution on health and the environment taking pollution along the river as a sample, and recommend effective solutions to curb the issues.

2.5. Chemical Pollutants and Toxicity

- Illustrate the factors responsible for climate change using a digital tool and analyse the past data to infer the changes in climate and communicate the results to the community.

2.6. Phenology and Climate Change

- Analyse the relationship between climate change and phenophases, and interpret the change in behaviour of living things based on phenophases.

2.7. Hazards and Disasters

- Analyse various types and causes of hazards with relevance to our country, and explain how the occurrence of the hazards has affected the lives of our Bhutanese people.

2.8.

- Analyse causes and effects of toxicity of any chemical pollutants in the environment through an experiment, and suggest ways to reduce the source of pollutants.

2.9. Climate Change

2.10. Disaster Risk Reduction

- Explore recent advancements in science and technology in the field of hazard and disaster monitoring, and suggest strategies with tools for GLOF mitigation in Bhutan.

3. Natural Resource Management

3.1. Biodiversity and Ecosystem Services

- Explain different levels of biodiversity, and analyse their benefits to recognize the importance of diverse forms of life.

3.2. Measuring Biodiversity

- Evaluate the status of biodiversity with the knowledge and understanding of measurement of species diversity in the community using different indices, and recognize the importance of biodiversity conservation.

3.3. Conservation of Biodiversity

- Recognize different conservation methods to prevent the loss of biodiversity, and analyse the importance of conservation of biodiversity.

3.4. Water Conservation

- Demonstrate the understanding of water quality, its testing and conservation strategies, and analyse challenges and tools and techniques needed to reduce the waste of water so that everyone has access to adequate, safe and affordable water.

3.5. Entrepreneurship and Land Waste Management

- Demonstrate the understanding of land pollution as an emerging social problem and land management to prevent environmental pollution, and transform the wastes to entrepreneurship ideas towards reducing the land pollution.

3.6. Energy Conservation

- Explain energy management systems and national energy security, and explore ways to improve energy efficiency at home and community, which results in sustainability of energy.

4. Sustainable Development

4.1. Development and Environment

- Evaluate the impact of development on the environment through the assessment of dimensions, indicators and models of development, and recognise the need to transit towards a holistic developmental approach.

4.2. Sustainable Development and Environment

- Evaluate the developmental activities of Bhutan using economic instruments, and analyse whether developmental activities are in line with the sustainable development approach.

4.3. Gross National Happiness for Sustainable Development

- Review Bhutan’s Environmental Policies and Strategies to recognise its contribution towards achieving sustainable development goals.

Table 3: *Learning Objectives and Contents_ Environmental Science, Class XI*

<table>
<tr><th rowspan="2">Learning Objectives (KSVA)</th><th rowspan="2">Core Concepts (Chapters/Topics/Thames)</th><th colspan="2">Process/Essential Skills</th></tr>
<tr><th>Scientific Methods and Engineering Practices</th><th>Society and Technology</th></tr>
<tr><td>• Discuss the characteristics of biomes and the factors that determine the distribution of biomes on the Earth.
• Analyse the characteristics of ecosystems in Bhutan.
• Explore the significance of biomes in the locality.</td><td>1.1. Biomes and Ecosystem
Scope: This topic elaborates the characteristics of terrestrial biomes of the world and emphasises on the factors (climate & vegetation) determining the distribution of biomes). It also explains the characteristics of ecosystems of Bhutan (forest, aquatic and agricultural ecosystem) and relates to the biomes of the world.</td><td>Obtaining, evaluating, and communicating information
• Obtain information from various sources on biomes and the factors that determine the distribution of biomes.
• Identify the biome by referring to the recorded characteristics.
Engaging in argument from evidence
• Classify different types of ecosystems in Bhutan according to their characteristics.
• Evaluate the claims, evidence, and reasoning behind explanations on the characteristics of ecosystems in Bhutan.</td><td>Using Digital Resources
• Use the internet or visit a library to glean information.
• Communicate finding.
• Use animation tools to prepare an animation on ecosystems to educate people in the community to appreciate and value the ecosystem they are part of.</td></tr>
<tr><td>• Describe adaptation of plants and animals.
• Classify various types of adaptation in plants and animals.
• Justify adaptive features of plants and animals as a means of survival in</td><td>1.2. Adaptation in Plants and Animals
Scope: This topic describes adaptation of plants and animals to different conditions of the ecosystem (drought, water abundance, moderate water, saline water).</td><td>Obtaining, evaluating, and communicating information
• Obtain information from various sources on different forms of adaptation in plants and animals.</td><td>Influence value formation
• Use various sources to obtain information.
• Communicate the finding to value the adaptive features of plants and animals.</td></tr>
</table>

the changing environment.			
• Explain biogeochemical cycles based on atmospheric and edaphic nutrient cycles. • Illustrate the process of biogeochemical cycles. • Evaluate how biogeochemical cycles are altered by anthropogenic activities.	**1.3. Biogeochemical Cycles** **Scope:** This topic explains how biogeochemical cycles (carbon, nitrogen, phosphorus and potassium) regulate the nutrient flow in the environment. It also evaluates the disruption of these cycles by anthropogenic activities.	**Communicating** • Collect information from various sources on biogeochemical cycles and their importance in nutrient flow in the ecosystem. • Use pictorial or theoretical representations to present information using ICT. • Gather the data of carbon emission in Bhutan to understand the periodic emission.	**Using Digital Resources** • Use web resources to gather data of carbon emission.
• Explain carrying capacity in relation to the availability of resources. • Relate carrying capacity to population growth curve. • Explain the influence of symbiotic relationships among the species on the carrying capacity.	**1.4. Carrying Capacity** **Scope:** This topic explains the relationship between carrying capacity and available resources and how the limiting factors - water and energy; predation; competition; space, affect the carrying capacity. It also includes how the symbiotic relationships among human and domesticated crops and animals, contributes in	**Constructing explanations and designing solutions** • Explore and analyse the carrying capacity in the context of resource availability to support the species.	**Using Digital Resources** • Explore the internet or visit the library for gathering the data of flora or fauna. • Plot the graphical representation.

	increasing the carrying capacity.		
• Explain coevolution and coadaptation in the ecosystem with examples. • Evaluate the interaction of coevolution and coadaptation among organisms in the ecosystem and humans in the social system. • Evaluate the factors that lead to changing relationships between the human and ecosystems. • Justify the changing relationship of humans with the environment for survival on the Earth.	**2.1. Human-Ecosystem Dynamics** **Scope:** This topic introduces the concept of coadaptation and coevolution of organisms and humans in the ecosystems. It covers the factors - human migration; new technologies; production and industrialisation; urbanisation and alienation from nature, leading to changing relations between human societies and ecosystems. It also emphasises on how human interactions modify ecosystems and the environment.	**Asking questions and defining problems** • Obtain information from various sources on coevolution and coadaptation • Gather information of species to understand the coadaptation and coevolution. **Obtaining, Evaluating and Communicating Information** • Obtain information from relevant sources on how human interactions lead to the modification of ecosystems and environment. • Explore and evaluate different literature on the changing relations between humans and the environment. • Design a community development plan to minimise environmental impact	**Using Digital Tools** • Use the internet or visit a library for information. **Influence value formation** • Raise awareness on how human activities lead to modification of ecosystem and environment. • Share the plan with the local government officials to be implemented as the community development plan.
• Explain the causes of natural resources degradation. • Evaluate the causes and impacts of over-exploitation of natural resources on	**2.2. Natural Resource Exploitation and its Impacts** **Scope:** Deals with the causes of overexploitation due to population growth, poverty, inefficient resources extraction, over-consumption of natural resources and	**Obtaining, evaluating and communicating information** • Evaluate the causes and impacts of natural resources (land, water, and forest) exploitation on carrying capacity of the ecosystem. • Visit a local community and explore the type of natural resource	**Influence Value Formation** • Use the internet or visit a library to learn about causes and impacts of overexploitation. • Share findings and ways to minimise overexploitation.

the carrying capacity of an ecosystem.	analyse its impacts on the carrying capacity of the ecosystem.	exploitation and its impact in the community. ● Suggest ways to minimise overexploitation.	
● Explain the elements of Ecological Footprint ● Estimate the ecological footprint and relate it with the ecological footprint of a country. ● Corroborate the correlation between the ecological footprint, increasing population and the changing lifestyle.	**2.3. Ecological Footprint** **Scope:** Deals with the elements of Ecological Footprint (bioproductive area, biocapacity, yield factor, national average yield and equivalence factor), and calculation of Ecological Footprint of a country in Global Hectares. It also relates the value of Ecological footprint to population and lifestyle to generate ideas for sustainable lifestyle.	**Analysing and interpreting data** ● Calculate the amount of biologically productive land required to sustain a population. ● Estimate the ecological footprint of the community. ● Draw a relationship between ecological footprint, population and changing lifestyle.	**Promoting Socio-cultural, Economic, and Human Values** ● Use a standard tool and ecological footprint equation. ● Communicate by sensitising on the proportional rise in impacts on the environment due to increasing population and changing lifestyle.
● Explain pollution with its types. ● Investigate the types of pollution, its causes, and effects on health and environment. ● Recognize that humans are the cause of pollution affecting their wellbeing.	**2.4. Pollution and its Types** **Scope:** This topic explores the types of pollution, causes of pollution and effects of pollution. It further discusses the water quality standards of Bhutan.	**Constructing explanations and designing solutions** ● Conduct surveys to identify pollution prevalent in the community. ● Identify the water quality standard as per the national standards and use the parameters to conduct a water quality survey in the locality.	**Using Physical Tools** ● Exhibit the plan to the community members and other relevant stakeholders to seek necessary support and put the plan in place.

• Explain toxicity of any chemical pollutants. • Design an experiment to test toxicity in the environment. • Evaluate the impacts of biomagnification on human health and environment. • Suggest ways to reduce the impacts of toxicity.	**2.5. Chemical Pollutants and Toxicity** **Scope:** This topic deals with the concepts of toxicity, toxicity of any chemical pollutants, movement of toxin (biomagnification) and its impacts on human's health and the environment.	**Analysing and interpreting data.** • Demonstrate experiments to understand the effects of toxicity. • Draw conclusions and suggest some ways to reduce the impacts of toxins.	**Influence human values** • Communicate findings and advocate on the harmful effects of toxins.
• Explain the factors that affect climate change. • Evaluate the impacts of climate change on human life and environment. • Analyse the data available to predict the future climate system and suggest ways to mitigate the causes.	**2.6. Climate Change** **Scope:** Introduce the concepts of greenhouse effect and climate change. It discusses the factors that affect climate change: forcings, feedbacks and tipping points. It also discusses the impact of climate change on biodiversity, agriculture, water, human lives etc.	**Obtaining, Analysing, interpreting data and communicating information** • Obtain information on factors responsible for climate change. • Conduct activity (experiment) to understand climate change. • Obtain information on impacts of climate change to human life and environment from various sources. • Interpret the data to predict the climate system or conduct surveys to understand the climate change and its impact in their locality. • Suggest some ways to reduce factors which cause climate change.	**Using Physical Tools** • Use web resources and libraries to understand climate change. • Share suggestions to reduce factors which cause climate change through suitable social media.
• Explain phenophases as the indicator of climate change.	**2.7. Phenology and Climate Change** **Scope:** This topic discusses how climate change	**Obtaining, evaluating, and communicating information** • Obtain information from various sources on phenology.	**Using Digital Resources** • Use the internet to obtain information, excel sheet to tabulate and analyse the data.

• Investigate the impact of climate change on the phenophases of plants and animals. • Recognise that the knowledge of phenophases as the indigenous practises to predict the time for growing crops.	influences the phenophases of plants and animals, and phenophases as the biological indicator of climate change.	• Carry out a survey on the phenophases change of plants and animals to evaluate the impact of climate change. • Draw a conclusion with scientific reasoning.	• Communicate your findings with logical scientific reasoning.
• Explain various types of hazards. • Explain the impacts of disaster with relevance to Bhutan and forecast future catastrophes. • Explain how the occurrence of the hazards has affected the lives of our Bhutanese people.	**2.8. Hazards and Disasters** **Scope:** This topic identifies types of hazards, occurrences, its causes and impacts.	**Constructing explanations and designing solutions** • Analyse potential hazards in the community and forecast future catastrophes. • Suggest ways to reduce risk and vulnerability so as to mitigate disaster in future.	**Promoting Socio-cultural, Economic, and Human Values** • Involve the community in collecting information. • Share possible future hazards and ways to reduce risk and vulnerability so as to mitigate the hazards/disaster.

• Explain the importance of technology in monitoring and mitigating a disaster. • Evaluate different types of disaster monitoring tools and develop mitigation strategies to prevent disaster.	**2.9. Disaster Risk Reduction** **Scope:** This topic describes effective disaster monitoring tools for earthquake, volcano, tsunami and GLOF.	**Constructing explanations and designing solutions** • Develop a list of most prominent hazards that could lead to disaster in Bhutan and explore effective disaster monitoring tools that can be used to monitor disaster in Bhutan. • Design a GLOF mitigation plan and create prototype disaster monitoring tools/systems.	**Carrying out STEM Activities** • Use the internet or visit a library for information. • Use social media to share your findings and advertise the GLOF mitigation designs and the prototype disaster monitoring tools/systems.
• Explain three levels of biodiversity. • List the benefits of biodiversity. • Justify the importance of biodiversity for the wellbeing of all life forms.	**3.1. Biodiversity and Ecosystem Services** **Scope:** This topic explains the different levels of biodiversity - genetic, species, ecosystem diversity. It explores direct and indirect use values of biodiversity.	**Constructing Explanation and communication.** • Gather information on the benefits of different diversity levels of Bhutan. • Analyse and write the report.	**Using Digital Resources** • Use the internet to obtain information, excel sheet to tabulate and analyse the data. • Communicate your findings with logical scientific reasoning.
• Identify different methods in measuring species diversity. • Measure the species diversity in the community using different indices to evaluate the status of the ecosystem. • Assess the significance of	**3.2. Measuring Biodiversity** **Scope:** This topic explores methods and indices to measure species diversity - Species richness, Shannon and Simpson Index.	**Planning and carrying out investigations** • Conduct literature review on different methods and indices used for measuring species diversity. • (Outdoor field excursion): Choose an area to assess the species diversity (two or more types of ecosystems. • Design the study (type of sampling, indices to use and the subject). • Record the data gathered. • Analyse the findings.	**Using Digital Resources** • Use excel or other available software in analysing the data. • Maintain a scientific journal (School level findings). • Communicate through a scientific symposium forum.

measuring biodiversity.			
• Explain species loss as a threat to biodiversity. • Explain in-situ and ex-situ as the means of conserving biodiversity. • Develop a species recovery plan for the threatened species of flora and fauna found in Bhutan.	**3.3. Conservation of Biodiversity** **Scope:** This topic discusses causes of biodiversity loss. It also explores threatened and endangered species of plants and animals in Bhutan. It explores In-situ conservation and Ex-situ conservation.	**Constructing Explanation and Communication.** • Conduct literature review to identify various threats and means in causing biodiversity loss. • Analyse the findings (relate species loss as a threat to biodiversity). • Identify different species of flora and fauna in Bhutan that are Globally Threatened as per the IUCN status (Prior knowledge required IUCN Red list categories). Tabulate the findings and conduct thematic analysis. **Constructing explanations and designing solutions** • Review literature and find out ways to carry out biodiversity conservation. • Design a plan for recovering any of the threatened species in Bhutan (Develop project proposal mentioning to conserve threatened or endangered species.	**Using Physical Tools** • Explore various journal articles (Tr. should teach the ways in exploring scientific papers). • Communicate the findings. **Influencing value Formation** • Use the internet for information. • Use standard format to develop innovative project proposals and communicate with relevant stakeholders.
• Design an appropriate watershed management strategy which addresses the challenges and enhances the quality	**3.4. Water Conservation** **Scope:** This topic entails exploring water conservation initiatives including watershed management and other relevant strategies practised in Bhutan, and monitor water quality based	**Planning and carrying out investigations** • Explore watersheds of Bhutan and water conservation strategies that are practised. Survey the community nearby on the uses of water and	**Promoting Socio-cultural, Economic, and Human Values** • Use ICT to develop a framework. • Communicate with the local government/community head about the community

and quantity of water in the community. • Determine water quality based on the physical, biological and chemical content of water to ensure that the water available is safe for consumption. • Evaluate various water conservation strategies, tools and techniques used to reduce the wastage of water so that everyone has access to adequate, safe and affordable water.	on physical, biological, and chemical content.	water conservation practices carried out by the community. • Classify the water conservation initiatives into different themes. • Develop a framework to manage the watershed in the area for conserving water (Prior knowledge required: Watershed management process and initiatives) **Obtaining, Evaluating and communicating Information** • Visit a small stream feasible for study. Conduct the water quality test (physical, biological and chemical). Tabulate the data and analyse and develop a report.	watershed management framework. **Using Digital Resources** • Use necessary equipment and tools to carry out water quality tests. • Communicate the findings and share the action plan to the community and community head to maintain clean water.
• Identify the solid and liquid wastes in the community and classify them for appropriate waste management strategies. • Practice waste management hierarchy in the school or at home. • Evaluate the value of waste in providing entrepreneurship opportunities to reduce the solid	**3.5. Entrepreneurship and Land Waste Management** **Scope:** This topic introduces the concept of land wastes - solid, liquid, and E-wastes, hazardous and non-hazardous wastes, waste treatment and disposal, entrepreneurship and land waste management, waste management hierarchy, waste management in Bhutan.	**Developing and using models** • Use the library or internet and obtain information on entrepreneurship and waste management hierarchy. Prepare a plan to establish entrepreneurship through solid waste management.	**Using Digital Resources** • Share the idea of solid waste management through social media.

wastes in school or at home.			
● Explain the basic energy management system that can be implemented in Bhutan for sustainable use of energy. ● Carry out energy auditing at home and design appropriate energy efficient strategies. ● Recognise the importance of sustainable energy to attain national energy security.	**3.6. Energy Conservation** **Scope:** This topic allows us to learn energy management systems, national energy security, and energy auditing, which are essential in developing strategies to improve energy efficiency.	**Influence human values** ● Use the web resources to obtain information and a standard tool to carry out 'Home Energy Audit'. ● Share ways to improve energy efficiency with parents.	**Influence human values** ● Use the web resources to obtain information and a standard tool to carry out 'Home Energy Audit'. ● Share ways to improve energy efficiency with parents.
● Analyse the dimensions and indicators of development. ● Assess limitations of dimensions and indicators of development from the environmental perspective. ● Deduce the level of impact of development on the environment based on Kuznets Environmental Curve,	**4.1. Development and Environment** **Scope:** This topic covers the concept by defining development, dimensions and indicators of development. The dimensions and indicators as a holistic approach to development and limitations of indicators of the development.	**Obtaining, Evaluating and Communicating Information** ● Carry out small research on Bhutan's developmental approach. Evaluate whether the dimensions and indicators are taken into consideration during the process of development. ● Prepare MS PowerPoint presentation. **Obtaining, Evaluating and Communicating Information** ● Use the internet to prepare a simulation of Kuznets Environmental Curve.	**Using Digital Resources** ● Use the internet or visit a library to obtain information. ● Use MS PowerPoint to prepare and communicate the findings. **Using Digital Resources** ● Use the library and internet to explore information about various models of development. ● Share the findings to friends in the class

Mehboobul Haq's Model and Five Stage Development Model of development.			
• Create a short documentary video on "**Future of My community**" considering the three dimensions of sustainable development. • Evaluate the importance of economic instruments in curbing environmental issues against the force of development. • Analyse whether the economic development activities in Bhutan consider human and environmental development.	**4.2. Sustainable Development and Environment** **Scope:** This topic introduces the concept of sustainable development, dimensions of sustainable development, the key objectives of sustainable development to examine developmental activities using economic instruments such as; Price - based, Property right, and, Legal, voluntary and Information based instruments	**Analysing and Interpreting data** • Design an awareness program for promoting sustainable Development in the community.	**Promoting Socio-cultural, Economic, and Human Values** • Communicate the plan and conduct an awareness program in the community to promote sustainable development activities.

• Analyse the meaning of philosophy of Gross National Happiness, its pillars and domains as means for holistic development. • Review Bhutan's environmental policies and strategies to meet the sustainable development goals. • Justify the relevancy of GNH and SDGs for Bhutan.	**4.3. Gross National Happiness for Sustainable Development** **Scope:** This topic deals with the philosophy of Gross National Happiness, its pillars and domains. Review Bhutan's environmental policies and strategies to meet the sustainable development goals (MDG).	**Analysing and Interpreting data** • Carry out small research on Gross National Happiness and its contribution to holistic development. • Review environmental developmental policies and strategies of Bhutan to see how it contributes to MDG.	**Using Digital Resources** • Use internet resources • Share a report to the class.

Class-wise Competency (Class XII)

By the end of class XII, a learner should be able to:

1. Systems in Nature

1.1. Earth Community Ecology

- Apply the knowledge of community characteristics and ecosystem services to carry out ecosystem service valuation towards making informed decisions on ecosystem conservation, preservation and restoration.

1.2. Ecological Succession and Restoration

- Demonstrate an understanding of ecological succession, cause and factors of ecological succession, and explore ways for succession to a desired ecosystem.

2. Environmental Issues and Concerns

2.1. Carbon Footprint

- Analyse carbon footprint and how its increase leads to unsustainable development, and recognise the need for change in the lifestyle, and suggest innovative ways to reduce pressure on the natural resources.

2.2. Urbanisation, Industrialization and Environmental Changes

- Corroborate the relationship between the population size and changing lifestyle with carbon footprint, and justify how increase in carbon footprint would assert more pressure on our limited natural resources.

2.3. Degradation of Land and Water Resources

- Evaluate the causes and impacts of the land and water degradation by using ICT and field visits within the community, and suggest means of minimising land and water degradation.

2.4. Air Quality Index

- Investigate the air quality using AQI and indices by using different technologies, and understand the causes of air pollution and measures to reduce air pollution.

2.5. Pollution Reduction

- Investigate the air quality using AQI and its effects on human's health, environment and the wellbeing of communities, and suggest ways to minimise air pollution.

2.6. Biological Pollutants

- Explain the effects of biological pollutants and GMOs to human health and environment, and sensitise the local community on preventive measures backed by scientific evidence as strategies to mitigate the impending biological disaster.

2.7. Mitigation and Adaptation to Climate Change

- Analyse the vulnerabilities and impacts of climate change, and design its mitigation and adaptation measures for communities in Bhutan.

2.8. Phenology and Climate Change

- Demonstrate an understanding of phenology and climate change by conducting scientific research, and write a manuscript to communicate the results to a larger audience.

2.9. Disaster Risk Reduction Management

- Analyse the disaster management cycle and roles and responsibilities of relevant stakeholders to formulate a mitigation plan to reduce severity of the risk associated with hazards.

2.10. Disaster Management Practises in Bhutan

- Analyse disaster management practices in the country, region and the world, and recommend improvements for a resilient community.

3. Natural Resource Management

3.1. Benefits of Biodiversity Conservation

- Demonstrate the understanding of biodiversity benefits for supporting the organisms on the Earth and the socio-economic development of the country to explain the importance of biodiversity conservation.

3.2. Efforts to Manage Biodiversity

- Examine the roles of national policies and legislations, international treaties and conventions for the conservation of biodiversity, and recognise the importance of those policies in managing biodiversity.

3.3. Measures to Promote Biodiversity Management

- Analyse and describe the measures of biodiversity management at community and national level in Bhutan, and demonstrate the understanding of one's own roles towards the conservation of biodiversity.

3.4. Challenges in Biodiversity Management

- Explain some of the factors and challenges affecting the biodiversity management in Bhutan, and suggest ways to address those challenges at the individual and community levels and inform the policy makers.

3.5. Water Management and Conservation

- Design and practice water management and conservation strategies to raise awareness on improving the quality of water and sustainable use of water.

3.6. Land Use and Land Conservation

- Study land use land cover change by exploring appropriate tools, and assess the impact to strategize proper measures for sustainable land use practices.
- Explore strategies for land management and land conservation, and suggest ways to ensure efficient and sustainable use of land resources.

3.7. Alternative Energy Sources and Green Technology

- Demonstrate the understanding of alternative energy sources and green technology, and relate the ideas in creating innovative ways of using alternative sources of energy to promote green energy.

4. Sustainable Development

4.1. Environment Management

- Analyse the diverse initiatives of the government towards minimising the environmental degradation, and recognize the significance of the green economy towards the sustainable use of natural resources.

4.2. Sustainable Development Goals and Indicators

- Discuss the sustainable development goals and the strategies to address the challenges of implementing sustainable development goals, and formulate indicators to measure sustainable development goals for your community.

4.3. Gross National Happiness and Sustainable Development

- Analyse Bhutan's Economic Developmental Policy from the point of GNH, and recognise its contribution towards achieving the sustainable development goals.

Table 4: *Learning Objectives and Contents_ Environmental Science, Class XII*

Learning Objectives (KSVA)	Core Concepts (Chapters/Topics/Thames)	Process/Essential Skills	
		Scientific Methods and Engineering Practices	Society and Technology
• Differentiate between major and minor communities with examples. • Explain characteristics	**1.1. Earth Community Ecology** **Scope:** This topic explains the two types of community, major and minor, and its characteristics which include	**Obtaining and communicating information** • Observe and compare different communities; major and minor communities based on their characteristics, ecological services	**Using Digital Resources** • Explore available digital sources to obtain information and derive explanations on

of a community. ● Evaluate the ecosystem services and its importance for the wellbeing of Bhutanese people. ● Carry out ecosystem service valuation that can be used while developing cost effective strategies for nature restoration and management.	structure, dominance, diversity, periodicity, stratification, ecotone and edge effect, ecological niche, competition, productivity and bio-stability. It also explains the types of ecosystem services such as provisioning, regulating, cultural and supporting, and analysis of the importance of its valuation through market price, productivity, hedonic pricing and benefit transfer methods.	and evaluate its importance for the well-being of Bhutanese people. ● Review literature on the characteristics of communities and prepare presentations of their findings **Constructing explanations and designing solutions** ● Develop an ecosystem service valuation tool to evaluate ecosystem services derived by the community. ● Carry out ecosystem services valuation. ● Prepare a presentation to share findings.	ecological communities, ecosystem goods and services. ● Appreciate the dynamic provisions of the ecosystem. ● Explore digital resources to learn and develop ecosystem service valuation tools. ● Communicate the result to the community.
● Explain ecological succession and its types. ● Analyse the factors affecting ecological succession. ● Explain the evolution of a plant community based on the steps of ecological succession. ● Apply the knowledge of ecological succession in the management and restoration of degraded ecosystems to the desired ecosystems.	**1.2. Ecological Succession and Restoration** **Scope:** This topic explains ecological succession and its classification based on inhabitation (primary and secondary succession). It discusses natural and anthropogenic disturbances of ecological succession and describes the factors (biotic, topographic and climatic) affecting ecological succession. It also covers classification of organisms into different communities; pioneer communities, seral communities, climax community, and the basic	**Obtaining and communicating information** ● Review literature on natural and anthropogenic disturbances of ecological succession. ● Obtain information on factors that affect ecological succession and share the findings with logical reasoning. **Planning and carrying out investigations** ● Carry out a field trip, select a disturbed area where a landslide had occurred in past years. ● Observe succession and represent observation in the form of diagrams **Constructing explanations and designing solutions** ● Review literature on restoration and management of ecological	**Using of Digital Resources** ● Explore information from different digital sources. ● Communicate the findings. **Using Digital Resources** ● Explore the evolution of a plant community based on the steps of ecological succession. ● Use appropriate software for drawing ecological succession. **Using Digital Resources** ● Use digital resources to gather information

	steps of ecological succession (nudation, migration, ecesis, aggregation, competition, invasion, reaction and stabilisation or climax). It also includes application of the knowledge of ecological succession in restoration and management of degraded ecosystems to desired ecosystems.	succession. • Develop strategies to manage ecological succession to restore degraded ecosystems into desired form	on ecosystem restoration and share ecosystem restoration strategies through social media.
• Explain carbon footprint in the context of development. • Calculate carbon footprint. • Analyse the carbon footprint to suggest innovative ways to reduce human ecological footprint.	**2.1. Carbon Footprint** **Scope:** This topic explains about carbon footprint and its calculation using online tools. It also relates the carbon footprint to ecological footprint to innovate ways to reduce pressure on our natural resources.	**Obtaining, evaluating, and communicating information** • Review literature on carbon footprint and evaluate effective ways to reduce pressure on natural resources.	**Using Digital Resources and Multimedia** • Use the internet to calculate carbon footprint. • Share ways to reduce carbon footprint through social media.

• Investigate the impact of urbanisation and industrialisation to the community and the environment. • Suggest measures to address negative impacts to the environment	**2.2. Urbanisation, Industrialization and Environmental changes** **Scope:** This topic relates the impacts of urbanisation and industrialisation to the community and environment. It also covers the measures to address negative impacts to the environment.	**Obtaining, evaluating, and communicating information** • Use various resources to obtain information. • Carry out a field visit, and evaluate their positive and negative impacts of development on social, economic and environment. • Develop a plan to address some of those negative impacts.	**Influence Value formation** • Use the internet to explore the impacts of urbanisation and industrialisation, and to develop an effective plan to address the impact. • Use social media to create awareness and share a plan.
• Evaluate the causes and impacts of land degradation on social, economic and wellbeing of living organisms. • Suggest ways to minimise land degradation. • Conduct situational analysis of the water resources in the local community and make evidence-based recommendations for the sustainable use of the water resources.	**2.3. Degradation of Land and Water Resources** **Scope:** This topic elaborates on the causes (desertification, alkanization, acidification, salinization, soil erosion) of land degradation, and its impact on environment, economy and society. It also focuses on accessibility and equitable distribution of freshwater, it's over-utilization and contamination, and analyses sustainable use of water resources through community surveys.	**Obtaining, evaluating, and communicating information** • Gather information on land degradation: causes, process and impact of land degradation to the community and country as a whole. • Develop a poster representing land degradation and impacts. **Asking questions and defining problems** • Carry out a detailed survey on water resources (freshwater) in the locality with respect to availability, accessibility and equitable distribution of freshwater, and over-utilization and contamination. • Draft evidence-based recommendation to be shared with the concerned agency.	**Using Digital Resources** • Use digital resources to gather information. • Share posters and create awareness on the impact of land degradation through social media. **Promoting Socio-cultural, Economic, and Human Values** • Explore the internet to gather information on water resources. • Involve the community in carrying out a survey. • Share a recommendation to the community for the

			sustainable use of water resources.
• Explain the ways of determining the air quality. • Assess the air quality using the air quality index. • Justify the need to improve the quality of air.	**2.4. Air Quality Index** **Scope:** This topic explains about the determination of air quality index. It also discusses on the health hazards based on AQI range and levels)	**Obtain information from various sources** • Apply air quality index to check air quality and quantify the impacts on human health. • Calculate AQI and interpret the data to sensitise on quality of air.	**Influence Value formation** • Use the internet to explore the determination of AQI and related health concerns. • Use social media to create awareness.
• Discuss the emerging causes of air pollution. • Explore modern technologies used in reduction of air pollution. • Justify the need to use modern technologies in the reduction of air pollution.	**2.5. Pollution Reduction** **Scope:** This topic explains environmentally-friendly technologies to reduce air pollution - carbon capture and storage technologies, flue-gas desulphurisation and thermal oxidiser.	**Obtain information from various sources** • Conduct a library research or browse the Internet to identify the different technologies used to reduce air pollution. • Carry out a field visit nearby to find out the feasibility of using technologies to reduce the pollution.	**Influencing Value Formation** • Share findings using any social media on pollution reduction
• Explain biological pollution with examples. • Investigate the effects of biological pollutants and GMOs on human health and the environment.	**2.6. Biological Pollutants** **Scope:** This topic entails the concept of biological pollution (GMOs and genetic pollutants), its impact on human health and environment. It also explores preventive measures.	**Planning and Carrying out Investigations** • Investigate the effects of biological pollutants and GMOs to the environment and society. • Put forward logical scientific arguments on the detrimental effect of GMOs. • Design ways to minimise the impact of biological and genetic pollution.	**Using Digital Resources and multimedia** • Use various sources to gather information on biological pollutants and GMOs. • Sensitise the public by sharing the findings through social media for healthy living.

• Explain mitigation and adaptation to climate change • Design climate change mitigation measures for a locality. • Design an adaptation plan and implement at local level to combat climate change.	**2.7. Mitigation and adaptation to Climate Change** **Scope:** This topic evaluates the vulnerabilities and impacts of climate change. It also covers the development of climate change mitigation measures. It discusses the steps of the adaptation process to address the impacts of climate change.	**Constructing explanations and designing solutions** • Evaluate vulnerabilities and impacts of climate change. • Develop standard climate change mitigation measures for Bhutan and mitigation measures to be implemented at local level. • Develop adaptation plans to combat climate change in the locality.	**Influence Value Formation** • Share mitigation measures and adaptation plans to the community and create awareness on the impact of climate change.
• Conduct scientific research on phenology and climate change by following a standard scientific method • Communicate the findings in the form of an article/short communication/review paper etc.	**2.8. Phenology and Climate Change** **Scope:** This topic discusses phenology. It explains the steps of scientific investigation on phenology - observing and formulating, developing hypotheses, gathering evidence, drawing conclusions and sharing results.	**Planning and carrying out investigations** • Review literature, carefully designed standard method to investigate phenology and analyse the data. • Write a scientific manuscript for communicating the findings using various digital resources.	**Using Digital Resources** • Use data analysis software such as Microsoft Excel, SPSS, STRATA, GIS, QGIS, R-program etc. • Share the findings to validate the findings.
• Explain mitigation using the disaster management cycle and the ways by which it reduces the risk. • Plan and carry out disaster mitigation activities at school and community level. • Recognise the need for DRR at all levels.	**2.9. Disaster Risk Reduction (DRR)** **Scope:** This topic describes the phases of disaster management - preparedness, response, recovery and mitigation. It explores disaster risk assessment and formulating mitigation plans.	**Constructing explanations and designing solutions** • Obtain information from various sources and analyse the phases of the disaster management cycle, and interpret mitigation as a process to reduce the severity of the impact of a disaster. • Develop a disaster mitigation plan to reduce disaster in school or in the community.	**Promoting Socio-cultural, Economic, and Human Values** • Construct a model (diagram) to illustrate the mitigation phase. • Share and implement a mitigation plan in school or in the community to reduce disaster.
• Explain the standard process involved to assess the resilience. • Evaluate the disaster	**2.10. Disaster Management Practises in Bhutan** **Scope:** This topic explores characteristics of a resilient	**Planning and carrying out investigations** • Obtain information on the characteristics of a disaster resilient	**Influence Value Formation** • Analyse the data, interpret, and provide

resilience of a school or a community. ● Evaluate disaster management practices in Bhutan to provide necessary recommendations.	community and standard process involved to assess the resilience. It also discusses disaster management practices in Bhutan such as flood, earthquake, fire, windstorm and landslide.	community. ● Evaluate the standard process involved to assess resilience. ● Develop a tool or explore standard tools and carry out a survey to find out the status of a school's resilience. **Constructing explanation and designing solution** ● Review literature and evaluate disaster management practices in Bhutan. ● Write recommendations based on experience and literature to improve the management practices.	necessary recommendations to promote resilience against disaster. ● Involve school to make a well-informed decision based on the status of the school's resilience **Using Digital Resources** ● Visit a library or community or explore the internet for information on disaster management practices in Bhutan. ● Share recommendations through social media.
● Explain the benefits of biodiversity conservation in terms of cultural, economic and environmental wellbeing. ● Investigate how the biodiversity contributes to the livelihood and wellbeing of community in the locality.	**3.1. Benefits of Biodiversity Conservation** **Scope:** This topic entails cultural, economic, and ecological benefits of biodiversity conservation against natural disaster, recreation and tourism, agriculture and food security, genetic resources, source of food and raw materials and balance in the ecosystem.	**Analysing and constructing explanation** ● Conduct literature review of various benefits of biodiversity conservation. ● Develop a poster showing all benefits.	**Using Digital Resources** ● Communicate to the public by sharing posters to instil a value of rich biodiversity.

• Explain the significance of policies, legislation and international convention in biodiversity conservation. • Analyse national policies and legislations, and international treaties adopted by Bhutan for the conservation of biodiversity.	**3.2. Efforts to Manage Biodiversity** **Scope:** This topic covers national policies and legislations, and international treaties and conventions adopted to conserve biodiversity.	**Obtaining, evaluating, and communicating information** • Obtain information on national policies and legislations and international treaties and conventions to conserve biodiversity. • Analyse and write down impacts and benefits of such policies and treaties.	**Promoting Socio-cultural, Economic, and Human Values** • Use various sources to obtain information and communicate the impacts and benefits of policies and treaties among groups
• Explain the importance of indigenous methods in biodiversity management. • Explain National Biodiversity Strategies and Action Plan (NBSAP). • Interpret the application of Biodiversity Management System (BMS) in biodiversity conservation.	**3.3. Measures to promote biodiversity management** **Scope:** This topic includes measures to promote biodiversity management at community and national level.	**Engaging in argument from evidence** • Visit the nearby community or Dzongkhag Forest office and find out the biodiversity management system that we practice in Bhutan. • Analyse its impact and benefits and write a report.	**Using Digital Resources** • Visit the library or internet to obtain information. • Communicate the findings.
• Identify some of the challenges in biodiversity management in Bhutan. • Design innovative ways to mitigate the challenges of biodiversity management.	**3.4. Challenges in Biodiversity Management** **Scope:** This topic covers the challenges faced in biodiversity management including human-wildlife conflicts.	**Constructing explanations and designing solutions** • Conduct a survey in the local community to identify human wildlife conflicts and analyse the findings. • Design a solution (Innovative ideas as a strategy either in the form of an action plan or equipment to mitigate	**Carrying out STEM Activities** • Use the scientific process to collect and gather the information of human-wildlife conflict. • Use ICT or any other innovative ways to

• Analyse the causes of human wildlife conflicts with examples of threats to human life.		the conflict).	design a solution to mitigate biodiversity management challenges. • Communicate the findings to the public through social media (You may even choose to publish in a scientific journal).
• Explain water conservations with its benefits. • Identify and explain water conservation techniques/methods practised in the community or in the country.	**3.5. Water Management and Conservation** **Scope:** This topic begins with the concept of water conservation, carry out research on water conservation methods, legal instruments on water conservation)	**Constructing explanations and designing solutions** • Refer to the Water Act 2011 and do a field visit to find out water conservation techniques practised in the community. • Gather information on rainwater harvest, and design a model to harvest rain water.	**Using Digital Resources** • Use suitable software to design rainwater harvesting system models. • Share the model to the community.
• Explain land use and land cover change with causes of land cover change. • Explain sustainable land management approach to develop land management strategies for efficient use of the land. • Determine the soil quality through appropriate tests to ascertain the suitability of soil for specific	**3.7. Land Use and Land Conservation** **Scope:** This topic introduces the idea of land use land cover change, design mitigation measures for land use change and carry out soil test, explore legal instruments and conservation through agriculture, mine reclamation and ethnoecology	**Constructing explanations and designing solutions** • Identify the land cover changes using internet resources. • Select any area within Bhutan to identify the land use change (For example: Thimphu, Paro, etc.) • Study the land cover changes over the years. • Identify the causes and design a solution to mitigate the changes. **Planning and carrying out investigations** • Obtain information from various sources, visit nearby communities and	**Using Digital Resources** • Use internet resources: mountain geoportal accesses the land use coverage. • Share the findings and design solutions through social media **Promoting Socio-**

purposes. • Design innovative land conservation strategies for the local community through the evaluation of land conservation strategies practiced in Bhutan to promote sustainable use of land.		interview elder people on conservation of land. • Do a scientific writeup on land conservation methods practised by a particular community. **Analysing and interpreting data** • Obtain information from various sources. • Collect soil samples from different areas and study soil properties. • Carry out soil quality tests and identify suitable soil types for crops.	**cultural, Economic, and Human Values** • Share write up to the public through social media to appreciate and to encourage other communities to choose and implement best methods. **Using Physical Tools** • Use soil kits to carry out a soil quality test. • Communicate your findings.
• Assess the best alternative energy source and devices that are suitable for the community. • Design an energy efficient building plan that can be used as a model for the community. • Evaluate the benefits of green technology for the environment and wellbeing of humans.	**3.8. Alternative Energy Sources and Green Technology** **Scope:** This topic allows to explore alternative energy sources, green energy initiatives (hydro and wind generated electricity, biogas, and solar energy), and advantages and challenges in adopting alternative energy sources. green technology and alternative energy devices.	**Investigation and Analysing** • Conduct literature review of various alternative energy and devices. • Analyse and evaluate their suitability in Bhutan and Community. • Do a scientific write up on the best energy source and energy device including their pros and cons and benefit to the community. **Constructing explanations and designing solutions** • Obtain information on green technologies and carry out an outdoor field excursion to visit any building construction site. • Identify the raw materials used for the construction. • Evaluate the green technology components practised.	**Promoting Socio-cultural, Economic, and Human Values** • Explore the internet for information on alternative energy sources and devices. • Share your write-up to the public through social media. **Using Digital Resources** • Use the internet to obtain information on green technologies. • Share your design to the community.

		• Design an energy efficient building by incorporating green technology components	
• Examine Green Economy Initiatives across different sectors in Bhutan to identify the benefits and challenges and suggest alternatives to address the challenges. • Evaluate how Environmental Management tools and Environmental Management System models contribute in increasing resource efficiency and reducing environmental degradation. • Suggest an Environmental Management Plan for your school using the key elements of the Environmental Management System.	**4.1. Environment Management** **Scope:** This topic begins by discussing the concept of green economy, green economy practises across different sectors such as; agriculture, transportation, manufacturing, waste management, tourism, water management and energy buildings. Identify the benefits, challenges and alternatives to address the challenges. Introduce Environmental Management tools such as Environmental Impact Assessment (EIA), Strategic Environmental Assessment (SEA), Life Cycle Assessment (LCA), Environmental Audit, International Organisation for Standardisation (ISO) Certification) and the Environmental Management System model.	**Obtaining and evaluating information** • Use the internet and books to explore information. • Brainstorm	**Using Digital Resources** • Use the internet to explore information. • Use computer to write the proposal

• Evaluate and prioritise the sustainable development goals for your community. • Design a development activity for your school or community considering GNH indicators. • Evaluate how the SDGs are incorporated in the local government development plan and identify the challenges in achieving these goals.	**4.2. Sustainable Development Goals and Indicators** **Scope:** This topic begins with sustainable development concept, three dimensions. Discuss Sustainable Development Goals (SDG's), targets, and indicators of sustainable development. Evaluate Bhutan's five-year development plan and the challenges in achieving SDG goals.	**Obtaining, evaluating, and communicating information** • Search books or online resources for the concept, dimension, goals and indicators of sustainable development. • Invite Gup or Gewog Administrative Officer, or visit Gewog help you evaluate incorporation of SDG goals in FYP .	**Promoting Socio-cultural, Economic, and Human Values** • Use the internet or visit a library to obtain information. • Communicate the findings within the class
• Analyse the Economic Development Policy of Bhutan to measure its contribution towards achieving sustainable development goals. • Evaluate how the Mainstreaming Acceleration and Policy Support (MAPS) approach helps in addressing the challenges of implementing SDGs in Bhutan.	**4.3. GNH and Sustainable Development** **Scope:** This topic begins by reviewing Economic Development Policy of Bhutan, assess how it helps in achieving SDGs, United Nations Development Group's support in addressing challenges through Mainstreaming, Acceleration and Policy Support approach.	**Obtaining, evaluating, and communicating information** • Search books or online resources for the Economic Development Policy of Bhutan. • Search books or online resources for the United Nations Development Group's Mainstreaming, Acceleration and Policy Support (MAPS)	**Promoting Socio-cultural, Economic, and Human Values** • Use the internet or visit a library to obtain information. • Communicate the findings within the class

5 Teaching and learning approaches

The effective teaching and learning approaches help learners visualize abstract concepts and relate to their life. It is important to adopt a wide variety of teaching learning strategies to help learners achieve the learning standards and develop competencies expected of the learners. Some of the intent of diverse approaches include building interdisciplinary skills, strengthening knowledge, developing skills and values, enhancing deeper and lifelong learning, and to promote the development of 21st century skills (collaboration, creativity, communication, and critical thinking),

The following are some of the suggested teachings and learning approaches to be adopted where appropriate.

14.1 Place Based Education

Place based education is an approach that allows learners to immerse into local culture, heritage, ecology, social and economic as the context for an experiential and real time engagement. Acknowledges that learning happens not only in formal educational setting but also outside of school in families and communities. This reinforces connections to one's home, family, community, and world.

This approach is informed by the principles and strategies of exploratory, inquiry and discovery-based learning. It adopts the use of 7E model as the means of engaging in the teaching and learning process. Cognizant of significance of this approach in science education, curriculum materials are designed that stimulate teachers and students investigate in constructing scientific concepts and knowledge and discourage rote learning.

For example, carry out research to investigate the impact of alcohol on health of people in your community. Follow the ethics and protocol of research.

14.2 Dimension of effective pedagogy

Effective pedagogical dimensions are those dimensions of pedagogy, which illustrate effective learning outcomes. Effective pedagogy should consider that that change is exponential and the landscape of jobs are changing. With all that in mind, there is a need for effective pedagogical practices for 21st century learners. The elements of effective pedagogical practices for 21st century learners are creating safe and inclusive learning environments fostering respect for diversity and creating caring and enthusiastic classrooms. The 21st century classroom is a learner centred and collaborative, warm colourful, well organized personalized spaces for arts and crafts, science, nature, music, group projects, group discussions, reading corner and ICT. All these ultimately help nurture 21st century citizens.

For example, design an advocacy program to create awareness on green practices to avoid use of synthetic polymers and reduce the impact on global warming. Also, design an experiment to analyse the chemical nature of antacid given in the hospital or design an experiment to analyse a sample of cold drinks for presence of harmful chemicals in it.

14. 3 Autonomy, flexibility, and adaptability (teacher as a facilitator/localised curriculum)

Learner autonomy is the strategy where learners are encouraged to take responsibility of what they learn and how they learn to promote thinking and learning skills (creativity, critical thinking, digital literacy, learning to learn), and social and emotional skills (communication, collaboration, emotional development, social development).

Flexibility and adaptability is a strategy where learners are given freedom on how, what, when and where they learn. For example**,** explore the information on the meaning of nature of chemical bond, types of chemical bond, duplet and octet rules using relevant resources.

14.4 Reflective practices (where am I going? How do I reach there?)

Reflective practices is all about thinking deeply about our experiences and learning from it to improve our future practice. Reflective practices promote creativity and deeper learning in learners**.** This either entails learners, individually or in groups, are stimulated to gather and reflect on a specific theme or learning topic or problem be solved. This can take place anywhere and anytime. For example, engaging learners apply the knowledge of properties of metals to design a roof for houses in the locality. This necessitates learners to reflect on the learnt concept, relate to the problem in hand and construct the roof.

14.5 Blended learning

Blended learning is a strategy utilizing a combination of traditional classroom-based learning method with the digital technologies, use of ICT software, google apps, online resources, and others. This strategy is particularly significant in the 21st century education as it brings forth stimuli variation and make learning challenging, at the same time fun.
For example, in the teaching of electricity, having introduced the concept of current, potential difference and resistance of the conductor, learner uses PHET apps in deepening the understanding on the concepts and principles of conductivity.

14.6 Differentiated/Inclusive/ Personalised instruction

Differentiated instruction is an approach wherein students' individual learning styles, levels of readiness and differences are considered. Research studies have proven that this method benefits a wide range of students, from those with learning disabilities to those who are considered high ability. This approach or method can be referred to differentiation of instruction in teaching with the same material to all students using a variety of instructional strategies. Further, it may also require the teacher to deliver lessons at varying levels of difficulty based on the ability of each student.
Generally, teachers deploying the differentiation instruction in the classroom may:

- Diversify teaching styles to align with the students' learning styles.
- Group students by shared interest, topic, or ability for assignments.
- Assess students' learning using formative assessment and diverse assessment techniques and tools.
- Establish an ambient learning environment to create a safe and supportive environment.
- Continually assess and vary teaching style and teaching pace to meet students' needs.

For example, the teacher should use a variety of teaching learning approaches to cater to the varied needs of the learners. For instance, topics like mechanisms of chemical reactions, photosynthesis, environmental pollution, and mechanical advantages of machines may be approached through inquiry or exploratory learning or the teacher may explain the concept to match the needs of the learners.

14. 7 Use of information technology

Information technology is an important tool for addressing varied learning styles of learners. For instance, some learners who are quiet in class may participate actively in online forums and contribute useful ideas. Different online assessment tools with mechanisms to support learning help motivate learners. The use of multimedia tools in information technology would motivate visual and auditory learners to learn better. For example, explain isomerism in hydrocarbons, nuclear reaction, meiosis using simulation; study the structural formula of alcohol to design 2D/3D molecular model of alcohol with its functional group; use of simulation to learn about anatomy and physiology of animals.

14.8 The use of assistive technology

The assistive technology is assistive, adaptive, and rehabilitative devices for learners with disabilities. The teaching learning activities in science should provide equal opportunities to learn for learners with disabilities. The following are some of the suggestive devices that can be made available to the learners in chemistry class. Mobility aids such as wheelchairs, walkers, canes, crutches; hearing aids for learners with hearing impairments; cognitive aids such as computer or electrical devices to help learners with memory and attention or other challenges of thinking skills.

Computer software and hardware such as voice recognition, programmes, screen readers, screen enlargement applications to help learners with mobility and sensory impairments. Tools such as automatic page-turners, book holders, and adapted pencil grips to help learners with disabilities.

14.9 Individualised learning/Learner centred/ Learner ownership (lifelong learning)

The personalized or individualised learning facilitates students establish learning goals based on their personal, academic and career interests. Teachers and parents provide support.

The significant elements of this approach may include the following:
• flexible, anytime/everywhere learning.
• redefined teacher's role as facilitator, guide and evaluator.
• project-based or authentic learning opportunities.
• student-driven learning path.
• progress upon the mastery of the topic and skills and is competency-based learning.

14.10 Subject specific strategies

The following are some of the strategies that can be applied to teaching and learning of science.
i. Laboratory Investigation: Laboratory investigation is an important part of the chemistry learning process. This strategy actively engages learners and helps them to develop scientific skills. It also helps learners understand the process of scientific investigation and develop a deeper understanding of scientific concepts.
ii. Claim Evidence Reasoning (CER): According to the C-E-R model, an explanation consists of a claim that answers the question, evidence from students' data and reasoning that involves a "rule" or scientific principle that describes why the evidence supports the claim. This is an important strategy in science to help learners work through problems to help arrive at a scientific explanation.

This strategy helps learners develop better understanding of a problem and gives the ability to communicate the thoughts clearly and scientifically.
iii. Process Oriented Guided Inquiry Learning (POGIL): It is a student-centred instructional approach which consists of students working in small, self-managed teams on specially designed guided inquiry materials. For example, compare molarity, molality, normality, and mole fraction as different units for expressing the concentration of solutions.

iv. Project Based Learning: Project based learning is an approach in which learners acquire a deeper knowledge and skill through active exploration of complex questions, real world challenges and problems. This strategy engages learners in learning that is deep and long – lasting and inspires learners learn as personalised learning. The project-based learning supports active engagement of learners and facilitates the development of 21st century skills needed to succeed in their life.
For example, design a prototype that can be used to produce biofuel from local organic waste and may solve energy problems in your locality.
V. Problem Based Learning: It is a learner – centred approach to learning that involves groups of students working to solve a real-world problem, quite different from the direct teaching method of a teacher presenting facts and concepts about a specific topic to a classroom of students. The problem-based learning approach not only strengthens teamwork, communication, and research skills in learners but they also sharpen their critical thinking and problem-solving skills essential for life-long learning. Example, apply the knowledge of volumetric analysis and neutralization reaction to design an experiment to compare the effectiveness of two or more samples of antacids.
vi. 7 E Method: The **7E** Model is a learning cycle composed of seven steps, namely elicit, engage, explore, explain, elaborate, evaluate, and extend. This model is a learner-centred model. This model provides opportunities for learners to actively participate in the learning process and master the competencies.
The practice of 7E model in science teaching can stimulate learners to remember the subject matter, motivates learners to learn, learn to understand concepts through experimental activity, provide opportunities for learners to think, search, find, and can relate the concepts to real life application.
vii. Divergent Thinking: It is a method of generating multiple ideas and multiple solutions to a problem. It is a process of seeing a lot of possible answers to a question. This strategy may be encouraged through project work, activities on designing an experiment, designing a model or in the way we put up questions in the classroom. For example, chemistry promotes finding creative and innovative ways to reduce waste, conserve energy, and discover replacements for hazardous substances. Apply the principles of green chemistry to design and formulate a chemical preservative that is less toxic compared to highly toxic formalin which is being used as a preservative in the laboratory/ how life would and civilization be different if radioactive substance was not discovered.
viii. Design Thinking: It is a strategy that can help solve problems creatively. Design thinking considers all the creative problem solving through the lens of human centric design or human centric approach. For example, blocked drains can be very unpleasant. Common causes of blocked drains in homes are fats, hair, and food waste. Using the knowledge of science, suggest chemical methods that might be used to unblock drain.

ix. Backward Design: It is also called backward planning or backward mapping, is a strategy used to design learning experiences and instructional techniques to achieve specific learning goals. There are three stages of backward design, which includes identifying the desired results, identifying the evidence of learning, and designing the instructional plan. This strategy can be used to plan a unit/ chapter/ topic in science.
For example, design a device, which uses has high energy efficiency in relation to energy consumption and national energy security.

6 Assessment and Reporting

Assessment is an integral part of the teaching and learning process. It involves gathering information through various assessment techniques and making sound decisions. Assessment provides information to the teacher about students' achievement in relation to the learning objectives. With this information, the teacher makes informed decisions about what should be done to improve teaching methods and enhance the learning of the students. Assessment is also used a method to place the learner in next hierarchal level of learning content based on required learning objectives met level.

15.1 Aims and Purpose of Assessment

In the competency-based curriculum, the curriculum recommends to focus on the "Assessment in learning" and "Assessment for learning" (formative- CA for effective teaching and learning), and "Assessment of learning" (summative- competency attainments). The "assessment for Learning" (Hargreav, 2001) is the process of seeking and interpreting evidence to be understood by the teachers and learners as where the learners are in their learning, where they need to go, and how best to get there. Assessment for learning covers how teachers gather and use evidence about teaching and learning to decide whether learners are in their learning and how learning and teaching might have to change to help learners to take the next steps. The "Assessment of Learning" is used to measure the degree to which objectives have been achieved. Information collected through this type of assessment is used mainly to measure the attainment of competencies.

Assessment measures the extent to which desired knowledge, skills and attitudes are attained by students. While it complements the teaching and learning process, it also provides formative and summative feedback to teachers, students, schools, and parents.

15.2 Principles of Assessment

Assessment of children's learning involves complex processes requiring teachers' professional judgement. Although curricular policy lays the foundation for student learning, teachers ultimately decide how to assess, what to assess, and when to assess. In order to make the right and fair assessment, it is necessary that teachers adhere to these basic measurement principles.

There are four basic principles of assessment: reliability, reference points, validity, and record-keeping.

15.2.1. Reliability

Reliability is a measure of consistency. It is the degree to which student results are the same when they take the same test on different occasions, when different scorers score the same item or task, and when different but equivalent tests are taken at the same time or at different times. There is a need for assessment to be reliable and this requires clear and consistent processes for the setting, marking, grading and moderation of assignments.

15.2.2 Reference Point

The interpretation of any kind of measurement depends on reference points. It is only by clearly distinguishing the reference points that teachers can provide students, parents, and the general public with meaningful information about what is deemed important, and what the stages are in the journey from emergent to proficient.

In assessment, there are three reference points teachers can use when considering a student's performance. (Refer National Curriculum)

15.2.3. Validity

The definition of validity can be summarized as how well a test measures what it is supposed to measure. Validity ensures that assessment tasks and associated criteria effectively measure student attainment of the intended learning outcomes at the appropriate level. Valid assessments produce data that can be used to inform education decisions at multiple levels, from school improvement and effectiveness to teacher evaluation to individual student gains and performance.

Validity of classroom assessment depends several factors. (Refer National Curriculum Framework).

12.3.4 Record Keeping

The records should include detailed and descriptive information about the nature of the expected learning as well as evidences of students' learning, and should be collected from a range of assessments techniques and tools. (*Rethinking Classroom Assessment with a Purpose in Mind, Manitoba Education, Citizenship and Youth, 2006).*

15.3 Domains of Assessment in Science

The assessment in science is focused on three domains of learning – the Scientific Knowledge (SK), Working Scientifically (WS) and Scientific Values and Attitudes (SV). These three domains of learning are assessed both in formative and summative assessment method.

15.3.1 Scientific Knowledge (SK)

This domain focuses on core concepts. The scientific knowledge helps the learner to develop new technologies, solve practical problems and make informed decision individually or collectively. In this domain the learner should be able to demonstrate knowledge and understanding in relation to:

a. scientific phenomena, facts, laws, definitions, concepts, and theories
b. scientific vocabulary, terminology, conventions (including symbols, quantities, and units)
c. scientific instruments and apparatus, including techniques of operation and aspects of safety
d. scientific quantities and their determination
e. scientific and technological applications with their social, economic, and environmental implications.

15.3.2 Working Scientifically (WS)

This domain encompasses scientific methods and engineering design; and society and technology to bring the integration of STEM education. This domain identifies eight scientific methods and engineering design that mirror the practices of professional scientists and engineers. Use of this domain is intended to strengthen students' scientific skills and develop understanding of the nature of science (NGSS). Students also demonstrate the skills to use the technology and society to learn the concepts, and design the conceptual model or working model of new technology that helps to solve the societal issues.

In the domain area of scientific and engineering methods, student demonstrate the scientific skills in relation to:

a. Asking questions (for science) and defining problems (engineering).
b. Developing and using models.
c. Planning and carrying out investigations.
d. Analysing and interpreting data.
e. Using mathematics and computational thinking.

f. Constructing explanation (for science) and designing solutions (for engineering).
g. Engaging in argument from evidence.
h. Obtaining, evaluating, and communicating information

Society and Technology, student demonstrate the scientific skills in relation to:

a. Exploring Digital Resources.
b. Using Physical Tools.
c. Carrying out STEM Activities.
d. Promoting Socio-cultural, Economic Environment, and Human Values.

15.3.3 Scientific values and attitudes (SV)

Scientific methodology which starts with observations and questions are usually inspired by scientific values and attitudes. Through the science education, learners demonstrate curiosity, honesty, open-mindedness, creative and critical thinking, confident and persistent, objectivity, responsibility, and collaboration.

15.4 Shift in Assessment modality.

Since the New Normal Science Curriculum focusses on doing science than teaching science, modality of assessment is shifts to performance-based assessment. This approach of assessment seeks to measure the student learning based on how well learner can perform on practical real task. It demands student to create a product or answer the questions that manifest learner's skills and understanding. Therefore, in addition to the written tests, teachers can also conduct performance-based assessment using the technique of assessment mentioned.

The following chart summarizes some of the changes in the area of assessment. Therefore, the assessment in science curriculum framework encompasses the following emphases.

Less Emphasis on	More Emphasis on
Assessing what easily measure	Assessing what is most highly valued
Assessing discrete knowledge	Assessing rich, well structed knowledge
Assessing scientific knowledge	Assessing scientific understanding and reasoning
Assessing to learn what do not know	Assessing to learn what students do understand
Assessing only achievement	Assessing to improve teaching and learning
End-of-term assessment by teacher	Student engaged in ongoing assessment of their work and that of others
Development of external assessment by measurements experts alone	Teachers involved in the development of external assessments.

15.5 Types of Assessment

Assessment in science is generally carried out through three modes – continuous formative assessment, continuous summative assessment, and summative assessment. Each mode of assessment has its own purpose, assessment techniques and tools, recording, and reporting. These assessment modes help to understand and guide teaching and learning, help learner progress, report the performance of the learner, and evaluate the efficacy of curriculum materials and instructions for timely interventions.
The following sections explain each mode of assessment in terms of purpose, techniques and tools, and the reporting processes:

15.5.1 Continuous Formative Assessment (CFA)

The continuous formative assessment focusses on assessing learner's progression and their learning needs daily. It is aimed at identifying learning needs of the learner, providing feedback, and designing interventions and remedial measures. It also enables teachers to understand what teaching methods and materials work best. However, CFA does not attest performance level such as banding, grading, or classifying learners into different categories.
CFA is carried out using different assessment techniques, including but not limited to assignment, class activity, experiment, project work, and fieldtrip. The learner's performance and achievement level are ascertained using relevant assessment tools in accordance to the assessment techniques such as rubrics, rating scale, checklist, anecdotal record, narrative feedback, etc., by maintaining an assessment portfolio.

15.5.2 Continuous Summative Assessment (CSA)

The continuous summative assessment focuses on grading the learner's performances and provides feedback accordingly. It also enables teachers to understand the efficacy of teaching methods and materials used. Grading of learner's performance and achievement is carried out using appropriate assessment techniques and tools, and recorded in the assessment portfolio. Different assessment techniques and tools are used, based on the nature of task and the assessment domain, to carry out CSA.

15.6 Assessment Technique and Tools

Assessment Technique
The assessment technique is used to assess the domains of learning, gauge the learning progress and gap of a learner, collect information on teaching performance and instruction to help modify and improve the teaching strategies based on learner's performance and needs. It also allows the teacher to reinforce the lesson and decide which methods and materials are beneficial in promoting learning.
The following are the common assessment techniques that are widely used:

i. **Assignment:** It is an extended activities given to the learners to teach a concept, encourage self-learning, explore additional information on the concept, etc. The assignment in the form of homework, presentation, debate, writing a report, journaling, model making, etc. can be given to enhance the intellectual, analytical, interpretation, recording, reporting, and communicating skills of the learner.
ii. **Class activity**: It allows face to face interaction between teacher and learner and assesses the leaner's understanding of theory and instruction. The activities such as presentation, discussion, debate, quiz, etc. can be used to enrich the teaching learning process and strategies in the class.

iii. Practical work: It allows the learner to relate the theory to real life experience, develop scientific skills, and understand the process of scientific investigation and understanding of scientific concepts. The practical work can be used to enliven the science lesson and should be carried out frequently.
iv. **Experiment:** It is a scientific procedure undertaken to validate a known fact, test a hypothesis, learn the skills of manipulating the variables, etc. It should be carried out frequently to strengthen the teaching learning process.
v. **Project work:** It is an avenue for the learner to synthesize knowledge based on information and data obtained from various sources of learning. The learner gets an opportunity to carry out independent study using a science inquiry processes to acquire the skills of observation, recording, analysing, interpreting, and reporting. Hence, one project work, following the components of science inquiry, should be carried out in each academic session.
vi. **Scrapbook:** It is like journaling where the learner collects a scientific clipping, specimens, study samples, art works, print media, pictures, photographs, and other science related scrap works, which are appealing to their interests, supported by a caption or a description. It helps learner become creative and self-reflective as they collect, write, and keep record of their observations. The learner should be made to maintain one scrapbook each.
vii. **Test and examination:** It is used as an avenue to test the learning progress and gap of a learner for follow-up and promotion. While the test may be conducted based on the need, one examination at the end of each term can be conducted.

Assessment Tool

The assessment criteria and tools which are objective, valid and reliable help in obtaining the right information on the progress of learner. The quality of information acquired through assessment is determined using right tools and descriptors chosen for assessment. The assessment tools and samples are given below:

i. **Checklist:** It offers "yes" or "no" format in relation to achievement of a specific criteria by a learner. It can be used for recording observation of an individual, a group or whole class.
ii. **Rating scale:** It allows teacher to indicate the degree or frequency of the behaviours, skills and strategies displayed by the learner. It has scale-based criteria to describe the quality or frequency of the work with precise and reliable descriptive words. The teacher can use it to record observations and the learner can use it for self-assessment.
iii. **Rubric:** It presents a set of criteria with a fixed measurement scale and a detailed description of each level of performance. It helps to increase the consistency and reliability of scoring.
iv. **Anecdotal Record:** It helps to record specific observations of a learner based on behaviour, skills, and attitudes in relation to the expected learning outcome. It provides cumulative information and direction for further instruction. It can be used for the on-going observation.

Assessment Portfolio

Since the major part of assessment focuses on CFA and CSA, it is imperative to maintain individual assessment record in the form of assessment portfolio. The assessment portfolio enables the teacher to maintain a purposeful information on learner's work, learning progress and gap, and necessary remedial supports and follow-up.

The portfolio also provides relevant information on the progress of the learner to various stakeholders including parents to seek timely support and intervention. Hence, the assessment portfolio should be made accessible to the parents/guardians periodically. A standard assessment portfolio, like the suggested sample given below, can be used for uniformity:

Following are the suggested assessment technique and tools.

Assessment technique	Assessment Tools	Digital Assessment Tools
• Practical work • Projects • Teacher observations • Reflections / Journals • Model-making • Posters • Games and quizzes • Debates • Drama/Show and Tell • Learning Trails • Journal • Peer Assessment • Demonstration • Self-Assessment • Science Journal Entries • Standardized Test • Visual Displays • Research Report/Presentation • Pencil-and-Paper Tasks • Laboratory Reports • Interpretation of Media Reports of Science • Exhibition • Paper and pencil test • Observation	• Checklists • Anecdotal Record • Rubrics • Rating scale • Marking Scheme	• Google Forms • Plickers • Edulastic • Poll Everywhere. • Socrative.com • Nearpod • Playposit • Spiral • Formative • Classkick • Padlet • Recap • Kahoot • Quizizz • Quizlet • Quizalize • Triventy • SketchParty TV

15.7 Assessment Record and Report

The records should include detailed and descriptive information about the nature of the expected learning as well as evidences of students' learning collected from a range of assessments techniques and tools. (*Rethinking Classroom Assessment with a Purpose in Mind, Manitoba Education, Citizenship and Youth, 2006).*

In addition, assessment should provide clear, accurate, consistent, and timely information on assessment tasks and procedures and should be made available to students, staff and other external assessors or examiners. (*Refer appendix 1 for detailed assessment and reporting*)

7 Enabling Conditions

Appropriate and adequate conditions are pre-requisites for effective delivery curriculum in general, and science curriculum. A conducive school environment ensures that the intentions of the curriculum are achieved. Therefore, the following enabling conditions are imperative.

16.1 School Administration & Management

School administration and management plays an import role in implementing the education process successfully. The role of school administration and management in the school context can be manifested in different ways such as educational management, guidance, instructional management, and community services. Instructional management is an important role and responsibility to be ensured by the school administration and management for successful implementation of National School Curriculum Framework. Therefore, a school administration and management must implement and ensure the following tasks:

- Conduct instructional conferences to keep updated with paradigm shift and refresh the existing knowledge and skills.
- Ensure that content for teaching and learning is in line with national documents and goals.
- Ensure that integration of process/essential skills are implemented as reflected in NNSCF
- ensure that learning outcomes and assessment standards are correctly arranged to allow progression.
- Provide a platform to include the inclusive instruction to learner with various learning barriers.
- Provide staff development program to support for collaboration, development of coaching relationships, use of action research, provision of resources for self-development, and apply knowledge based on evidence and record.
- Develop teacher reflection program to reflect on classroom teaching strategies, instructions, and assessment.
- Oversee the curriculum planning in the school are aligned with learning objectives and activities (student centred), management of assessment strategies, effective use of time and resources and implement the intended curriculum.
- Manage a conducive physical environment and adequate teaching learning materials, adequate learning space with modern facilities to enhance teaching and learning.

16.2 Professional Capacity of Science Teacher

Teachers are the main agent who implement the intended curriculum as envisioned and aspired by public to achieve the national educational vision through various approaches and strategies. Therefore, the quality of professional capacity of science teachers determines the process and outcome of education. In order to augment their professional capacity, the teachers must ensure the following tasks:

- Self-preparation in advance to set the goals, plan a systematic process on teaching and assessment and preparation of teaching learning materials.
- Enhance interaction with student to motivate the learners, recognize diversity in students to select varied instructional strategies, address the classroom issues, communicates the feedback with appropriate interventions.
- Build community in classroom for learner to feel comfortable in the classroom to participate actively in every activity, do authentic and genuine assessment about learning and to be fair and consistent in treatment of every student.
- Participate in any professional development program to keep updated with new development for professional growth.
- Keep updated with professional knowledge and skills related to one's own subject through informal or formal training or programmes.
- Carry out educational action research to have first-hand information on modification or application of teaching strategies and skills.

- Evaluate and assess student's performance in period basis using the assessment various assessment technique and tools.
- Carry out performance-based assessment to ensure the implementation of STEM education.

16.3 Stakeholders:

a. Ministry of Education

Ministry of education is mandated to look after overall education provision, promotion, facilitation, formulation of policy guidelines on education. It also coordinates the development and deployment of human resource, implementation and monitoring of planned activities, and review and provide support services. Therefore, the ministry of education being the apex of education body has bigger roles and responsibilities in facilitating the effective implementation of the curriculum as reflected in the following.

- Ensure adequate human resources, infrastructure development, adequate curriculum support materials and budgetary support to enable effective curriculum implementation of the science curriculum.
- Establish protocols to provide timely monitoring to ensure adequate human resources, infrastructure development, adequate curriculum support materials and budgetary support to enable effective curriculum implementation.
- A sound protocol for carrying out monitoring and support services effectively must be put in place in order to bridge the gap between the intended and implemented curriculum.
- Monitoring and support at the national and dzongkhag levels is to:
  - Check whether schools adhere to the policies related to the implementation of curriculum,
  - Identify shortcomings and gaps in the curricular policies and take necessary measures to address these gaps,
  - Conduct needs assessment (both professional and resources) at the school level and make necessary arrangements to address these needs, and
  - Provide timely feedbacks and report to the relevant agencies to improve service delivery, coordination, and fix accountability if necessary.

b. Department of Curriculum and Professional Development

Department of Curriculum and Professional Development as the national epicentre for education innovation and transformation shall determine the national school curricula and teacher professional development programmes, and strive to improve the overall mainstream education system.

- Review, innovate, design, and develop the national curriculum and professional development programmes based on feedbacks from the field.
- Conduct research related to curriculum and disseminate the information for incorporation and improvement.
- Develop and provide timely professional development for smooth implementation of curriculum.
- Disseminate the curricular changes and ensure the changes are implemented in the schools.
- Conduct periodic monitoring for professional support services.

c. Bhutan Council of School Evaluation and Assessment

BCSEA as the professional body is mandated to gauge the health of the education through the conduct of examinations and high-stake test. The examination and test ascertain the achievement of the desired learning outcomes, and gauge the quality of education in reference to international standard. Thus, the BCSEA is mandated to carry out the following in relation to the school curricula implementation.

- Conduct national assessment to monitor student performances.
- Conduct board examinations based on the mathematics curriculum.
- Provide professional development in assessment.

- Disseminate result analysis report to various stakeholders.

d. Local Government & Community

Local government is responsible for the function of delivering a range of services and infrastructure required by their individual communities and as per the directives of the central government. Local government plays an important role in translating the policy and plans into action at grassroots level. Therefore, to ensure the smooth implementation of the science curriculum, local government is mandated to execute following functions

- Disseminate information and ensure the changes are implemented in the schools based on national directives.
- Facilitate the placement of human resources and supply of material resources.
- Facilitate professional development programmes based on the needs of the school leaders, teachers and other staff within the dzongkhag and thromde.
- Monitor school level curriculum implementation and report to relevant agencies.
- Provide time to time feedback on the effectiveness of curriculum to relevant agencies, and facilitate the provision of infrastructure and equipment necessary in schools for science education.

e. Role of parents

Parents play a vital role in the effective implementation of any curriculum. They should guide, encourage, and provide parental guidance and support in learning and development, and collaborate with school to monitor the progress of their children. Parents should also provide a conducive home environment that support learning of their children which helps in development of creativity, sharpen their focus, and increase their motivation for learning.

- Parent are kept updated with paradigm shift in curriculum and provide necessary support to formulate curriculum through feedback and suggestion to central agencies.
- Guide their children vital to enhance successful learning of the content as intended.
- Follow up on the progress of their children and provide support for learning and feedback to other stakeholders for better quality education.
- Participate in school programmes as and when required to keep informed about the enrichment programmes for the children.

f. Role of Students

Students are the main consumer of the objectives of curriculum who would be the main product of a result of education process driven through various curriculum instructions and dimensions. For the prosperity and betterment of a society, the foremost role of student is development of knowledge, skills and values through the well-planned activities implemented in schools. Therefore, student is mandated to fulfil the education goals through the roles mentioned below.

- Participate actively in carrying out the activities as instructed by teachers since every activity has intention to fulfil learning objectives.
- Participate in any enrichment program to relate the conceptual understanding into practical application.
- Provide genuine feedback to teachers and school administration for improvement of teaching and learning in schools.
- Ensure the self-awareness of intended curriculum to motivate learning.
- Share the opinion freely to teachers, friends and others with regard teaching and learning.

16.4 Physical Resources

Curriculum implementation depends largely on resources available in schools. Lack of resources necessary for the execution of teaching and learning can inhibit effective curriculum implementation. Providing essential materials allows teachers to focus their attention on teaching their learners, rather than tracking down materials they do not have.

In order to effectively implement curriculum and create conducive teaching and learning environment, the schools should be equipped with:

- Adequate multiple representations such as model, pictogram, posters, and animated and simulated models to support innovative teaching and learning
- Technology support: Hardware like computers and laptop should be made available and software (like teaching and learning resources, providing link for important mathematical resources, using dynamic software (like simulations and animations) for teaching science concept) should be made available.
- Each school should establish equipped a science laboratory (Physics, Chemistry and Biology) to provide space for experimentation, innovation and exploration of science concepts and appropriate knowledge creation, and initiate science education enrichment programs in schools as the platform for students to relate and apply the learnt concepts and skills in the real-life setting. Students are informed of the opportunities and challenges in the field of science and in the society. Its impact is profound in fostering the development of transversal skills, digital literacy, and aware of science in the society.

8 Cross Curricular Linkage

Cross curricular studies are the conscious effort to apply knowledge, principles, and/or values to more than one academic discipline. Cross curriculum connections make learning more holistic and meaningful for learners. Learners develop the understanding that nay life problems call for the application of knowledge, skills, and values for diverse field of studies. However, in the world outside school, work rarely fits the narrow boundaries of a single academic discipline. A doctor needs skill in biology, chemistry, mathematics, psychology, and English. A newspaper reporter needs a knowledge of English and history as well as science and statistics. The following are some of the activities that promote cross curricular studies in chemistry.

17.1 Science and Language

There are many correlations between science and language in terms of overlapping of processes and skills. The common features that are observable in science and language are the analysis of data and information, formation and statement of explanations and conclusions as well as the general dialogue, interaction, and discourse (Akerson & Flanigan, 2000). From this common feature of overlapping, inquiry-based task can be provided to construct knowledge along with skills, practices, and attitudes in both disciplines.

17.2 Science and Mathematics

The common features between science and mathematics as stated in literature and curricula are linked to concepts, skills, and practices. There are many areas common to science and mathematics at the conceptual and practical levels. The common concepts of measurement, geometry, and linear momentum etc. At the level of skills, problem solving, and using data for experimentation, analysis the data, communicate and explanation are basically accepted as common skills overlapping and assisting each other to learn the concepts and skills. At the level of attitudes, there is the desired attitude to quantify and appreciate the quantification of states and concepts along with the linkage to everyday life experiences (Davison et al., 1995; Lonning & DeFranco, 1997; Pang & Good, 2000).

17.3 Science and History

Even though there has been research on how to implement the integration of science and history, the emphasize on the importance of scientific discoveries in history and the development of humankind has been evident in the society. This involves observing and understanding the importance of scientific progress in important social reforms and changes. This, in turn, can help pupils appreciate the general interaction between science and society.

17.4 Science and Religion

Science and religion are related based on habits and skills, such as critical thinking and inquiry-based activities. Jegede and Aikenhead (1999) suggest that teaching culturally oriented subjects, such as religion, can have benefits by incorporating science-like projects and inquiry methods through the scope of problem solving. This could include engaging learners in tasks where they must use scientific methods and data to foster the development of positive attitudes and take decisions that concern human rights, racism, or environmental issues.

17.5 Science and Geography

Baerwald (2010) sums up that geography generally deals with topics such as regional analysis, spatial analysis as well as interactions between humans and the environment, climate, and flora and fauna. These are topics that can be linked to science subjects. The projects that are based on the development of skills and attitudes such as hypothesizing, observation, and critical thinking which are developed as skills in problem-based learning in science can be used for contextualized learning areas such as “deforestation and ecological disasters”, “natural disasters and policies required”, “impact of tourists or industrial development on the natural environment”, or “the influence of the landscape of one country on its’ economic activities”. This kind of approach can trigger discourse around topics that engage both science and geography ideas.

9 Glossary

- **Analyse:** To study or determine the nature and relationship of something by analysis
- **Apply:** To put into operation or effect
- **Calculate:** To used when a numerical answer is required. In general, working should be shown.
- **Classifying materials:** Identifying each material according to its subject, so that materials on similar subjects are grouped together
- **Compare:** To examine the character or qualities of especially in order to discover resemblances or differences
- **Construct:** Something formulated or built systematically
- **Create:** To produce or bring about by a course of action or behaviour

- **Deduce/Predict:** To make a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted from an earlier part of the question.
- **Define (the term(s) ...):** For only a formal statement or equivalent paraphrase, such as the defining equation with symbols identified, is required.
- Derive: To determine by reasoning or deduction
- **Describe:** To state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to phenomena or to experiments.
- **Design:** To create, fashion, execute, or construct according to plan
- **Determine:** To determine quantity by calculation, substituting measured or known values of other quantities into a standard formula.
- **Discuss:** To give a critical account of the points involved in the topic.
- **Estimate:** To make such simplifying assumptions as may be necessary about points of principle and about the values of quantities.
- **Exhibit:** To present to view
- **Explain:** To show the logical development or relationships
- **Explore:** To investigate, study, or analyse.
- **Formulate**: To prepare according to a formula
- **Identify:** To establish the identity
- **Interpret:** To explain or tell the meaning
- **Investigate:** To make a systematic examination
- **List:** To given several points and not be exceeded the limit.
- **Measure:** To be obtained from a suitable measuring instrument
- **Model:** Structural design, miniature representation, a type or design of product, computer simulation
- **Patterns:** A reliable sample of traits or acts
- **Perform:** To carry out or do
- **Relate:** To have or establish a relationship
- **Research:** Studious inquiry or examination
- **Show:** To make algebraic deduction to prove a given equation.
- **Simulation:** Examination of a problem often not subject to direct experimentation by means of a simulating device
- **Sketch**: Applies to diagrams, implies that a simple freehand drawing is acceptable
- **State:** Implies a concise answer with little or no supporting argument, e.g., a numerical answer that can be obtained 'by inspection'.
- **Suggest:** Is used in two main contexts.
- **Verify:** To ascertain the truth or correctness by examination, research, or comparison
- **What is meant by:** Implies that a definition should be given, together with some relevant comment on the significance or context of the term(s).

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