Appendix III

Updated Physics (Secondary 4-6) Curriculum and Assessment Framework

(Consultation Draft)

Curriculum Development Council

June 2026

Preamble

Physics (Secondary 4-6) Curriculum and Assessment Frameworks (Consultation Draft) is a consultation document sets out the proposed update of the Physics Curriculum for Senior Secondary Level. This curriculum document presents the proposed curriculum rationale and curriculum framework and assessment framework of Physics (Secondary 4 – 6), including the learning targets, curriculum emphases and curriculum contents and public assessment. It also includes two Annexes, namely "The Use of Digital Educational Tools and Artificial Intelligence for Learning, Teaching and Assessment of Physics" and "Connection across Learning of Senior Secondary Science Subjects", which provide further guidance on promoting effective pedagogical use of digital and AI tools, as well as strengthening curriculum connection among the science subjects. The views collected from this consultation will be taken into consideration in the development of *Science Education Key Learning Area Physics Curriculum and Assessment Guide (Secondary 4-6)*.

Views and suggestions on this document may be sent to:

Chief Curriculum Development Officer (Science)

Science Education Section, Innovation Technology Education Division

Education Bureau

Room E232, 2/F, East Block

Education Bureau Kowloon Tong Education Services Centre

19 Suffolk Road, Kowloon Tong, Hong Kong

Fax: 2194 0670

E-mail: science@edb.gov.hk

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Chapter 1 Introduction

1.1 Background

Science education cultivates students' curiosity about the world and enhances scientific thinking. Through systematic inquiry, students will develop scientific knowledge and skills to help them evaluate the impact of scientific and technological developments. This will prepare them to become lifelong learners in science and technology and responsible citizens, and to contribute to our scientific and technological world.

Building on the Science Education curriculum across primary and junior secondary education, Physics, along with Chemistry and Biology, is offered as an elective subject under Science Education Key Learning Area in the senior secondary curriculum.

The *Physics Curriculum and Assessment Guide (Secondary 4-6)* was first published in 2007. It was then updated in January 2014 and November 2015 in response to the recommendations made in the Short-term Review and the Medium-term Review in 2012 and 2014 respectively as well as the Ongoing Renewal of the School Curriculum thereafter to fine-tune the senior secondary Physics curriculum and assessment.

Following the recommendations from the Task Force on Review of School Curriculum and the corresponding optimisation of the four senior secondary core subjects in 2021, the curriculum and assessment of the elective subjects, including Physics, were also reviewed along the same directions to formulate measures to create space for students and cater for learner diversity. A working group was established under the CDC-HKEAA Committee on Physics in November 2023 to review and revise the Physics curriculum. On top of creating space for students and catering for learner diversity, the Physics curriculum was reviewed with the aims of strengthening the interface with the updated Science (Secondary 1-3) curriculum for further developing students' scientific literacy, enabling them to understand the impact and application of science for life and society, and fostering their science foundations for innovation and future pathways. The review also incorporated the directions set out in the report by the Task Force entitled "Optimise the curriculum for the future, foster whole-person development and diverse talents", the Curriculum Development Council's Secondary Education Curriculum Guide (CDC, 2017), the Science Education Key Learning Area Curriculum Guide (Primary 1 – Secondary 6) (CDC, 2017), and the Supplement to the Science Education Key Learning Area Curriculum Guide – Science (Secondary 1 to 3) Curriculum Framework (CDC, 2025).

1.2 Curriculum Rationale

The Physics Curriculum is designed to enthuse and nurture students to become scientifically literate, while providing a strong foundation in science that enables them to innovate and pursue further studies and careers in science and technology. It emphasises the cultivation of curiosity about the physical world and universal laws, the strengthening of scientific thinking, and the development of an understanding of how physical knowledge is generated, communicated and applied.

Building on these directions, the Physics Curriculum articulates two closely linked rationales: (i) **developing scientific literacy through physics**, enabling students to understand and apply physical laws and theories, scientific thinking and scientific inquiry skills to explain phenomena, solve problems and make informed decisions in daily life; and (ii) **providing strong foundations for innovation and future pathways**, by equipping students with essential physics concepts and scientific practices needed to progress to Innovation and Technology-related studies and careers. Coherent learning experiences that integrate core physics ideas, scientific inquiry processes, and values and attitudes enable students to explain scientific phenomena, solve problems and make evidence-based judgements, while preparing them to participate constructively in an increasingly innovation-driven and sustainability-focused world.

1.2.1 Developing scientific literacy through physics

The Physics Curriculum aims to develop students' scientific literacy by integrating scientific knowledge, inquiry practices, and values and attitudes through meaningful learning experiences. By engaging in various learning experiences, such as experimental investigations, conceptual learning on physics models, scientific inquiry, data analysis, use of physical representations, and socio-scientific discussions, students learn to apply scientific thinking to explain phenomena, solve problems, and evaluate science-related issues in personal, societal and global contexts.

Students gain an understanding of how physics knowledge is generated, tested and refined, and learn to construct evidence-based explanations using appropriate physical language and representations. They also examine the ethical, social, economic and environmental implications of physical and technological developments. This strengthens their ability to make informed decisions, recognise the strengths and limitations of science, and take responsible actions in a society shaped by scientific advancement and sustainable development.

1.2.2 Providing strong science foundations for innovation and future pathways

Physics involves the study of universal laws, and of the behaviours and relationships among a wide range of physical phenomena. With a solid foundation in physics, students should be able to appreciate both the intrinsic beauty and quantitative nature of physical phenomena, and the role of physics in many important developments in engineering, medicine, economics and other fields of science and technology.

The Physics Curriculum equips students with solid theoretical knowledge, practical competence and scientific reasoning skills. Through inquiry-based learning and application of concepts in authentic contexts, students develop quantitative reasoning and data analysis skills, critical thinking and an appreciation of the nature of science and its connections with technology, society and the environment.

When students take Chemistry and/or Biology together with Physics at the senior secondary level, the coherence across science subjects further strengthens their conceptual understanding and transferable competencies. Shared principles and inquiry practices reinforce learning, promote interdisciplinary thinking and enhance students' capacity to apply knowledge across domains. Such integrated preparation supports progression to post-secondary studies in science, engineering, health sciences and other innovation-driven fields, enabling students to contribute to scientific advancement and sustainable development in a knowledge-based economy.

1.3 Curriculum Aims

The overarching aim of the Physics Curriculum is to provide students with physics-related learning experiences that develop scientific literacy, enabling them to participate actively in a rapidly changing knowledge-based society, prepare for further studies or careers in Physics- and STEAM-related fields, and become lifelong learners in science and technology.

The broad aims of the Physics Curriculum are to enable students to:

- develop interest and maintain a sense of wonder and curiosity about physics and science;

- construct and apply physics knowledge to explain and solve problems using physical laws and models, and appreciate the relationship between physics and other disciplines;
- understand the nature of science, including the usefulness, limitations and evolving nature of scientific knowledge;
- acquire scientific knowledge, inquiry skills and scientific reasoning to investigate physical phenomena and address unfamiliar situations with creativity and resilience;
- think, communicate and collaborate scientifically, and discuss, evaluate and make informed judgements on physics-related issues using the language of science;
- recognise the social, ethical, economic, environmental and technological implications of physics and develop a commitment to act as responsible citizens in promoting sustainable development; and
- become lifelong learners in science, and be prepared for further studies and future careers in science, technology and engineering-related fields.

Chapter 2 Curriculum Framework

The Physics (S4-6) curriculum framework embodies the key knowledge, skills, values and attitudes that students are to develop at senior secondary level. It forms the basis on which schools and teachers can plan their school-based curriculum, and design appropriate learning, teaching and assessment activities.

At the heart of the curriculum are three key emphases: “Scientific Inquiry”, “Computational Physics” and “Nature of Science”. These emphases, which stem from the curriculum rationale, guide the design and implementation of the curriculum, aiming to develop students’ scientific literacy as well as their capacity and commitment to integrate and apply knowledge and skills across disciplines to address real-world challenges effectively and creatively.

This curriculum serves as a continuation of the Science (S1-3) Curriculum. With careful consideration of students’ prior knowledge and everyday experiences, it is designed to cover major aspects of physics, and to highlight close connection to social, technological and environmental issues. The curriculum framework has three interconnected components: Learning Targets, Curriculum Emphases, and Curriculum Content. Figure 2.1 represents the relationships between the various components.

<table>
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<tr><td>Knowledge and Understanding</td><td>Skills and Processes</td><td>Values and Attitudes</td></tr>
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Figure 2.1 Diagrammatic Representation of the Physics Curriculum Framework

2.1 Learning Targets

2.1.1 Knowledge and understanding

Students are expected to:

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

2.1.2 Skills and processes

Through studying physics, students are expected to develop generic skills, including basic skills, thinking skills, skills of using digital tools and artificial intelligence (AI), and personal and social skills. More specific skills and processes in physics are:

(1) Asking questions and defining problem
(2) Planning and carrying out investigations/designing and carrying out solutions
(3) Analysing and interpreting data
(4) Developing and using physical models
(5) Constructing scientific reasoning and argumentation

(1) Asking questions and defining problem

Students are expected to:

- identify attributes of objects or natural phenomena;
- ask relevant questions in a concise and objective manner;
- use digital tools, including AI, to search for, select and organise physics information;
- propose hypotheses for scientific phenomena and devise methods to test them;
- identify dependent and independent variables in investigations;
- clarify and analyse problems related to physics;
- suggest creative ideas or solutions to problems; and
- propose solution plans and evaluate their feasibility.

(2) Planning and carrying out investigations/designing and carrying out solutions

Students are expected to:

- apply knowledge and principles of physics to solve problems;
- devise appropriate strategies to deal with issues that may arise;

- devise plans and procedures to carry out experiments;
- select appropriate methods, apparatus and digital tools (e.g. data-loggers and sensors, spreadsheets, AI-generated computer simulations) to carry out investigations;
- observe and record experimental observations accurately and honestly;
- select appropriate apparatus and materials for an experiment;
- carry out experiments according to the planned procedures;
- propose plans for further investigations, if appropriate;
- handle apparatus properly and safely;
- measure to the precision allowed by the instruments;
- recognise the limitations of instruments used; and
- search, retrieve, reorganise, analyse and interpret scientific information from libraries, the media, the Internet and multi-media software packages.

(3) Analysing and interpreting data

Students are expected to:

- interpret observations and experimental data; and
- evaluate experimental methods and suggest possible improvements;
- put forward suitable reasoning to choose between alternatives;
- organise and analyse data, and infer from observations and experimental results;
- use proper graphical techniques appropriately to display experimental results and to convey concepts;
- use appropriate digital tools (e.g. spreadsheets, graphing software and AI) to process, interpret and present experimental data and scientific information;
- produce reports on investigations, draw conclusions and make further predictions;
- evaluate experimental results and identify factors affecting their quality and reliability; and
- use information technology to manage and present information, and to develop habits of self-directed learning.

(4) Developing and using physical models

Students are expected to:

- utilise appropriate digital tools (e.g. AI) to identify complex patterns and regularities in the natural world to construct models for predicting future trends;
- examine evidence and apply logical reasoning to draw valid conclusions;
- present concepts of physics in mathematical terms whenever appropriate;
- understand the fundamental roles and functions of models in exploring observed natural

phenomena;
- realise the need of modifying existing models when new evidence is found;
- examine theories and concepts through logical reasoning and experimentation;
- adopt the best models which can explain counter-intuitive phenomena; and
- integrate concepts within a framework of knowledge, and apply this to new situations.

(5) Constructing scientific reasoning and argumentation

Students are expected to:

- make well-informed decisions based on the examination of evidence and arguments;
- support judgments using appropriate scientific principles;
- recognise preconceptions or misconceptions with the aid of experimental evidence;
- comprehend articles involving physics terminology, concepts and principles;
- use appropriate terminology to communicate information related to physics in oral, written or other suitable forms;
- organise, present and communicate physics ideas in a precise and logical manner;
- work effectively through liaising, negotiating and compromising with others in science project teams to construct scientific reasoning and argumentation;
- evaluate the reliability, limitations and possible biases of information, explanations and visualisations produced by digital tools and AI, by comparing them with trusted scientific information sources; and
- distinguish among fact, opinion and value judgment in processing scientific information.

2.1.3 Values and Attitudes

(1) towards themselves and others

Students are expected to:

- develop and possess positive values and attitudes such as curiosity to the nature or phenomenon, honesty, respect for evidence, perseverance and tolerance of uncertainty through the study of physics;
- develop a habit of self-reflection and the ability to think critically;
- be willing to communicate and comment on issues related to physics and science;
- develop open-mindedness and responsive to ideas and constructive criticism from team members;
- be able to show tolerance and respect towards the opinions and decisions of others even in disagreement;

- demonstrate ethical and responsible use of digital tools and AI in science context, including protecting data privacy, acknowledging AI and digital assistance appropriately, and avoiding plagiarism;
- act responsibly to accomplish allocated tasks and be aware of the importance of safety for themselves and others; and
- be committed to safe practices in their daily lives.

(2) towards physics and the world we are living in

Students are expected to:

- appreciate achievements in physics discovery and recognise their limitations;
- accept the provisional status of the knowledge and theory of physics;
- apply the knowledge of physics rationally in making well-informed decisions or judgments on issues in their daily lives; and
- be aware of the social, economic, environmental and technological implications of the advancements in physics.

(3) towards learning as a lifelong process

Students are expected to:

- recognise the evolutionary nature of scientific knowledge, thereby understand the importance of constant update of knowledge in the world of science and technology;
- be exposed to new developments in physics, science and technology and develop an interest in them;
- recognise the importance of lifelong learning in our rapidly changing knowledge-based society;
- develop their study skills to improve the effectiveness and efficiency of their learning;
- engage in self-directed learning activities in the study of physics; and
- develop basic learning habits, abilities and attitudes that are essential to the foundation of lifelong and independent learning.

Figure 2.2 summarises the learning targets of the curriculum.

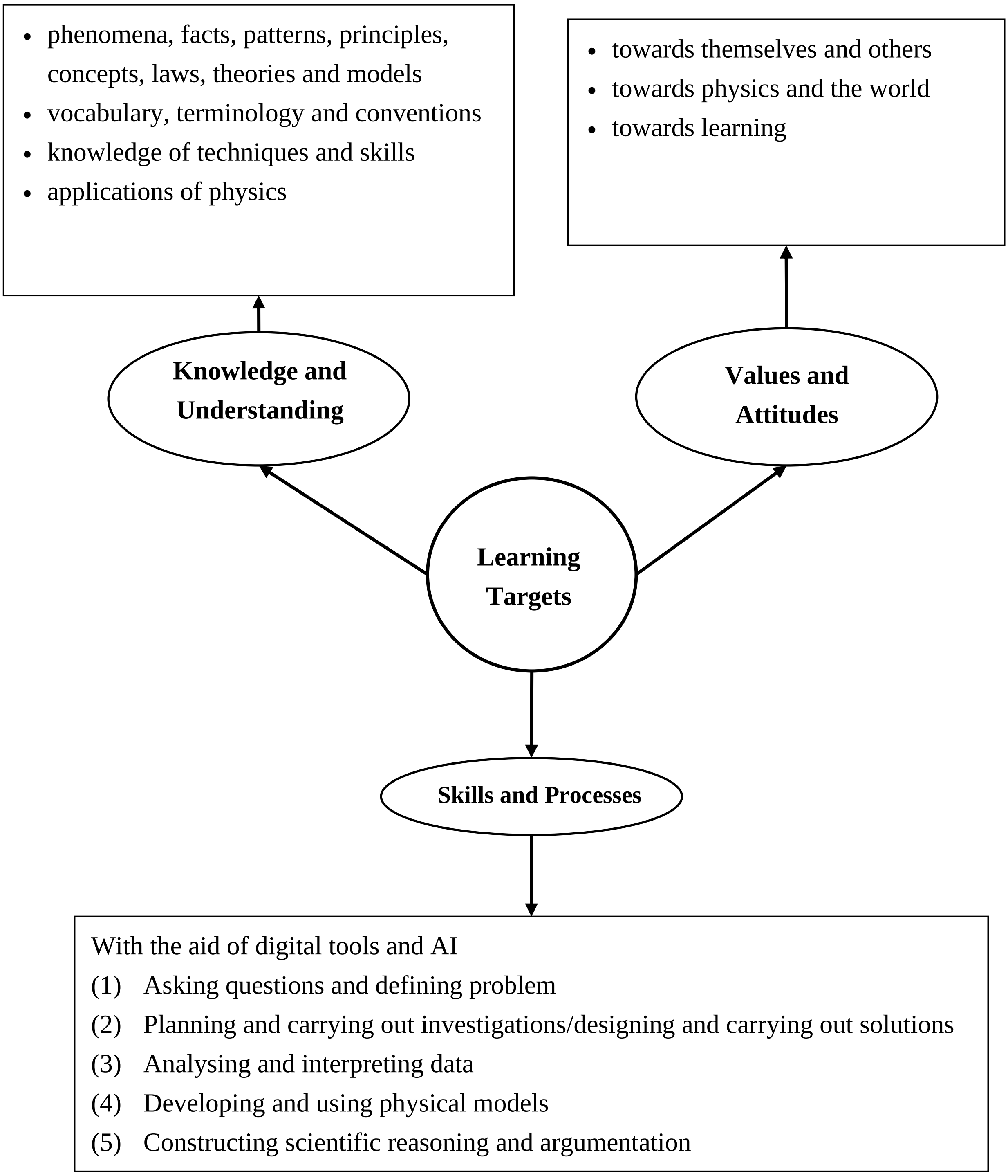

Figure 2.2 Learning Targets of the Physics Curriculum

2.2 Curriculum Emphases

Three Curriculum Emphases, **Scientific Inquiry, Computational Physics** and **Nature of Science** are the important components of this curriculum for students to build up essential skills to face the recent and future challenges of rapidly evolving innovation and technology (I&T).

2.2.1 Scientific Inquiry

Students are expected to acquire inquiry skills that usually used in Physics through practical activities and inquiry-based learning activities to understand how physicists devise physical models and solve problems.

<u>Scientific Inquiry Skills for Physics (S4-6)</u>

Measurements, data analysis and error treatments are essential skills in studying Physics. Students should learn using apparatus safely, measuring numerical data accurately with appropriate data analysis and error treatments in order to draw reasonable conclusions. It is crucial to use appropriate units and the order of magnitude to describe the physical world in a sensible manner.

The curriculum emphasises the scientific inquiry skills in the aspects of experiment Techniques, data Analysis, order of accuracy and Error treatment, and awareness of Safety.

1. Experiment Techniques

i. calibrate apparatus before measurements

ii. make rough preliminary measurements and calculations where appropriate, e.g. to assess the best range for accurate measurements

iii. read to the maximum accuracy of linear and angular scales, such as ruler, spring balance and protractor

iv. make alignments accurately or locate peak value(s)

v. connect and check electrical circuit components according to a circuit diagram; draw a circuit diagram for a given simple circuit that already connected up

2. **Data Analysis**

i. know the SI base units and the corresponding physical quantities

ii. derive units as products or quotients of the base units

iii. handle data properly, and display and present results in tabular and/or graphical form

iv. plot graph or fit curve accurately with suitable choice of scales

v. transform formulae into linear graphs; e.g. plot y against $\frac{1}{x}$ for xy = constant, plot y against $\frac{1}{x^2}$ for inverse square law

vi. interpret physical meaning of quantities from graphs; e.g. intercepts, slope, area under the graph

3. Order of **Accuracy** and **Error Treatment**

i. repeat measurements and identify outliers in order to reduce the effect of random error

ii. quote results to a number of significant figures and/or decimal places reasonably in keeping with their estimated accuracy

iii. identify absolute and relative (or percentage) error

iv. estimate maximum error in simple cases

v. make sense appreciation to order of magnitude and accuracy of common measurements (not merely of scale readings)

4. Awareness of **Safety**

<u>Practical activities</u>

Practical activities offer students opportunities to apply physics concepts and develop scientific inquiry skills under practical context. These learning opportunities enable students to develop competency in analysing data with appropriate use of graphs and calculations. Students are also expected to recognise the limitations of measurements and justify whether the errors are within the acceptable range to support the experiment result.

Wide variety of practical tasks are listed in the suggested learning and teaching activities in Chapter 2.3. Some of them are identified as key practical tasks of which target on equipping students with essential scientific inquiry skills in physics. Teachers should exercise professional judgement in integrating practical tasks in the learning and teaching of relevant topics, either demonstration or students' hands-on practical, and align with the requirements of School-based Assessment (SBA) when arranging hands-on practical tasks for students. Details would be included in Chapter 3: Assessment of the Physics (S4-6) Curriculum and Assessment Guide. Computational Physics experiments are encouraged. Nevertheless, it is noteworthy that they differ from simply utilising readily available simulations. For details, please refer to session 2.2.2.

2.2.2 Computational Physics

Computational Physics is to apply computational methods to model physical phenomena for solving problems, this can be exemplified in different topics in the Physics (S4-6) curriculum. It combines physical concepts with the application of mathematical modelling and computer programming. It should cover the process of analysing real world problems, formulating and solving models, interpreting the solutions as real world solutions, and evaluating the models. This is an effective strategy to promote digital education and facilitate students in learning advanced innovations and technology. Figure 2.3 shows the essential elements in Computational Physics:

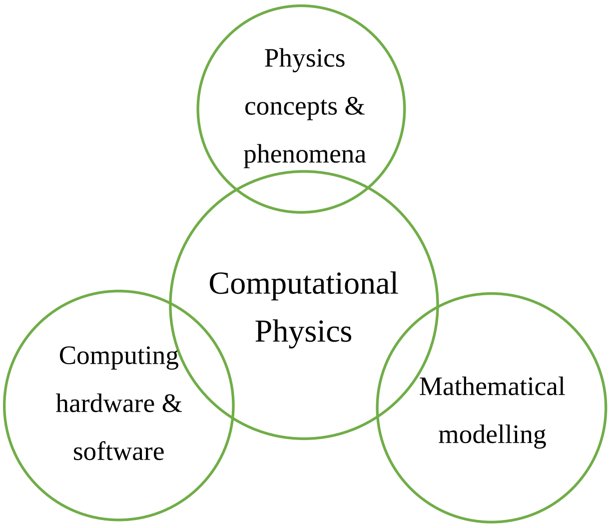

Figure 2.3 Essential elements in Computational Physics

In Computational Physics learning activities, students can reveal the underlying mechanism within complex systems and foster a greater appreciation for computational advancement in physics problems. Computers enable simulating phenomena by progressions of parameters with very small intervals, or measure and record data at extra high frequency. Students can make use of computing power to probe deep in applying and consolidating relevant physical concepts during the learning process.

Two kinds of learning activities are suggested to implement Computational Physics: **building computational models** and **computer-assisted data analysis**.

Building Computational Models

This is to apply computational methods to build models representing physical systems or phenomena. Students may build computational models to experience its underlying mechanism that mimics real-world scenarios. This is different from using simulations that are readily available in illustrating physics concepts. Students should engage in the model-building process by making appropriate approximations and simplifications to solve a physics problem. Teachers can adopt appropriate software to conduct the learning activities, such as Python, C++, spreadsheet or visual programming language (VPL), based on students' learning needs and readiness.

Students are expected to be able to:

- translate physics into computer program codes
- build algorithms using conditional logic in programming
- develop and use computational models to simulate or predict physical phenomena
- modify the model in response to new evidence or by introducing complexity

During S4 – S6, students can explore establishing numerical methods to build computational models of physical systems which are difficult to solve analytically. Two widely applicable techniques are the Monte Carlo method and the Finite Difference method.

The Finite Difference method approximates derivatives in differential equations using discrete differences, enabling numerical solutions for problems like projectile (modeling position over time), where students set up grids, apply boundary conditions, iterate steps, and visualise results, this helps students understand smaller intervals results in more accurate simulations. The Monte Carlo method employs random sampling to simulate probabilistic phenomena, such as estimating radioactive decay half-lives or particle diffusion by generating large numbers of random trials and computing statistical averages, helping students understand convergence, probability in physics, and statistical uncertainty.

These methods extend the learning of computational physics and can be implemented using spreadsheets with guided templates, allowing students to modify parameters, validate against theory, and appreciate computational physics as a powerful tool for investigating complex systems. Teachers can adapt the computational model building learning activity examples with reference to students' abilities and the teaching context.

Computer-Assisted Data Analysis

This is to attempt different ways to gather and analyse data with the aid of computer, include creating or collecting data, preparing data for analysis, making claims from data, and presenting data logically and systematically. Basically, students should learn analysing a set of raw data by computer, including fitting linear graphs or curves, interpreting values from graphs and justifying the effect of error. Spreadsheet is commonly used for this purpose, such as putting experimental data of the amount of energy transfer versus temperature to find the specific heat capacity.

Students are expected to be able to use computing tools to

- Collect, import, and organise raw experimental or simulated data into appropriate digital formats (e.g. entering measurements into spreadsheets, importing data files from data loggers, and structuring data with clear headings, units, and significant figures)
- Prepare datasets for analysis by performing basic operations such as unit conversions, calculating derived quantities (e.g. averages, rates, or ratios), identifying and handling outliers or anomalous values, and applying appropriate error estimation skills
- Create and fit appropriate graphical representations using spreadsheet functions or built-in tools, including plotting linear relationships (e.g. $y = mx + c$), and adding trendlines with displayed equations to model physical phenomena
- Interpret graphical outputs by extracting key parameters (e.g. slope of curve and intercepts), justifying the physical significance of results, evaluating the impact of measurement uncertainties and random/systematic errors on conclusions

Students can learn various computational methods in obtaining data sets, such as extracting open data from observatories or generating data with the aid of computers. Various kinds of tools are readily available, such as motion video analysis (MVA), software-define radio (SDR) and various kinds of mobile Apps. Teachers can start teaching students to use computing devices for data collection and analysis in S4, using MVA to investigate linear motion and mobile Apps to investigate inverse square law of intensity. Students can acquire essential skills in collecting, analysing and interpreting data in tables and graphs.

Implementation and Progression of Computational Physics

Teachers should note that **building computational model** and **computer-assisted data analysis** are not mutually exclusive in authentic tasks, but often to be an integration of them. This classification offers a framework for reference to facilitate implementation. At early stages and in connection with the curriculum, teachers may introduce simple Computational Physics activities under Classical Physics, such as modelling simple motions, analysing physical quantities in thermal physics and variations of intensity. At later stages, teachers can introduce more complex computational physics task, such as simulating superposition of wave, electric field and magnetic field patterns, and radioactive decay process. Under different schools' specific context, students' skills related to Computational Physics may be diversified. Teachers should exercise professional judgement to integrate Computational Physics into their learning and teaching to meet students learning needs.

In general, the learning progression for implementing Computational Physics in this curriculum can be resolved in three key dimensions. In **physics concepts and phenomena** dimension, students progress from working with concrete, everyday examples (e.g. simple linear or circular motions) to handling more abstract ideas and integrating multiple concepts in complex systems (e.g. wave superposition, electric and magnetic field patterns, or radioactive decay processes). Regarding **computing hardware and software** dimension, the progression moves from guided activities using ready-made templates or simple tools to increasingly self-directed programming, where students gain sophistication in selecting and manipulating hardware and/or software in translating mathematical relationships into functional computer code. Finally, in **mathematical modelling** dimension, the demand on students' mathematical skills grows from basic applications (e.g. equations of linear accelerated motion) to more advanced and complex formulation of equations, including approximations, numerical methods, and validation against theoretical or experimental results. Teachers should adapt the pace and depth of these progressions according to their school's specific context and students' readiness, ensuring that Computational Physics activities remain engaging, accessible, and closely aligned with the core and extension topics of the curriculum. More examples could be found in suggested learning and teaching activities in Chapter 2.3.

Use of AI in Computational Physics

Vibe coding is a kind of coding where users express their intention using plain speech and the AI transforms that thinking into executable code. In computational physics, vibe coding allows students to use natural language to describe physical systems, which an AI then translates into functional programming code. Vibe coding removes the technical barriers, including debugging syntax errors, managing library imports, or fixing minor formatting, acting as a bridge that allows students to move directly from theoretical concepts to computational models. This approach transforms the student from a passive learner into a virtual researcher, with assistance of AI to manage the complexity of the coding while they focus on the profound behaviours of the physical world.

For the initial model-building phase, teachers can guide students to prompt the AI with specific physical constraints. For instance, a student might prompt the AI to "create a visual simulation of a simple pendulum using the small-angle approximation". Once the AI generates the working script, teachers can guide students to focus studying the parameters by identifying and manipulating key variables within the program code, such as the pendulum's length or the acceleration due to gravity. Through observation, students can then develop an understanding of the relationship how the oscillation period changes in response to the adjustments of these parameters. After mastering the simple pendulum, teachers may lead students to extend the learning experience through introducing more complex, real-world variables that go beyond the initial model made by vibe coding by modifying the existing program code. For example, teachers might challenge students to study damping factor of the simple pendulum.

This teaching approach integrates “computational thinking" and "scientific inquiry", emphasising students' use of technological and digital tools to solve problems in real situations, and developing reasoning, creativity and critical thinking skills across data analysis, modeling and experiments.

2.2.3 Nature of Science

Nature of science refers to the beliefs and attitudes towards the knowledge about the natural world, the methods, and the processes through which scientific knowledge is acquired, and the sociocultural and historical influences involved. The study of the nature of science could increase students' learning interests, enhance their understanding of scientific knowledge, and facilitate them to make informed decisions about science-related issues in their daily lives.

Some physics-related stories are suggested in each topic to facilitate the introduction nature of the science through history. Teachers can also adopt diversified learning and teaching activities, such as practical activities, scientific investigations and reading articles, for students to experience nature of science.

Students are expected to:

- be aware of the dynamic nature of physical knowledge and understand that science is a human endeavour;
- be aware that physical laws and theories are developed through observations, hypotheses, experimentations, analyses and inferences;
- understand the nature and limitations of scientific activity; and
- recognise the contributions of various physicists and scientists to understanding and applying physics.

2.3 Curriculum Structure and Organisation

The content knowledge of curriculum consists of three major parts: Classical Physics, Physics in daily life and Modern Physics.

Classical Physics encompassing theories developed since Ancient Greek provides a foundational understanding of the natural world. Major areas include Newtonian mechanics, thermal physics, wave theory and electromagnetism. Despite its limitations in explaining phenomena at the microscopic levels or fast motion that comparable to speed of light, classical theories remain essential for understanding everyday objects and systems, and it forms the basis for many technological applications.

Physics is integral to our daily life, influencing socio-scientific issues, such as sustainable development and nuclear safety, and enabling students to make informed decisions. Physics foundations are crucial for innovation, problem solving and technology development. Professionals in fields such as engineers and modelling experts leverage relevant knowledge and skills into practical solutions, bridging the gap between researches and technological advancements.

Modern Physics is regarded as having emerged in the late 19th century, particularly through quantum theory and relativity, which help us understand the microscopic and macroscopic worlds. Unlike classical physics, which is deterministic, quantum effects introduce uncertainties, while relativistic effects explain the deviations observed in measurements of high-speed motion. This knowledge has been widely applied in recent engineering and technology.

A proportion of lesson time has been allocated for conducting practical tasks, scientific investigations/engineering design activities and computational physics tasks. Through these learning experiences, students can develop essential scientific inquiry skills in physics.

2.3.1 Curriculum Structure and Time allocation

The curriculum consists of four major components: Classical Physics, Physics in daily life, Modern Physics and Scientific Inquiry in Physics. The suggested curriculum structure and time allocation (in hours) for the major components are listed in the following table:

Content		Core	Extension	Total
Classical Physics	Mechanics	39	15	54
	Thermal Physics	13	3	16
	Waves	33	5	38
	Electricity and Magnetism	32	4	36
Physics in daily life	Physics and Engineering	8	14	22
	Physics and Society	20	3	23
Modern Physics	Quantum Physics	14	14	28
	Astrophysics and Relativity	6	11	17
	Sub-total:	164	70	234
Scientific Inquiry in Physics				16
	Total lesson time:			**250**

2.3.2 Curriculum Organisation

The curriculum is organised into three content knowledge parts and Scientific Inquiry in Physics. The concepts and principles of physics are inter-related. They cannot be strictly confined by any artificial topic boundaries. The order of presentation of the topics in this Chapter generally follows the historical development in Physics. Mechanics contains fundamental concepts for understanding particle motions in Thermal Physics, oscillations in Waves and force fields in electromagnetism. Classical Physics laid down the foundation for students to learn Physics in daily life and Modern Physics. Teachers may adopt teaching sequences that best cater for students' learning needs.

The content of each topic is organised into the following parts:

Overview

This part is an introduction to the topic. It provides an overview of the key concepts and important physics principles, briefly explaining the main points of each topic and the relationships between its various sections or sub-themes.

Nature of Science

This part suggested some stories about physicists' research findings, new discoveries or how physics connected to technology and society. Teachers can make reference of these stories to help students in understanding and appreciating the nature of science under Physics context.

Student Should learn and Should be Able to

This part lists out the intentions of learning (students should learn) and learning outcomes (students should be able to) that students should achieve in the knowledge content domain of the curriculum. The learning outcomes depict the cognitive level of the curriculum content that students should grasp. Some learning outcomes require fundamental cognitive ability (e.g. state, realise), while there are learning outcomes that draw on higher cognitive ability (e.g. explain, interpret). Teachers should observe these learning outcomes to design learning and teaching activities and set appropriate assessment tasks to monitor students' learning progress.

Key practical tasks

Key practical tasks are selected learning activities to equip students with solid foundations in relevant concepts and scientific inquiry skills in physics. Teachers are recommended to integrate these tasks for students when teaching the relevant topics of the units. These tasks offer flexibility in the modes of implementation, such as the choices of measuring device, either demonstration or students' hands-on practical, and the depth of investigations.

Suggested Learning and Teaching activities

This part suggests activities through which students may achieve the learning outcomes. This list includes a wide range of activities, such as practical work, investigations, projects and discussion tasks. They are for teachers' reference only and not mandatory. Teachers should exercise professional judgment in arranging activities to cater for the interests and abilities of their students.

Suggested Computational Physics activities

This part suggests computational physics activities through which targets on offering opportunities for students to build computational models within the topic. They are for teachers' reference only and not mandatory. Teachers should exercise professional judgment in arranging activities to cater for the interests and abilities, particularly the computing competency, of their students.

Science, Technology, Society and Environment (STSE) connections and socio-scientific issues (SSI)

This part suggests activities with high students' daily relevancy, helping them to connect physics knowledge to technology, society and the environment around them. It is to nurture students' positive values and attitudes to apply physical laws and theories, concepts and skills to discuss, investigate and solve everyday problem, so to build positive values and attitude. Teachers should exercise professional judgment in selecting SSI to be relevant and interesting to their students.

Core and extension

The curriculum content is designed with Core and Extension component part to cater for students of different abilities and needs. The contents in Core cover the fundamental concepts while that in extension are considered cognitively more demanding. The underlined text represents the extension component.

2.3.3 Curriculum Contents

Classical Physics

1. Mechanics

Overview

Mechanics is a fundamental field in Physics since the Ancient Age, the Greek philosopher Aristotle proposed heavier objects fall faster. After over thousand years, the Italian physicist Galileo Galilei queried Aristotelian physics through his thought experiment and Leaning Tower of Pisa experiment, showing that the acceleration due to gravity is independent of objects' mass. Students are encouraged to understand how scientific knowledge was developed by evidence and observations through experiments.

Newton developed a sort of laws, later known as Newtonian Mechanics, to describe the motion of an object and the forces on it. Through studying Newtonian Mechanics, students can learn modeling of statics, kinematics and dynamics using graphical and algebraic methods. Another fundamental concept in Classical Mechanics, law of conservation of energy in a closed system, is introduced through studying mechanical work done as a process of energy transfer, and deriving kinetic energy and gravitational potential energy. The study of motion is extended to projectile motion, circular motion, and simple harmonic motion. The concepts of mass, weight and gravitational force are extended to an investigation of gravitation.

To relate mechanics with technology, society and the environment, students apply the concept of power and energy efficiency in various machines and vehicles. Students also learn how to compute quantities such as momentum and energy in examples involving collisions. The relationship among the change in the momentum of a body, impact time and impact force is emphasised. In addition, students can explore various kinds of oscillations and resonance phenomena in daily life.

Nature of Science

- Isaac Newton inferred the Universal Law of Gravitation from the observations by Johannes Kepler, who observed the relationship between the period and semi-major axis of celestial bodies. Teacher can specify that scientific knowledge is based on observations, while inferences also played an important role in formulating a law or theory.

Students should learn	Students should be able to
a. Vector and scalar	• describe the change of position of objects in terms of distance and displacement • distinguish between vector and scalar quantities • use scalars and vectors to represent physical quantities
b. Kinematics • Motion graphs • Uniform motion • Uniformly accelerated motion • vertical motion under gravity • Air resistance	• define velocity as the rate of change of displacement $v = \frac{\Delta s}{\Delta t}$ • define acceleration as the rate of change of velocity $a = \frac{\Delta v}{\Delta t}$ • define average speed as the distance travelled in a given period of time and average velocity as the displacement changed in a period of time • distinguish between instantaneous and average speed/velocity • present information on displacement-time (s-t) graphs, velocity-time (v-t) graphs and acceleration-time (a-t) graphs for moving objects • determine displacement, velocity and acceleration from motion graphs • apply equations of uniformly accelerated motion to solve problems $v = u + at$ $s = \frac{1}{2}(u + v)t$

Students should learn	Students should be able to
	$s = ut + \frac{1}{2}at^2$ $v^2 = u^2 + 2as$ • interpret the uniform motion and uniformly accelerating motions of objects using algebraic and graphical methods • state the acceleration due to gravity of free-falling object is approximately constant near the Earth surface • estimate the acceleration due to gravity experimentally • solve problems involving the vertical motion of free-falling objects using equations of uniformly accelerated motion and motion graphs • describe the effect of air resistance on the motion of objects falling under gravity
c. Force and motion • Addition and resolution of forces • Newton's Laws of motion • Moment of a force	• use free-body diagrams to represent the forces acting on objects • find the vector sum of coplanar forces graphically and algebraically • resolve a force graphically and algebraically into components along two mutually perpendicular directions • describe the meaning of inertia and its relationship to mass • describe situations in which objects are at rest or in uniform motion using Newton's First Law of motion

Students should learn	Students should be able to
	• describe situations in which objects are accelerated under the effect of a net force ($F = ma$) using Newton's Second Law of motion • state Newton's Third Law of motion and identify action and reaction pair of forces • apply Newton's Laws of motion to solve problems involving motion in one dimension • define moment of force as the product of the force and its perpendicular distance from the pivot • describe the effect of torque on a rigid body • state the conditions for the equilibrium of forces acting on a rigid body and solve problems involving a fixed pivot • interpret the centre of gravity and determine it experimentally
d. Work, energy and power • Mechanical work • Gravitational potential energy ($P.E.$) • Kinetic energy ($K.E.$) • Law of conservation of energy in a closed system • Power and efficiency	• interpret mechanical work done as a way of energy transfer • define mechanical work as $W = Fs\cos\theta$ • derive $K.E. = \frac{1}{2}mv^2$ and $P.E. = mgh$ • define power as the rate of energy transfer, $P = \frac{W}{t}$ • state the law of conservation of energy • define energy efficiency as the ratio of the amount of useful energy/power output to energy/power input, and apply it to solve problems

Students should learn	Students should be able to
	• solve problems involving mechanical work, rate of energy transfer, conservation of energy and energy conversions with consideration of energy loss
e. Momentum • Linear momentum • Change in momentum and net force • Law of conservation of linear momentum	• realise momentum as a quantity of motion of an object and define momentum $p = mv$ • describe a net force acting on an object for a period of time results in a change in momentum (impulse) • relate net force to rate of change of momentum based on Newton's Second Law of motion • describe the law of conservation of momentum and relate it to Newton's Third Law of motion • distinguish between elastic and inelastic collisions • solve problems involving momentum in one dimension
f. Projectile motion	• describe the shape of the path taken by a projectile launched horizontally or at an angle of projection • describe the independence of horizontal and vertical motions • solve problems involving projectile motion
g. Periodic motion	• define angular displacement θ using radian as unit

Students should learn	Students should be able to
• kinematics in uniform circular motion • <u>centripetal force</u> • kinematics in Simple Harmonic Motion (SHM) • forced oscillation, damping and resonance	• define angular velocity ω as the rate of change of angular displacement $\omega = \frac{\Delta\theta}{\Delta t}$ • relate tangential velocity v to angular velocity by $v = r\omega$ • relate period, frequency and angular velocity by $T = \frac{1}{f} = \frac{2\pi}{\omega}$ • state centripetal acceleration as a vector pointing towards the centre of uniform circular motion and apply $a = \frac{v^2}{r} = r\omega^2$ to solve problems • <u>realise the centripetal force of a uniform circular motion as the resultant force and solve problems</u> • define SHM as motions that acceleration a and displacement x are related by $a \propto -x$ • describe SHM in terms of displacement, velocity, acceleration, period and frequency • present information on displacement-time graph for SHM • identify SHM and forced oscillation, and recognise the occurrence of damping and resonance in daily life • <u>relate displacement of SHM with angular frequency, amplitude and time using trigonometric functions and solve problems</u>

Students should learn	Students should be able to
h. Gravitation	• state Newton's law of universal gravitation $F = \frac{GMm}{r^2}$ • define gravitational field strength as force per unit mass $g = \frac{F}{m}$ • determine the gravitational field strength at a point above a celestial body • solve problems related to gravitational force, gravitational field and circular orbits of celestial bodies

Key practical Tasks

- determine the velocity and acceleration of a moving object
- find the acceleration due to gravity of an object
- examine the vector nature of forces
- determine the angular velocity of a uniform circular motion (e.g. a whirling rubber bung/rotating disc)

Suggested Learning and Teaching Activities

- investigate the factors affecting frictional force, such as the mass, magnitude of applied force and contact surface area
- verify Newton's second law of motion ($F = ma$) experimentally
- examine conservation of mechanical energy of toy roller coaster/simple pendulum
- determine the output power of an electric motor by measuring the rate of energy transfer
- estimating the work required for various tasks, such as lifting a book, stretching a spring and climbing Lantau Peak
- estimating the K.E. of various moving objects such as a speeding car, a sprinter and an air molecule
- investigate the application of conservation principles in designing energy transfer devices

- evaluate the design of energy transfer devices, such as household appliances, lifts, escalators and bicycles
- measure the change of momentum and force acting on objects during a collision
- perform monkey and hunter experiment to demonstrate the independence of horizontal and vertical motions in projectile motion
- demonstrate the simple harmonic motion as projection of uniform circular motion
- find the acceleration due to gravity using simple pendulum method ($T=2\pi\sqrt{\frac{l}{g}}$)
- investigate the factors affecting the period of a simple harmonic motion
- demonstrate the force oscillation and resonance phenomena (e.g. Barton's pendulums, spring-mass system vibrated with signal generator)
- discuss the applications of damping in daily life
- study the collapse of the Tacoma Narrows Bridge that due to its lack of sufficient damping factors to counteract the forced oscillations
- search some natural phenomena that make use of the principle of resonance
- use dimensional analysis to check the numerical result of a Mechanics problem
- challenge their preconceived ideas on motion and force by posing appropriate thought-provoking questions (e.g. "zero" acceleration at the maximum height and "zero" gravitational force in space shuttle)
- contrast the application of Newton's Laws of motion with conservation laws in solving problems in motion, in order to increase students' awareness of the power and elegance of the conservation laws

Suggested Computational Physics activities

- use motion video analysis software or Apps to analyse different kinds of motions
- use computer to program and simulate some motions (e.g. free fall on different planets, projectile motion with or without air resistance, SHM with or without damping)

STSE connections and socio-scientific issues

- discuss the relationship between energy efficiency, environment and sustainable development
- discuss the dilemma for modern transportation in choosing between speed and safety; and between convenience and environmental protection
- compare the emission of carbon/energy consumption per people in using private cars versus massive transport

- investigate the danger of speeding and its relation to the chances of serious injury or death in car accidents can be related to the concepts of momentum and energy
- evaluate the safety design of vehicles (e.g. seatbelts, airbags, crash test)
- discuss the use of principles in mechanics in traffic accident investigations
- search and discuss the advancement of national technology in transports (e.g. high speed train, low carbon power source vehicles)
- discuss the use of technological devices including terrestrial and space vehicles (e.g. Shenzhou spacecraft)
- evaluate the technological design of modern transport (e.g. airbags in cars, tread patterns on car tyres, hybrid vehicles, magnetically levitated trains)
- suggest improvements to the recreational activities and sports equipment with the support of principles in mechanics
- explore the careers that require an understanding and application of kinematics and dynamics

2. Thermal Physics

Overview

This topic examines the concept of thermal energy and transfer processes which are crucial for the maintenance and quality of our lives. Students should learn the conservation of energy in the heat transfer processes. The energy required to change the states of an object is usually much higher than that for temperature change of an object in the same state. Through comparing their values of energy transfer, students could build sense in the order of magnitude.

Attention should be paid on the microscopic interpretations of various phenomena, particularly the relationships among temperature, internal energy and energy transfer. Students are encouraged to understand the random nature for the motion of molecules under kinetic theory. Emphasis should be put in understanding the distributions and average values of speed and kinetic energy among molecules, such that these are an introductory idea to statistical physics.

Nature of Science

- James Clerk Maxwell made foundational contributions to the kinetic theory of gases; he proposed that molecules travel in straight lines until they collide, a hypothesis that naturally led to the derivation of the distribution of molecular speeds. Ludwig Boltzmann extended Maxwell's work by generalising the energy distribution among molecules and providing a statistical basis for the laws of thermodynamics. Together, these two scientists revealed the microscopic motions of gas molecules, paving the way for the future development of quantum mechanics and statistical physics. Using these models of thermal physics, teachers should emphasise how microscopic molecular theory can be utilised to explain macroscopic phenomena..

Students should learn	**Students should be able to**
a. Heat transfer • Heat and internal energy • Heat capacity and specific heat capacity	• realise temperature as the degree of hotness of an object • interpret temperature as a quantity associated with the average kinetic energy due to the random motion of molecules in a system

Students should learn	Students should be able to
	• define heat as the energy transferred as a result of the temperature difference between two objects • describe two objects are in thermal equilibrium using zeroth law of thermodynamics • describe the effect of mass, temperature and state of matter on the internal energy of a system • relate internal energy to the sum of the kinetic energy of random motion and the potential energy of molecules in the system • define heat capacity $C = \frac{Q}{\Delta T}$ and specific heat capacity $c = \frac{Q}{m\Delta T}$ • determine the specific heat capacity of a substance • realise the practical importance of high specific heat capacity of water • solve problems involving heat capacity and specific heat capacity
b. Change of State • Latent heat and specific latent heat • Evaporation	• realise the change of states of matter at melting point and boiling point • realise latent heat as the energy transfer during the change of state without temperature change

Students should learn	Students should be able to
	• interpret latent heat in terms of the change of potential energy of the molecules during a change of state • define specific latent heat of fusion $l_f = \frac{Q}{m}$ and vaporisation $l_v = \frac{Q}{m}$ and solve related problems • explain the occurrence of evaporation below boiling point, the cooling effect and factors affecting the rate of evaporation in terms of molecular motion
c. Gases • General gas law • <u>Kinetic theory</u>	• state Boyle's law (*p*-*V* relationship), pressure law (*p*-*T* relationship) and Charles' law (*V*-*T* relationship) of a gas • determine absolute zero by the extrapolation of pressure-temperature or volume-temperature relationships • use Kelvin as a temperature scale • combine the three relationships (*p*-*V*, *p*-*T* and *V*-*T*) of a gas to obtain the relationship $\frac{pV}{T}$ =constant • solve problems involving the general gas law $pV=nRT$ • <u>realise the random motion of molecules in a gas</u> • <u>realise gas pressure resulted from molecular bombardment on container wall</u>

Students should learn	Students should be able to
	• relate macroscopic quantity temperature with microscopic quantity average molecular kinetic energy by $K.E_{\text{average}} = \frac{3RT}{2N_A}$ • interpret the change of temperature from the Maxwell-Boltzmann distribution • solve problems involving kinetic theory

Key practical Tasks

- Determine the specific heat capacity of a substance (e.g. water, metal block)
- Determine the specific latent heat of fusion and vaporization of water
- Examine Boyle's law of a gas

Suggested Learning and Teaching Activities

- calibrate a thermometer and reproduce fixed points on the Celsius scale
- use mixture method to estimate specific heat capacity of a substance
- perform experiments to study the cooling curve of a melted substance and determine its melting point
- determine factors affecting the rate of evaporation
- examine pressure-temperature and volume-temperature relationships of a gas and determine the absolute zero experimentally
- observe the random motion of molecules inside a smoke cell using a microscope and video camera
- use mechanical gas model to simulate gas molecules movements and explain gas laws

Suggested Computational Physics activities

- simulate random walk of molecules
- simulate motions of gas molecules inside a container and illustrate Maxwell-Boltzmann distribution

STSE connections and socio-scientific issues

- study the significance of high specific heat capacity of water in contributing the lives of a planet
- study the crucial row of ocean flow in restraining the temperature range around the world
- apply the concepts of heat capacity and latent heat in different weather phenomena
- read the sustainable development goals and the international treaty on climate change to understand the connections between science, technology, society and environment

3. Waves

Overview

This topic examines the basic nature and properties of waves. Students are encouraged to connect from the motions of point mass in mechanics to a chain of oscillations in wave motions. Many motions in mechanics transmit energy from one place to another, together with the transfer of matter. In contrast, traveling waves as means of transmitting energy without transferring matter. The foundations for describing wave motion with physics terminology are laid, including graphical representations of waves and simple wave diagrams. The basic properties and characteristics displayed by waves are examined through observing water waves; reflection, refraction, diffraction and interference are studied.

Two common kinds of waves, light and sound, are to be studied in details. The characteristics of visible light as a part of the electromagnetic spectrum are studied. Sound as an example of longitudinal waves is examined and its general properties are compared with those of light waves. Students also learn about ultrasound. The general descriptions of musical notes are related to the terminology of waves and the phenomena of resonance in musical instruments would also be studied.

Nature of Science

- In the 17th century, Isaac Newton made foundation to optics such that light was regarded as particles-like rays. His principle can explain how light rays reflected, refracted and dispersed. However, Thomas Young performed double-slit experiment that showed interference pattern of light in 1801, such that particle-like rays cannot explain this wave property. Teacher can emphasise scientific principles, theories or laws are subject to be revised based on new evidence.

Students should learn	Students should be able to
a. Nature of waves • Wave motion and propagation • Traveling waves and stationary waves	• recognise wave motion in terms of oscillation • realise travelling waves as transmitting energy without transferring matter • relate wave energy to amplitude • distinguish between transverse and longitudinal waves

Students should learn	Students should be able to
	• describe wave motion in terms of waveform, crest, trough, compression, rarefaction, wavefront, phase, displacement, amplitude, period, frequency, wavelength and wave speed • describe the superposition of traveling waves and the formation of a stationary wave (transverse wave only) • interpret displacement-time and displacement-distance graphs for travelling waves and stationary waves (transverse wave only) • apply $v = f\lambda$ to solve problems
b. Properties of waves • Reflection • Refraction • Diffraction • Interference	• describe the reflection of waves at a plane barrier/reflector/surface • examine the condition for a phase change on reflection • describe the refraction of waves across a plane boundary of different media • realise the change in wave speeds during refraction and define refractive index in terms of wave speeds • describe the diffraction of waves through a narrow gap and around a corner • examine the effect of width of slit on the degree of diffraction

Students should learn	Students should be able to
	• describe the interference of waves resulted from superposition • distinguish between constructive and destructive interferences of waves • examine the interference of waves from two coherent sources • determine the conditions for constructive and destructive interferences in terms of path difference • draw wavefront diagrams to show the properties of waves
c. Light waves • Reflection and refraction • Polarisation, diffraction and interference • Intensity	• state that the speed of light and electromagnetic wave in a vacuum is 3.0×10^8 m s^{-1} • state the range of wavelengths for visible light and other parts of the electromagnetic spectrum • examine the polarisation of light as an evidence for light as transverse wave • realise reflection and refraction as the wave properties of light • realise the occurrence of total internal reflection of light and its daily applications • realise diffraction and interference as evidences for the wave nature of light

Students should learn	Students should be able to
	• examine the interference pattern in the Young's double slit experiment • examine the diffraction pattern when light passes through the plane transmission grating • define intensity as power per unit area in classical wave theory • recognise the intensity distribution of the fringe pattern in the Young's double slit experiment • discuss daily applications of light and electromagnetic waves using properties of waves • apply $d\sin\theta = n\lambda$ to solve problems related to light source passing through a plane transmission grating • apply $\Delta y = \frac{\lambda D}{a}$ to estimate the wavelength of the light source used in the Young's double slit experiment
d. Sound waves • Wave properties in sound • Audible frequency • Musical notes	• realise sound as an example of longitudinal waves and possesses the properties of waves • realise that sound can exhibit reflection, refraction, diffraction and interference • compare the general properties of sound waves and those of electromagnetic waves • realise the existence of ultrasound beyond the audible frequency range

Students should learn	Students should be able to
	• discuss the applications of ultrasound in ranging, cleaning and imaging • compare musical notes using pitch, loudness and quality in terms of waveforms • relate frequency and amplitude with the pitch and loudness of a note respectively • recognise the role of resonance in producing sound in musical instruments

Key practical Tasks

- illustrate stationary wave at different frequencies (e.g. string, Kundt's tube) and estimate the wave speed
- determine wavelength of monochromatic source using plane transmission grating
- examine the inverse square law of intensity of light
- receive radio/microwave signals from artificial and natural objects for simple data analysis

Suggested Learning and Teaching Activities

- demonstrate transverse wave and longitudinal wave using long spring
- illustrate phase change on reflection using a slinky spring
- perform ripple tank experiment to observe properties of waves
- study the factors affecting the properties of waves in water waves, microwaves or sound waves
- illustrate the superposition of two pulses using slinky spring
- illustrate the superposition of transverse wave using oscilloscope
- examine the conditions for constructive and destructive interference from two coherent sources
- examine polarisation of light using polarisers

- determine the effects of wavelengths, slit separation or slit-screen distance on an interference pattern in double slit experiment
- examine fringe pattern using Young's double slits and estimate the wavelength of the monochromatic light source
- determine audible frequency range experimentally and examine the existence of ultrasound
- use mobile App to measure loudness and pitch, and study the interference pattern of sound
- demonstrate resonance of sound waves (e.g. resonance box, water xylophone)
- observe an ultrasound image of body organs and gather information
- demonstrate the principles of pulse-echo using ultrasound transmitters and receivers
- design and make a distancing device using sonic sensor

Suggested Computational Physics activities

- simulate superposition of transverse waves
- simulate the formation of stationary wave

STSE connections and socio-scientific issues

- study the impact of discovery of electromagnetic waves to the technological advances in the various area, including telecommunications and smart living
- participate amateur radio direction finding (ARDF) activity to appreciate the use of radio in sport and promote healthy lifestyle
- investigate the medical use in related to physical principles, such as endoscope, transducer, X-ray scanning and CT scanning
- explore the application of electromagnetic waves found in household, such as Wifi transmitters, sensors of remote controls and smart camera
- discuss the dilemma of convenient information exchanges and the protection of privacy upon the rapid developing telecommunication technology

4. Electricity and Magnetism

Overview

This topic examines the basic principles of electricity and magnetism. The inter-relationships among charges, current, voltage, resistance, energy and power are examined. With the introduction of Kirchhoff's laws for the concepts of conservation, the foundation for basic circuitry is laid. The abstract concept of an electric field is introduced through its relationship with the electrostatic force.

The concept of magnetic field is applied to the study of electromagnetism. The magnetic effects of electric current and some simple magnetic field patterns are studied. Students also learn the factors that affect the strength of an electromagnet. A magnetic force is produced when a current-carrying conductor is placed in a magnetic field. An electric motor requires the supply of electric current to the coil in a magnetic field to produce a turning force causing it to rotate.

Nature of Science

- Charles-Augustin de Coulomb performed experiments involved the use of a torsion balance, a sensitive device that could measure the attractive and repulsive forces between charged objects. In 1785, he formulated Coulomb's law, which describes the electrostatic force obeys the inverse square law between two point-charges. His work introduced the concept of the inverse square law, which shared an incredibly similar mathematical structure with Newton's law of gravitation that developed about 100 years ago in 1687. Teachers can emphasis the importance of understanding laws/theory developed from former scientists to formulate new knowledge.

Students should learn	Students should be able to
a. Electric current, electric potential, and resistance	• define electric current as the rate of net flow of electric charges • distinguish between the convention for the direction of electric current and the flow of electrons • define the electric potential difference (p.d.)/voltage between two points in a circuit as the electric potential

Students should learn	**Students should be able to**
	energy converted to other forms per unit charge passing between the points outside the source • define the electromotive force (e.m.f.) of a source as the energy imparted by the source per unit charge passing through it • define resistance $R = \frac{V}{I}$ and resistivity $\rho = \frac{RA}{l}$ • identify the variation of current with the applied p.d. between ohmic and non-ohmic conductors
b. Simple circuits and electrical power • Kirchhoff's Laws • Equivalent resistance in series and parallel circuits • Internal resistance • Electrical power dissipation	• state Kirchhoff's current law ($\sum I=0$) and voltage law ($\sum V=0$) • compare series and parallel circuits in terms of p.d. across components of each circuit and the current through them • derive the resistance combinations in series and parallel $R = R_1 + R_2 + \ldots$ for resistors connected in series $\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ for resistors connected in parallel • assign the electric potential of any earthed points as zero • compare the e.m.f. of a source and the terminal voltage across the source experimentally and relate the difference to the internal resistance of the source • state the power dissipation P in a simple circuit • derive $P = VI$, $P = I^2R$ and $P = \frac{V^2}{R}$

Students should learn	Students should be able to
	• solve problems involving simple circuits
c. Electrostatics • Electric charges • <u>Coulomb's law</u> • Electric field • <u>Electric field strength</u>	• examine the evidence for two kinds of charges in nature • realise the attraction and repulsion between charges • interpret charging and discharging in terms of electron transfer • <u>state Coulomb's law $F = \frac{Q_1Q_2}{4\pi\varepsilon_o r^2}$</u> • <u>solve problems involving forces between point charges</u> • describe the electric field around a point charge and between parallel charged plates • represent an electric field using field lines • explain how charges interact via an electric field • <u>define electric field strength at a point as the force per unit charge on a positive test charge placed at that point</u> • <u>state electric field strength around a point charge by $E = \frac{Q}{4\pi\varepsilon_o r^2}$ and between parallel plates by $E = \frac{V}{d}$ and solve related problems</u>
d. Magnetic field • Magnetic force and magnetic field	• examine the magnetic field pattern in the region around a permanent magnet • describe the behaviour of a compass in a magnetic field • represent magnetic field using field lines

Students should learn	Students should be able to
• Magnetic effect of electric current • Current-carrying conductor in magnetic field	• examine the magnetic field patterns associated with currents through a long straight wire, a circular coil and a long solenoid • apply $B = \frac{\mu_0 I}{2\pi r}$ and $B = \frac{\mu_0 NI}{l}$ to represent the magnetic fields around a long straight wire and inside a long solenoid carrying current respectively, and solve related problems • examine the existence of a force on a current-carrying conductor in a magnetic field and determine the relative directions of force, field and current • determine the factors affecting the force on a straight current-carrying wire in a magnetic field and represent the force by $F = BIl \sin\theta$ • determine the turning effect on a current-carrying coil in a magnetic field • solve problems involving current-carrying conductors in a magnetic field • represent the force on a moving charge in a magnetic field by $F = BQv\sin\theta$ and solve problems

Key practical task

- compare the *V-I* graphs of ohmic and non-ohmic conductors
- determine internal resistance of a power source
- measure the magnetic field strengths around a long straight wire and/or inside a long solenoid carrying current using hall probe/search coil

Suggested Learning and Teaching Activities

- examine a wire's resistivity through investigating the factors affecting the resistance of a wire
- identify parallel or series circuit in a bread board
- design and construct a simple circuit to perform a simple function using bread board and electronic components
- examine attractive and repulsive force upon different kinds of charges
- show the nature of attraction and repulsion of charges using simple electrostatic generation and testing equipment
- demonstrate bouncing metal ball between uniform electric field (parallel metal plates connected with EHT must be handled with care)
- measure magnetic field strength by using simple current balance
- use virtual reality device to visualise electric field and magnetic field patterns
- examine the existence of a force on a current-carrying conductor in a magnetic field and determine the relative directions of force, field and current
- examine $F = BIl\sin\theta$ by varying the length and current that affect the magnitude of the force
- demonstrate the deflection of electron beam by electric field and magnetic field using cathode ray tube
- read Maxwell's story of the development on electromagnetism
- study the development in definition of Ampere so to appreciate the evolving nature of science

Suggested Computational Physics activities

- simulate the electric field or magnetic field patterns

STSE connections and socio-scientific issues

- compare the voltage and energy storage labeled on different brands and types of dry cells, and discuss their respective applications
- study the formation of auroras by describing how charged particles are guided along helical paths by magnetic field lines, so to appreciate the natural phenomena from our atmosphere to outer space in the realm of astrophysics

5. Physics and Engineering

Overview

Engineering is a multidisciplinary field that applies scientific principles to solve complex problems and develop innovative technologies. This part aims at understanding how physics closely interconnected with engineering by introducing the use of design and optimisation of systems, devices, and processes across electricity generation, power transmission and aerospace engineering. Teachers should emphasise how the engineers leverage their expertise to address challenges in authentic situations, focusing on application of physical concepts, cost-effectiveness and efficiency. Students could appreciate the technological advancements, innovative engineering solutions and make sure the process comply with safety standards and regulations.

The structure of motor and generator is studied in terms of applying the principles of electromagnetism and electromagnetic induction. Students learn how electricity is generated, alternating current (a.c.) voltages are stepped up for transmission and stepped down with transformers for domestic use. In addition to the practical use and safety of household electricity, the applications of sensors for smart-living are also studied.

Our country's aerospace technology has been developing rapidly in the recent decades. The principles of fluid dynamics, gravitational potential energy and orbital motions are studied. Through combing these physics concepts with practical engineering applications to national flight and space exploration achievement, students enhance the appreciation to advanced technology and national pride.

Nature of Science

- Thomas Alba Edison who advocated direct current (d.c.), and Nikola Tesla who was the proponent of alternating current (a.c.), began the "The War of the Currents" for the market share of electricity use. Teachers can use this to illustrate that while scientists adhere to shared scientific methods and values, they may still make biased decisions or lack objective evidence when faced with commercial interests and personal reputation, thereby reflecting the human element in the development of science.

Students should learn	Students should be able to
a. Electricity generation and power transmission • Electromagnetic induction • <u>Faraday's Law</u> • Direct current (d.c.) and alternating current (a.c.) • Transformer and electricity transmission	• examine induced e.m.f. resulting from a moving conductor in a steady magnetic field or a stationary conductor in a changing magnetic field • apply Lenz's law to determine the direction of induced e.m.f./current • <u>define magnetic flux $\Phi = BA\cos\theta$</u> • <u>state Faraday's Law $\varepsilon = -\frac{\Delta\Phi}{\Delta t}$ and apply it to calculate the average induced e.m.f.</u> • describe the structure of a simple d.c. motor, d.c. generators and a.c. generators and how they work • discuss the occurrence and practical uses of eddy currents • distinguish between the operating voltage/current and their peak values of an a.c. system • describe the working principle of a simple transformer • relate the voltage ratio to turn ratio by $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ and apply it to solve problems • examine methods for improving the efficiency of a transformer • discuss the advantages of transmission of electrical energy with a.c. at high voltages • describe various stages of stepping up and down of the voltage in a grid system for power transmission

Students should learn	Students should be able to
b. Domestic electricity and smart living • Power rating • Safety in domestic electricity • Light emitting diodes (LED) • Sensors	• determine the power rating of electrical appliances • determine the operating current for electrical appliances and discuss the choice of fuses • use kilowatt-hour (kWh) as a unit of electrical energy • calculate the costs of running various electrical appliances • discuss the choice of thickness of power cables with the consideration of cost effectiveness and electricity safety • interpret the light emission of LED in terms of energy change in atomic level and discuss its energy efficiency and endurance • recognise the basic working principle of common sensors that operate by detecting or measuring physical quantities and converting them to into electrical signals • discuss daily application of sensing devices for smart living environment
c. Aerospace Science and Engineering • Aircraft in fluid • <u>Bernoulli's equation</u> • <u>Launching to space</u> • <u>Aerospace technology</u>	• derive continuity equation vA=constant from the conservation of mass and solve related problems for incompressible fluid • recognise the role of Bernoulli's principle and Coanda effect in generating lifting force for aircraft • <u>apply the Bernoulli's equation $P+\rho gh+\frac{1}{2}\rho v^2$=constant to solve problems related to aircraft, including pitot tube</u>

Students should learn	Students should be able to
	• apply Newton’s law of gravitation to explain motion of celestial bodies in circular orbits • distinguish the apparent weightlessness of a spacecraft between orbiting and traveling in space • interpret the meaning of gravitational potential energy and its expression $U = -\frac{GMm}{r}$ • apply conservation of mechanical energy to solve problems involving launching and motion of artificial celestial bodies or spacecraft • determine the escape velocity on a celestial body • recognise the diverse applications of satellites • appreciate the nation’s contributions to the development of aerospace technology

Key practical tasks

- design and construct an electric circuit, with the use of sensors, to perform a simple function design

Suggested Learning and Teaching Activities

- investigate the factors affecting the magnitude of induced current/e.m.f. of a moving coil inside a magnetic field
- examine a transformer’s voltage ratio and turns ratio
- investigate Faraday’s law $\varepsilon = -\frac{\Delta\Phi}{\Delta t}$ using signal generator across a solenoid and measure the induced e.m.f. across a coil surrounding the solenoid using oscilloscope

- gather and analyse information to identify how high tension cables are insulated from power pylons, protected from lightning strikes and cleaned from dirt
- demonstrate the conversion from mechanical energy to electrical energy using regenerative braking system
- demonstrate the heating and damping effect from eddy current
- compare the efficiency of cooking electrical appliances, such as microwave oven, electric heater and magnetic heater
- compare the power transmission among d.c. through cables and a.c. through stepping up and down of the voltage in a grid system
- build a circuit to generate electricity by solar energy or wind turbine
- demonstrate Bernoulli's effect using water flow through pitot tube or horizontal tube with a narrow section
- demonstrate the Coanda effect of curved surface under a fluid in motion (e.g. wind blow to circular cup, spoon under water stream)
- investigate the shapes of air foil affecting the uplifting force under air stream
- investigate the angle of attack against the uplifting force on air foil under air stream
- design and make an aircraft model using 3D printer
- search for the information on home-developed aircraft C919
- compare the working principles of helicopter, drone, hot air balloon and aircraft , and analyse their characteristics in connection with their functions
- carry out an energy audit on their own homes or schools – for example, measuring amount of electrical energy used at home in a month by reading the electricity bill and estimating what proportion of this energy is used for lighting, air-conditioning, heating water and cooking
- gather and analyse the use of sensors on their own homes or schools and study how the data transmitted and processed through computing and cloud systems for smart living
- construct models related to national aerospace technology, such as Long March rocket, Shenzhou spacecraft and Beidou satellite
- read the national space exploration projects (e.g. scientific research in Tiangong, Lunar and Mars exploration)
- read the story of Hong Kong's first astronaut entering Tiangong space station, such as the intensive training before launching and the role of payload expert
- visit to museums/sites related to aerospace technology (e.g. HK Space Museum, Government Flying Service, Guangdong Aerospace Research Academy)

Suggested Computational Physics activities

- simulate the orbital motions of celestial bodies

STSE connections and socio-scientific issues

- compare the functions, cost and energy efficiency of LED with other kinds of light sources such as incandescent lamps (e.g. filament light bulb, halogen lamp) and gas discharge lamps (e.g. linear or compact fluorescent lamp, high pressure mercury or sodium lamp, induction lamp)
- study the Energy Efficiency Labelling Scheme (EELS) in Hong Kong and information contained in Energy Labels
- gather and compare information related to end-use energy efficiency for air conditioners, lamps and cars
- study the recent development of national aerospace technology and the implication to society (e.g. low altitude economy, space economy)
- discuss the space competition and collaboration among different countries

6. Physics and society

Overview

Physics is deeply embedded in our daily lives, influencing everything from the time we wake up to the way we communicate. Radioactivity and sustainable development are the crucial concepts that are not intuitive but highly influencing to our daily life. Radioactive isotopes are widely used in medical purpose and nuclear power, while high standard of safety measures should be maintained to minimise potential hazards or any disaster that may lead to panic. Nuclear power and renewable energy sources are crucial for combating climate change and achieving sustainable development goals. They offer clean and increasingly competitive energy alternatives to fossil fuels, which not only target for carbon neutrality but also lower costs upon the advancing technology levels.

Physics-related expertise promotes technology advancements for improving our lives. Students are encouraged to explore how researchers and engineers contribute to the discovery of physics knowledge and technological breakthrough. In addition, various kinds of Physics-trained expertise are able to apply modelling skills to simulate various situations for problem solving in financial analytics, social interactions and complex systems.

Nature of Science

- Scientists worked in close cooperation with engineers during the Manhattan Project in World War II (WWII). The successful construction of atomic bomb led to an end of WWII. Teachers can emphasis how science and technology influenced each other in the development of nuclear weapon during WWII, and later nuclear power serves as a kind of clean and low carbon emission energy source.

Students should learn	Students should be able to
a. Radiation and radioactivity • X-rays • α, β and γ radiations • Radioactive decay	• realise X-rays as ionising electromagnetic radiations of short wavelengths with high penetrating power • realise the emission of X-rays when fast electrons hit a heavy metal target • discuss the medical and security use of X-rays • describe the origin and nature of α, β and γ radiations

Students should learn	Students should be able to
• Detection of radiation • Radiation safety • Radioactive isotopes	• compare α, β and γ radiations in terms of their penetrating power, ranges, ionising power, behaviour in electric field and magnetic field, and cloud chamber tracks • realise the occurrence of radioactive decay in unstable nuclides and its random nature • state the proportional relationship between the activity of a sample and the number of undecayed nuclei • define half-life as the period of time over which the number of radioactive nuclei decreases by a factor of one-half • determine the half-life of a radioisotope from its decay graph or from numerical data • realise the existence of background radiation • know the methods in detecting radiations using photographic film and GM counter • interpret radiation in terms of count rate using a GM counter • represent radiation equivalent dose using the unit Sievert (Sv) • discuss potential hazards of ionising radiation and suggest safety precautions in handling radioactive sources to minimise the radiation dose absorbed

Students should learn	Students should be able to
	• define atomic number as the number of protons in the nucleus and mass number as the sum of the number of protons and neutrons in the nucleus of an atom • represent nuclides using symbolic notations • define isotope • realise the existence of radioactive isotopes in some elements • discuss the uses of radioactive isotopes for radiotherapy, thickness inspection, tracers and medical imaging • solve problems involving radioactivity and radioactive decay
b. Energy sources and sustainable development • Renewable and low carbon energy sources • Environmental impact of energy consumption • Carbon neutrality	• recognise the needs and consideration for developing renewable and low carbon energy sources for achieving relevant sustainable development goals • realise the release of energy in nuclear fission and fusion • state mass-energy relationship $\Delta E = \Delta mc^2$ • use electron-volt (eV) and atomic mass unit as units of energy • apply $\Delta E = \Delta mc^2$ to determine the energy release in nuclear reactions • realise nuclear chain reaction

Students should learn	Students should be able to
	• describe the principle of the nuclear fission reactor and state the roles of moderator, coolant and control rods • realise nuclear fusion as the source of solar energy • describe photovoltaic effect as the process for a semi-conductor to generate voltage and electric current upon exposure to light • define solar constant as the total electromagnetic radiation energy radiated at normal incidence by the Sun per unit time per unit area at the mean distance between the Earth and the Sun measured outside the Earth's atmosphere • solve problems involving the solar constant • derive maximum power by wind turbine as $P=\frac{1}{2}\eta\rho Av^3$, where η is the efficiency, to solve problems • discuss the impact of extraction, conversion, distribution and greenhouse gas emission in the use of energy on the environment and society • discuss how the daily habits of individuals contribute towards achieving carbon neutrality, so as to mitigate the climate change • analyse the consumption data for different energy sources in Hong Kong and their specific purposes • appreciate the nation's contribution to the development of renewable and low carbon energy sources

Students should learn	Students should be able to
c. Physics for recent and future • Physics-related career • Physics and I&T	• realise the essential role of physicists and engineers in fostering the development of a sustainable society • appreciate various professions and specialists in applying physical models and simulations to solve authentic problems • appreciate the impact of discoveries in physics from history leading to modern technologies and recognise how emerging innovation and technology are shaping everyday life

Key practical tasks

- conduct Computational Physics experiment/use dice to simulate radioactive decay of isotope

Suggested Learning and Teaching Activities

- measure background radiation using GM counter
- demonstrate the random variation of count rate by using GM counter and a radioactive source
- identify sources of natural radiations and investigate why exposure to natural radiation is increased for airline crews and passengers
- determine the factors leading to an increase in the concentration of radon in high-rise buildings
- read the specification for commercial products containing radiation, such as smoke detectors
- assess the risks and benefits of using nuclear radiations in medical diagnosis
- search the process of handling radioactive wastes in Hong Kong
- estimate the half-life from a graph of activity plotted against time
- search for information on the use of radioactive dating, radioactive tracers, food irradiation and product sterilization

- discuss the worth and risks of using X-rays, ultrasound and radionuclides for patients
- search and discuss for the information on the ethics of developing and using nuclear weapons
- examine the efficiency of wind power generator with $P=\frac{1}{2}\eta\rho Av^3$
- examine the photovoltaic effect of solar cell
- study complex systems to simulate a social or natural issue, such as crowd control and forest fire
- organise or participate competition on solar cooker, wind power generation, solar car race or hydrogen car race
- study the resonance effect results from the interaction between electromagnetic waves of particular wavelengths and greenhouse gases
- study the most recent scientific development of nuclear fission and fission for nuclear power generation
- visit to low carbon energy source centre
- visit local power plants and the nuclear power plants in our country (e.g. Daya Bay)
- participate the talks conducted by speakers from the Electrical and Mechanical Services Department, Green Power, CLP Power Hong Kong Limited, Hong Kong Electric Company Limited, Towngas, MTR, or the Environment Protection Department to introduce the recent information on energy generation, transmission and consumption in society and alternative energy sources

Suggested Computational Physics activities

- simulate radioactive decay process

STSE connections and socio-scientific issues

- search and analyse the data of carbon emission and the temperature change
- analyse the reasons causing the serious nuclear disasters in the history and study the enhanced safety standards of the new generation of nuclear power plants as well as the limitations and advantages of small modular reactor (SMR)
- debate for comparing the use of nuclear reactors with other methods of producing electrical power in terms of cost-effectiveness, sustainable development, potential hazards, etc.
- investigate how the enhancing technology improves the safety and enhances the abundance of possible nuclear power fuels

- study the impact of extraction, conversion, distribution and use of energy on the environment and society, and their suitability for different situations
- discuss the ways to save electrical energy for reasons of economy and environmental protection
- discuss for the alternative generation and better use of electricity for more sustainable use in Hong Kong
- discuss a feasible plan for Hong Kong to achieve the goals of sustainable development

Modern Physics

7. Quantum Physics

Overview

Quantum Physics refers to the study of physical phenomena at the small scales, such as atoms and subatomic particles. The principles and theories that explaining microscopic world form the basis for cutting-edge technologies, such as electron microscopes, semiconducting chips and quantum computing.

Unlike classical physics, which are deterministic and causal in nature, quantum physics embraces a probabilistic approach that precise predictions of particles' physical parameters are impossible. From the Heisenberg's Uncertainty Principle, it is impossible to measure both the exact position and the momentum of a particle simultaneously with precision. In addition, energy in classical physics is observed to be continuous, meaning it can take on any value within a given range in macroscopic level. However, quantum physics introduces the concept of quantisation, asserting that the energy of quanta can only exist in discrete levels. Furthermore, the concepts such as photoelectric effect, wave-particle duality, and quantum superposition, demonstrate quantum properties that cannot be explained solely from classical theories.

Nature of Science

- In late 19th century, physicists explored the properties of tiny substances, now known as quantum particles. They found that classical theory failed to explain some of the observations, such as line spectra and photoelectric effect. Teachers should emphasis scientific laws or theories are the subject to revision when there exists new evidence through the transition from classical to quantum physics.

Students should learn	Students should be able to
a. Atomic Model	• recognise JJ Thomson's discovery of electron • describe Rutherford's construction of an atomic model consisting of a nucleus and electrons from the scattering experiments

Students should learn	Students should be able to
	• state the limitations of Rutherford's atomic model in accounting for the line spectra
b. Photoelectric effect • Evidence for light quanta • Einstein's interpretation of photoelectric effect and photoelectric equation	• describe photoelectric effect experiment and its results • state the limitations of the wave theory of light in explaining the photoelectric effect • state photons as light quanta and relate its energy to the frequency using $E=hf$ • describe how the intensity of light of a given frequency is related to the number of photons • realise the photoelectric effect as the evidence of particle nature of light • explain photoelectric effect using Einstein's photoelectric equation $hf - \phi = \frac{1}{2}m_e v_{\max}^2$ • apply $E=hf$ and Einstein's photoelectric equation to solve problems
c. Bohr's atomic model of hydrogen • Discrete energy levels • Electron transition among energy levels	• describe the special features of line spectra of hydrogen atoms and other monatomic gases • realise line spectra as evidence of quantised energy levels • realise that the energy levels of a hydrogen atom are quantised and can only take on certain discrete values • explain spectral lines of hydrogen atoms in terms of electron

Students should learn	Students should be able to
• Bohr's equation of electron energy of hydrogen atom	transitions between energy levels • distinguish between "quantum" and "classical" aspects in terms of quantisation of energy levels of Bohr's atomic model of hydrogen • realise the daily applications of photon absorption and emission resulting from electron transitions between energy levels of specific materials (production of X-ray and quantum dots in RGB displays) • represent the energy of an electron in a hydrogen atom at n^{th} energy level as $E_{tot} = -\frac{13.6 \text{ eV}}{n^2}$ • distinguish ionisation and excitation energies • derive the expression $\frac{1}{\lambda_{a\to b}} = \frac{-13.6 \text{ eV}}{hc}\left(\frac{1}{b^2} - \frac{1}{a^2}\right)$ for the wavelength $\lambda_{a\to b}$ of photon emitted or absorbed when undergoes electron transition between energy levels • interpret line spectra by the use of Bohr's equation of electron energy • apply $E = hf$ and $\frac{1}{\lambda_{a\to b}} = \frac{-13.6 \text{ eV}}{hc}\left(\frac{1}{b^2} - \frac{1}{a^2}\right)$ to solve problems
d. Wave-particle duality • de Broglie formula	• realise the wave-particle duality of electrons and light • describe evidences of electrons and light exhibiting both

Students should learn	Students should be able to
• Rayleigh criterion	wave and particle properties
	• apply de Broglie formula $\lambda = \frac{h}{p}$ to solve problems involving wave and particle properties of electrons
	• describe the limitations of optical microscope in observing substances of small scale
	• explain the advantage of high resolution of electron microscopes using de Broglie wavelength and Rayleigh criterion for minimum resolvable detail, $\theta \approx \frac{1.22\lambda}{d}$
e. Probabilistic nature and Heisenberg's uncertainty principle	• realise the probabilistic nature of quantum particles
	• realise the graphical representation of a quantum particle as normalised wave function $\psi(x)$ and the probability density at position x is $\lvert\psi(x)\rvert^2$
• Quantum superposition	• describe the superposition state of a quantum particle ψ using $\lvert\psi\rangle = a_1\lvert\phi_1\rangle + a_2\lvert\phi_2\rangle$, where $\lvert a_1\rvert^2$ and $\lvert a_2\rvert^2$ are the probability of obtaining states $\lvert\phi_1\rangle$ and $\lvert\phi_2\rangle$ respectively (normalised states only, i.e. $\lvert a_1\rvert^2+\lvert a_2\rvert^2=1$)
• Measurement of a quantum particle	• describe the effect of measurement of a quantum particle
• Heisenberg's uncertainty principle	• solve problems involving quantum superposition and measurement
	• realise the quantum tunnelling and discuss its application in scanning tunnelling electron microscope (STM)

Students should learn	Students should be able to
	• state Heisenberg's uncertainty principle • apply $\Delta x \Delta p \geq \frac{h}{4\pi}$ to solve problems • discuss the recent development and applications of quantum technology in various areas related to daily life (quantum computing, quantum cryptography and quantum communication)

Key practical tasks

- perform experiment using LED to estimate the value of Planck's constant

Suggested Learning and Teaching Activities

- perform an analogy activity to illustrate Rutherford's construction of atomic model by using a ball passing through a black box
- examine the photoelectric effect of gold leaf using monochromatic sources with different intensity and frequency
- perform experiment on the photoelectric effect using photocell to measure the stopping potential of monochromatic light
- perform electron diffraction experiment using electron gun with lattice to study its diffraction pattern
- use electron gun with Helmholtz coils to perform experiment of deflection of electron to estimate the charge to mass ratio of electron
- search and study the images captured by electronic microscopes
- observe emission line spectra and/or absorption line spectra of particular elements using plane transmission grating
- study the working principle of TV displays in using RGB primary colour that different from the full colour spectrum of sunlight
- perform experiment to show how the diffraction patterns of two monochromatic point sources demonstrate the limit of resolution for visible light
- use analogy to understand the probabilistic behavior in quantum world (e.g. Schrodinger cat)

- study the quantum tunnelling effect in radioactive decay and nuclear fusion occurring in the sun
- learn about scientists who contributed well to the development of quantum mechanics (e.g. J.J. Thomson, Max Planck, Albert Einstein, Ernest Rutherford, Niels Bohr, Louis de Broglie, Erwin Schrodinger and Werner Heisenberg)
- search and study the particle accelerator for researches in Atomic Physics, such as CERN, IHEP and SKEKB
- study the standard model of particle physics in explaining how the basic building blocks of matter interact and governed by four fundamental forces
- Visit to Hong Kong Science Museum for the exhibits about quantum technology
- Visit to Standards and Calibration Laboratory for the primary standards for physical measurements that make use of quantum effects (e.g. caesium beam atomic clock)

Suggested Computational Physics activities

- simulate the Rutherford scattering experiment

STSE connections and socio-scientific issues

- study the principles of qubits in quantum computing and compare that with traditional computers
- explore the recent displays using quantum technology to appreciate how quantum technology improves the energy efficiency
- study the daily application of quantum technology and how their development changed our life
- study the latest development of quantum technology and discuss the possible impacts to society and economics

8. Astrophysics and Relativity

Overview

Astrophysics is the study of universe with the applications of theory and laws of physics. It encompasses a wide range of phenomena, from the behavior of stars to the mysteries of black holes and dark matter. In addition, astrophysics offers theoretical framework, together with the aerospace technological advancements, enable space exploration to become possible. Students are given a brief introduction to the phenomena of the universe as seen in different scales of space. They are exposed to realise different ways to observe in unravelling the fundamental laws that govern the universe. Some basic properties and classifications of stars, and the expansion of the universe are introduced.

Relativity, as proposed by Albert Einstein, denotes a cornerstone of modern physics. This revolutionised Newtonian mechanics and explains the observed deviations from Newton's Law of Universal Gravitation. The principle of invariant light speed, length contraction and time dilation in special relativity are evidenced by observation, such as decay of muon from cosmic. For instance, satellite navigation systems must account for the relativistic effects for precise timing to pinpoint locations.

Nature of Science

- Before 20th century, the universe was considered static and unchanging. In 1920s, Edwin Hubble's observation using Hooker telescope revolutionised the understanding of the universe. With this powerful instrument, Hubble was able to observe distant galaxies and determine their distances, leading to the groundbreaking conclusion – the universe is expanding. Teachers can emphasise that this technological advancement enabled astronomers to gather data that challenged existing models and laid the foundation for modern cosmology.

Students should learn	Students should be able to
a. Observing the sky • Instruments to observe celestial bodies • Structure of the universe	• realise the use of different astronomical instruments in observing celestial bodies through visible spectrum and beyond

Students should learn	Students should be able to
	• recognise the basic features and hierarchy of celestial bodies including solar system, star, star cluster, nebula, galaxy and cluster of galaxies • determine the distance of a celestial body using the method of parallax • define and use basic terminologies including light year, astronomical unit and parsec (pc) as units of distance used to describe the spatial scale
b. Stars and the universe • Stellar luminosity • Hertzsprung-Russell (H-R) diagram • Stefan-Boltzmann law • Doppler effect	• describe the effect of surface temperature on the colour and luminosity of a star using blackbody radiation curves • classify stars on the H-R diagram according to their luminosities and surface temperatures • state Stefan-Boltzmann law ($P = \sigma A T^4$), and apply it to derive the luminosity $L = 4\pi R^2 \sigma T^4$ for a spherical blackbody • estimate the relative size of stars using H-R diagram and Stefan-Boltzmann law • realise the existence of spectral lines in the spectra of stars • describe the Doppler effect and apply $\frac{\Delta\lambda}{\lambda_o} = \frac{v_r}{c}$ to determine the velocity of celestial bodies • explain the existence of dark matter inferred from the rotation curve of stars around galaxies

Students should learn	Students should be able to
	• relate red shift to the expansion of the universe and infer to the Big Bang theory
c. Relativity	• state the limitations of Newtonian Mechanics in terms of space and time
• Frames of reference	• realise the laws of physics are valid in all inertial frames of reference
• Principle of invariant light speed	• realise that light propagates through empty space with a definite speed of light $c = 3\times10^{8}$ m s^{-1} is independent of the speed of the source or observer
• Time dilation	• state the time dilation $\Delta t = \frac{\Delta t_0}{\sqrt{1-\left(\frac{v}{c}\right)^2}}$ and length contraction $l = l_o\sqrt{1-\left(\frac{v}{c}\right)^2}$, and apply them to solve problems
• Length contraction	• use spacetime diagram to show the events occur and their light arrive across two distinct observers from different frames of reference
• Spacetime diagram	• state the limitations of special relativity in accounting the effect of gravity, and appreciate the spacetime curvature model from Einstein's General Relativity
	• recognise the important role of relativistic effect in the satellite navigation systems

Key practical tasks

- measure distance of an object using parallax method

Suggested Learning and Teaching Activities

- construct a simple antenna and connect to SDR for receiving radio signals from different sources, such as remote microphone, aircrafts and celestial bodies
- study the evolution of stars and observe their positions from H-R diagram
- observe absorption line spectrum (e.g. Iodine vapor)
- observe spectra of celestial objects under telescope (e.g. H-alpha)
- demonstrate Doppler’s effect using sound transmitter (e.g. rotating single-frequency sound emitter)
- perform experiment to examine objects’ motions obey laws of classical physics in an inertial frame that moving in constant velocity
- perform Michelson Morley experiment to examine speed of light is constant and independent of the motion of light source or observer
- study the fast-travel muon from cosmos can be detected on the Earth surface before decay as evidence supporting special relativity
- use cloud chamber to observe cosmic rays from the Universe
- use optical device and tuned sound beats to observe something traveling to be length contracted and time dilated respectively to simulate the world observed under special relativity
- study Schwarzschild radius and the recent discoveries about black hole
- study the discovery of gravitational wave from the Laser Interferometer Gravitational-Wave Observatory (LIGO) in 2016 that supported the prediction by Albert Einstein 100 years ago
- visit to the sites with astronomical instruments, such as Astropark and Ho Koon Nature Education cum Astronomical Centre
- observe astronomical phenomena with the naked eyes
  - compare the colour and brightness of different stars
  - recognise the Western and Chinese constellations and the apparent motion of celestial bodies in the sky
  - meteor showers
  - special astronomical events, such as lunar eclipse
- use optical telescopes to observe
  - the surface (impact craters, lunar Maria, rays, etc) of the Moon with telescope, estimate height and dimension of lunar features, etc.
  - planetary events like conjunction, elongation, opposition, etc.
  - sunspots and solar eclipses with proper safety measures taken
  - the features of major planets with a small telescope, such as the Great Red Spot, belts and satellites of Jupiter, the phases of Venus, and the ring of Saturn

- special astronomical events such as the opposition of Mars
- bright comets
- binary stars, nebula and deep sky objects
- regular / long-term observation projects for tracing the changes: lunar phase, Jupiter's moon motion, Great Red Spot, phases of Venus

- observe artificial satellites and receive radio signals from space stations using antenna
- appreciate the development of scientific research of our country by studying the information from national large research facilities in astronomy and cosmology, such as Five-hundred-meter Aperture Spherical Telescope (FAST) and Large High-Altitude Air-Shower Observatory (LHAASO), National Astronomical Observatories of China

Suggested Computational Physics activities

- simulate doppler effect
- simulate different frames of reference for simultaneity and time dilation

STSE connections and socio-scientific issues

- study the astrophysics discoveries which have stimulated the development of modern science and eventually changed our ways of living
- study the impact of cosmic rays or celestial bodies from outer space and our reactions to them, such as meteor and solar wind
- compare the calendar dates among different cultures and relate them with astronomical observations

9. Scientific Inquiry in Physics

Overview

A portion of lesson time is assigned for developing students' scientific inquiry skills through practical tasks and scientific investigations/engineering design activities to investigate physical phenomena or solve problems. Computational Physics should be implemented in connections with these tasks for equipping students' ability in applying cross-disciplinary skills. Students are expected to value the importance of using digital tools and AI critically and responsibly, recognising both their benefits and limitations in scientific inquiry; and appreciate the need to integrate digital technologies and AI with sound scientific reasoning when solving physics-related problems.

Teachers should arrange at least 8 practical tasks. Students' hands-on experience in performing these tasks are required. Teachers can select the experiments from the key practical tasks, and offer some school-based experiments to meet students learning needs.

Teachers should arrange at least one scientific investigation/engineering design activity for engaging students in an inquiry-based learning among the practical tasks. Through inquiry-based learning, students are expected to develop the scientific inquiry skills stated in chapter 2.2.1, and to be able to

- develop an investigation plan and justify its appropriateness
- put forward suggestions for ways of improving the validity and reliability of a scientific investigation/effectiveness and efficiency of a product
- use accurate terminologies and appropriate reporting styles to communicate findings and conclusions of an investigation
- use appropriate digital tools (e.g. data-loggers and sensors, spreadsheets, graphing software and AI), to collect, process and interpret data, search for and organise physics information, and evaluate the reliability and scientific accuracy of digital and AI-generated outputs
- evaluate the validity of conclusions with reference to the process of investigation and the data and information gathered.

Time Allocation

<table>
<tr><td></td><td>Practical tasks</td><td colspan="2">Scientific Investigation/ Engineering Design</td></tr>
<tr><td>Learning Targets</td><td colspan="3">Scientific Inquiry
• Laboratory Technique
• Data Analysis
• Order of Accuracy and Error Treatment
• Awareness of Safety

Computational Physics
• Building Computational Models
• Computer-Assisted Data Analysis</td></tr>
<tr><td>Process</td><td>• Prepare the experiment
• Use apparatus/ computational tools to conduct experiment
• Complete assignments/reports</td><td>• Develop and justify investigation plan
• Implement investigation plan
• Analyse preliminary data and refine the plan
• Report results and error analysis</td><td>• Define problem and design solutions
• Develop prototypes and conduct scientific tests
• Analyse data to determine optimal setting of the prototype
• Improve the prototype based on the analysed data</td></tr>
<tr><td rowspan="2">Estimated lesson time for each activity</td><td>~ 80 minutes</td><td colspan="2">~ 240 minutes</td></tr>
<tr><td colspan="3">At least eight (8) hands-on practical tasks performed by students, including at least one (1) Scientific Investigation/ Engineering Design activity</td></tr>
<tr><td></td><td colspan="3">16 hours</td></tr>
</table>

Implementation

Scientific investigations and/or engineering design aim to solve physics-related problems. It consists of inquiry-oriented activities that provide students with direct exposure to experience scientists' /engineers' work as community that reinforce the nature of science. In this connection, students can actively engage in their learning, formulating questions, investigating widely and then building new ideas and solving problems.

The nature of learning and teaching activity could be distinguished into Scientific Investigation and Engineering Design. An authentic task may not be solely either one but an integration of them. The following provides the general principle in designing the learning and teaching task for teachers' reference.

> ***Scientific Investigation*** *– focus on formulating science questions and constructing explanations*. Students learn conducting scientific investigation and develop relevant inquiry skills in primary and junior secondary levels. The process generally involves defining a problem, plan and investigate, gather data, organise and analyse their results, and communicate their findings. Through the process students could apply relevant physics concepts and science inquiry skills, so to enhance their understanding of the nature of science.
>
> Teachers can arrange the key practical tasks stated in session 2.3 or school-based experiments for scientific investigation by conducting them in inquiry-based oriented approach. Teachers are also encouraged to arrange some authentic or open-ended tasks. Some possible topics are suggested below:

- Investigating the factors affecting rate of cooling
- Justifying a motion to be uniform motion or uniformly accelerating motion
- Estimating the terminal velocity of an object
- Investigating the relationship of parameters in projectile motion
- Investigating the factors affecting the efficiency of a solar cell
- Estimating the distance of a celestial object from the Earth
- Analysing the radio signals from celestial bodies
- Programing a simulation of simple harmonic motion and study the damping factor
- Programing a complex system to illustrate social processes, such as forest fire, spread

of disease and crowd control

Engineering Design – *focus on defining problems and designing solutions*. Building on the "Engineering design and innovation" in Science (P1-6) and "Engineering Design" in Science (S1-3), students acquire the general principles in constructing and improving models. The process generally involves defining problem, designing solution, constructing product, carrying out testing and evaluating for improvement. Through the engineering design cycle, they could experience how products produced by making use of physics principle, technology and computational thinking skills so as to facilitate their learning in the innovation and technology.

Some possible topics for engineering design are suggested below:

- Designing and making a simple pendulum clock for presenting a specific period
- Constructing and improving the performance of a solar cooker
- Constructing and improving the performance a water rocket to meet a target in terms of height, accuracy or installation of parachute
- Designing and making an antenna to receive radio signal
- Making use of various kinds of sensors to construct a robotic system
- Constructing and testing a home-made wind turbine to generate electricity
- Constructing a renewable energy powered system for particular purpose, such as lighting and cooling
- Constructing a parking alarm system by programming sonic sensor with micro-computing device
- Constructing smart devices by programming and applying physics concepts for smart home or school campus, for example, using infrared sensor in automatic system

Chapter 3 Assessment Framework

3.1 Assessment Objectives

The assessment objectives of Physics are to evaluate the abilities of candidates to:

1. recall and show understanding of the facts, concepts, models and principles of physics, and the relationships between different topic areas in the curriculum framework;
2. apply knowledge, concepts and principles of physics to explain phenomena and observations, and to solve problems;
3. show an understanding of the use of apparatus in performing experiments;
4. demonstrate an understanding of the method used in the study of physics;
5. present data in various forms, such as tables, graphs, charts, diagrams, and transpose them from one form into another;
6. analyse and interpret data, and draw appropriate conclusions;
7. show an understanding of the treatment of errors;
8. select, organize, and communicate information clearly, precisely and logically;
9. demonstrate understanding of the applications of physics to daily life and its contributions to the modern world;
10. show awareness of the ethical, moral, social, economic and technological implications of physics, and critically evaluate physics-related issues; and
11. make suggestions, choices and judgments based on the examination of evidence using knowledge and principles of physics.

3.2 Assessment Design

3.2.1 Mode of assessment

The public assessment of Physics consists of a public examination component and a school-based assessment component as outlined in the following table:

Component			Weighting	Duration
Public Examination	Paper 1	Conventional Questions	52%	2 hours 15 minutes
	Paper 2	Multiple-choice Questions	28%	1 hour
School-based Assessment (SBA)			20%	——

3.2.2 Public examination

Paper 1 consists of conventional questions, including short questions, structured questions, and essay questions, set on both the Core and Extension components of the curriculum. It carries 52% of the subject mark. Candidates are required to answer **all** questions in Paper 1.

Paper 2 consists of multiple-choice questions set on both the Core and Extension components of the curriculum. It carries 28% of the subject mark. Candidates are required to answer **all** questions in Paper 2.

Questions set on the Extension component would **not** exceed 30% of the written paper marks.

3.2.3 School-based assessment (SBA)

School-based assessment (SBA) is compulsory for **all** school candidates. Candidates will be assessed by their teachers on their performance of a wide range of skills involved in practical work throughout S5 and S6. Candidates are required to perform a stipulated amount of practical work. The work should be integrated closely with the curriculum and form a part of the normal learning and teaching process. Candidates may also be required to design and conduct a scientific investigation with a view to solving an authentic problem. They are expected to make use of their knowledge and understanding of physics in performing such a scientific investigation, through which their generic skills, practical skills, process skills and reporting skills, etc. would be developed and assessed.

The table below summarises the minimum number of assessments required in S5 and S6 for the SBA, and the respective weighting in the subject:

<table>
<tr><th></th><th colspan="2">Minimum number of assessments</th></tr>
<tr><td>S5</td><td colspan="2">1 EXPT (6%)</td></tr>
<tr><td>S6</td><td>1 EXPT (6%)</td><td>1 SI (8%)</td></tr>
</table>

Over the two years of S5 and S6, there should be at least two assessments for experiments (EXPT) and one assessment for scientific investigation (SI).

For monitoring and authentication purposes, candidates are required to keep good custody of all their work in SBA until the publication of the HKDSE examination results.

Private candidates need not complete the SBA component. Their subject result will be based entirely on their public examination results.

The detailed requirements, regulations, assessment criteria, guidelines and methods of assessment are provided in the SBA Teachers' Handbook for HKDSE Physics published by the Hong Kong Examinations and Assessment Authority.

The Use of Digital Educational Tools and Artificial Intelligence for Learning, Teaching and Assessment of Physics

The 2024 Nobel Prize in Physics recognised how physics inspired the development of artificial intelligence (AI) tools used today. Integrating AI tools into physics lessons allows students to directly experience how scientific principles lead to technological innovation. This approach helps students understand the nature of science as a creative, evolving process that turns theoretical models into real-world applications.

Digital educational tools and AI provide support for learning and teaching and promote pedagogical innovation in Physics. Through the appropriate use of digital tools and AI-assisted strategies, teachers can design interactive learning activities, better understand students' learning progress and needs, and enhance teaching effectiveness through diversified pedagogical approaches.

With appropriate utilization of digital educational tools and AI-assisted teaching strategies, teachers can better design interactive learning and teaching materials, enabling experiments with efficient and effective data collection and analysis through computing devices, as well as simulating abstract physical phenomena for helping students to overcome the cognitive barriers on counterintuitive concepts.

Teachers may make appropriate use of AI and digital educational tools, including simulations, animations, visualisation and data analysis tools, to help students develop a deeper understanding of abstract physics concepts. Online learning platforms and AI-assisted tools may also be used to provide students with diversified learning experiences and timely feedback, thereby promoting self-directed learning and enhancing learning effectiveness.

The following table shows some examples of the applications of digital educational tools for teachers' reference:

Digital Educational Tools	Pedagogical Use
Mobile Devices	• Use built-in sensors (e.g. accelerometer, light sensor, microphone) of mobile device to carry out experiments or scientific investigations to study physical phenomena quantitatively. Bridging theory and everyday phenomena and enhances evidence-based reasoning. • Enable students to take videos of real-world motions (e.g. projectile, standing wave) and then analyse the motions qualitatively.
Data-loggers and Sensors	• Facilitate real-time data collection and graphical analysis in practical activities; promote scientific inquiry skills by allowing students to design experiments, observe patterns

	instantly, and focus on data interpretation rather than manual plotting.
Programming Software / Spreadsheet	• Enable students to practise data analysis, graphing, numerical simulations, and modelling of physical phenomena (e.g. motion, circuits, waves). • Promote computational thinking and allow interactive exploration of different possible scenarios, improve understanding of concepts through visualization, and develop scientific inquiry skills using computer.
Computer Simulations	• Enable students to visualise and manipulate abstract physical phenomena (e.g. electric fields, projectile motion, wave interference) in a risk-free virtual environment, helping them overcome intuitive misconceptions and develop conceptual understanding through inquiry-based exploration.
Online Real-time Experiment Platform	• Offer remote but real experiments enabling students to safely and repeatably practise experimental techniques and deepen understanding of underlying physics principles.
Multimedia Resources (Animations and videos)	• Animations and videos help students visualise abstract concepts. • Stimulate interest, support conceptual understanding, and allow repeated observation of experimental techniques and phenomena.
Artificial Intelligence (AI)	• Use AI, with the aid of vibe coding, to generate starter code for Physics simulations, allowing safe, repeatable investigation of difficult experiments (e.g. alpha-particle scattering, escape velocity). • AI guides students through experimental design and data interpretation, deepening understanding of the nature of scientific experimentation; students may also modify the code to test hypotheses, developing computational thinking alongside Physics modelling skills. • Assist teachers in designing curriculum-aligned learning, teaching and assessment materials tailored to students' needs, thereby creating curriculum space for laboratory work, discussion and deeper conceptual understanding.

The table below helps teachers identify and select appropriate digital educational tools according to specific purposes of learning activities in Physics, illustrating how different tools can be used flexibly and complementarily to support lesson design, learning activities and assessment.

Functions of Digital Educational Tools	Mobile Devices/ Data-logger and sensors	Programming software / spreadsheet	Computer Simulations	Online Real-time Experiment Platform	Multimedia Resources	AI
Build Computational Models		✓				✓
Practical work and data handling	✓	✓		✓		
Simulations for concepts illustration			✓			✓
Visualisation of abstract concepts					✓	
Assessment for learning and self-directed learning						✓

Pedagogical Considerations of Using AI in Physics

When applying AI (including GenAI) to support learning and teaching, teachers should strike an appropriate balance between AI-assisted learning, hands-on scientific investigations and other teacher-guided learning activities. Teachers are required to exercise professional judgement in determining the appropriate use of AI and to ensure that they continue to play the role of learning facilitators. Students should be provided with sufficient opportunities to engage in authentic learning experiences, including practical laboratory work, scientific investigations, reflective discussions on socio-scientific issues and scientific reasoning, so as to develop conceptual understanding and scientific inquiry skills.

For learning and teaching materials designed with the assistance of GenAI, teachers should clearly indicate the AI-generated components and avoid practices that may compromise academic integrity. Teachers should verify the authenticity, accuracy and consistency of AI-generated content before use. Where AI tools are used to support assessment or feedback, teachers should conduct manual review and moderation to ensure assessment quality and uphold academic integrity.

Teachers should also foster students' awareness of the ethical and responsible use of AI, including an understanding of its limitations and potential inaccuracies. Students should be guided to evaluate AI-generated outputs critically, verify information using authoritative sources, and use AI as an assistive tool rather than a substitute for scientific reasoning.

The Use of AI in Physics Lesson Setting

When planning Physics lessons, teachers should clearly define the learning objectives and consider how AI can be used to support students' engagement in scientific practices aligned with those objectives, such as applying physics concepts to novel problems, analysing and interpreting experimental data, and constructing explanations and evaluations.

When planning Physics lessons involving the use of AI, teachers should consider:

- the intended learning objectives and expected learning outcomes;
- how AI can support, rather than replace, students' conceptual understanding and inquiry;
- the provision of appropriate scaffolding and guidance for students' use of AI tools;
- learning strategies to consolidate understanding and promote knowledge transfer; and
- the balance between digital learning experiences and other teacher-guided learning activities, including practical laboratory work, scientific investigations, reflective discussion on socio-scientific issues and scientific reasoning.

Example of Using Digital Educational Tools and AI in Classroom Design

AI tools can assist in visualising the abstract microscopic world of Physics. With well-designed learning and teaching activities, teachers can create opportunities for students to link macroscopic properties with the interactions between molecules at the sub-microscopic level through active, interactive and constructive learning. When designing AI-assisted activities, teachers should focus on helping students apply relevant prior knowledge and transfer their acquired understanding to novel problems, while critically evaluating AI-generated content.

Topic: Thermal Physics: Kinetic Theory

Learning outcomes:

- realise the random motion of molecules in a gas
- realise gas pressure resulted from molecular bombardment on container wall
- relate macroscopic quantity temperature with microscopic quantity average kinetic energy
- interpret the change of temperature from the Maxwell-Boltzmann distribution

Learning activities	The Use of Digital Educational Tools / AI
1. Teachers first teach the fundamental knowledge of kinetic theory (e.g. gas molecules are performing ever random motions, and pressure arises from collisions of gas molecules with the container walls). Teachers then ask students to predict and sketch how gas molecules move and collide inside a sealed container based on their understanding of kinetic theory, and to select the parameters of gas molecules that being investigated (e.g. velocity, quantity, kinetic energy).	No AI
2. Teachers guide students to use vibe coding with the aid of generative-AI tools to create an interactive simulation to visualise the parameters of gas molecules (e.g. velocity, kinetic energy).	Using GenAI to create simulation
3. Students are guided to observe and test the generated simulation. Students may discuss with peers and use their knowledge of kinetic theory to evaluate whether it can simulate realistic physical phenomena and modify the simulation.	No AI
4. Students evaluate the molecular motions depicted in the AI-generated simulation using the appropriate physical laws and principles, and thus identifying and explaining any mistakes made in the simulation. After peer discussion, students can revise their generated simulations, and compare the original misconceptions with the corrected version.	Using GenAI to modify the simulation

Connections across Senior Secondary Science Subjects

In the course of the learning and teaching of Biology (S4-6), Chemistry (S4-6) and Physics (S4-6) curricula, students will encounter scientific inquiry skills, subject contents and mathematical skills that are interconnected across science subjects. These shared learning elements are important components that constitute the nurturing of students' scientific literacy. Specifically, although these science curricula are offered as distinct elective subjects at the senior secondary level, they are underpinned by shared scientific principles and modes of inquiry in science. Students taking two or three science electives therefore experience reinforcement in science learning, as concepts and skills developed in one subject often deepen and extend student's understanding in another.

To enhance the coherence and depth of learning across Biology, Chemistry and Physics , this section highlights explicitly the common scientific inquiry skills, interrelated subject contents and mathematical skills articulated in the respective curricula. By recognising these shared elements, teachers can adopt a more integrated approach to science teaching, not only reinforcing the shared scientific skills, but also developing students' understanding of science when students are engaged in the process and practice of science. In particular, Physics teachers should not focus solely on subject-specific knowledge within the physics discipline, but should also consciously cultivate the shared scientific competences common to all science subjects. This shared emphasis supports progression from Science (S1-3) curriculum, strengthens coherence within the Science Education KLA, and equips students with the competencies required for evidence-based inquiry, critical evaluation of data, and informed decision-making in scientific and real-life contexts.

Common scientific inquiry skills across Biology (S4-6), Chemistry (S4-6) and Physics (S4-6) curricula

Experimenting, data processing and scientific reasoning skills are fundamental to Biology, Chemistry and Physics at the senior secondary level. Together, they form the foundation of scientific inquiry as emphasised in the Science Education Key Learning Area. These skills are progressively developed through Science (S1-3) curriculum and enable students to generate reliable empirical evidence, analyse data quantitatively and qualitatively, evaluate experimental limitations, and draw valid and evidence-based conclusions.

Through the practical tasks recommended in the respective Curriculum and Assessment Guides for the senior secondary science curricula, students experience the evidence-driven and systematic nature of scientific investigation. The shared emphasis on scientific inquiry not only strengthens the learning of valued competences among the three science disciplines but also reinforces transferable skills such as critical thinking, problem-solving, and collaboration, while cultivating positive values and attitudes including integrity in data handling, commitment to safety and awareness of ethical considerations in scientific practice.

1. Experimenting skills

By conducting the key practical tasks set out in the respective Curriculum and Assessment Guides, ranging from structured practical work and inquiry to more open-ended investigative studies, students actively engage in the essential processes of scientific inquiry in a systematic and reflective manner, including observation, hypothesis formulation, experimental design, data collection, data interpretation, and conclusion drawing. Engaging in practical activities across Biology, Chemistry, and Physics enables students to both deepen subject-specific understanding and appreciate the common principles underlying scientific practice across disciplines, such as the tentative yet evidence-based nature of scientific knowledge, the importance of validity and reliability, and the role of creativity and perseverance in advancing understanding.

The following **experimenting skills** are commonly articulated across the three subjects, with clear progression from the junior secondary level:

E1 Planning and designing investigations
E2 Risk assessment and safe laboratory practices
E3 Selecting and handling apparatus and materials
E4 Controlling variables and ensuring reliability
E5 Accurate and precise measurement and observation
E6 Data collection and recording
E7 Evaluation and improvement of experiments

E1 Planning and designing investigations

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Formulate testable hypotheses or research questions based on observations or relevant prior scientific knowledge • Identify questions to study and make predictions • Select appropriate methods and justify experimental approaches • Identify independent, dependent, and control variables • Design logical and feasible procedures to address the research question • Plan and write experimental procedures	✓ Formulating a hypothesis based on observed phenomena ✓ Identifying independent variables, dependent variables and control variables ✓ Choosing from alternative experimental methods or improving the method for a scientific investigation

E2 Risk assessment and safe laboratory practices

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Carry out risk assessments for experiments / scientific investigations • Implement appropriate safety measures (e.g. use of personal protective equipment, proper handling of chemicals, high-voltage electrical equipment, or biological specimens) • Demonstrate responsible laboratory practice, including proper waste disposal, adherence to safety rules (e.g. always attending a heat source), and appropriate emergency procedures • Conduct investigations safely to collect valid and reliable data	✓ Using apparatus appropriately and safely

E3 Selecting and handling apparatus and materials

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Select apparatus and materials appropriate to the required precision, scale, and nature of the investigation • Use instruments and materials properly and competently • Handle materials efficiently to minimise waste and ensure experimental feasibility	✓ Using apparatus appropriately and safety

E4 Controlling variables and ensuring reliability

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Design controlled experiments to investigate relationships (correlational or causal) between variables • Identify potential confounding factors and minimise their effect • Use repeated trials and averaging measurements to reduce the effect of random errors • Assess reliability and suggest improvements to enhance experimental design	✓ Setting up a controlled experiment to identify causal relationships ✓ Identifying independent variables, dependent variables and control variables

E5 Accurate and precise measurement and observation

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Use measuring instruments correctly and read scales to appropriate precision • Distinguish between accuracy and precision • Make careful qualitative observations (e.g. colour change, precipitate formation, behavioural response, unexpected phenomena) • Comment on accuracy and precision in scientific measurements	✓ Making qualitative observations and recording quantitative measurements ✓ Commenting accuracy and precision in a scientific measurement

E6 Data collection and recording

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Collect sufficient and relevant data to address the research question • Record measurements with appropriate units and significant figures • Record raw data systematically in tables or structured formats • Perform initial data processing where appropriate (e.g. averaging or unit conversions) • Present data clearly to facilitate further analysis	✓ Making qualitative observations and recording quantitative measurements ✓ Using tables and graphs for organising and presenting data

E7 Evaluation and improvement of experiments

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Evaluate the feasibility, validity and reliability of experiments • Suggest ways to improve the feasibility, validity, and/or reliability of experiments • Identify limitations and sources of error in experiments • Propose refinements or alternative approaches for future studies	✓ Choosing from alternative experimental methods or improving the method for a scientific investigation

2. Data processing skills

After collecting data from experiments, students are required to process and analyse the data in order to draw valid conclusions to support or refute the set hypothesis. The fundamental knowledge and skills are developed in the Science (S1-3) curriculum. At the senior secondary level, these skills are further strengthened and applied with greater mathematical rigour and conceptual depth across Biology, Chemistry and Physics.

The following **data processing skills** are commonly articulated across the three science subjects, with clear progression from the junior secondary level:

D1 Use of SI unit, prefixes and derivation of units
D2 Significant figures and treatment of measurement errors
D3 Graphical presentation of relationships and functions
D4 Data analysis and interpretation

D1 Use of SI unit, prefixes and derivation of units

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Use SI units appropriately when expressing physical, chemical and biological quantities • Perform unit conversions accurately, including the use of prefixes and scientific notation • Derive and interpret compound units from base SI units where appropriate • Represent quantities with appropriate order of magnitude	✓ Using scientific notation, significant figures and ratio for expressing and comparing scientific data

D2 Significant figures and treatment of measurement errors

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Record measurements with appropriate precision according to the measuring instrument used • Express calculated results using an appropriate number of significant figures • Distinguish between accuracy and precision • Reduce the effect of random errors through repeated measurements and averaging • Identify anomalous results and evaluate their impact on reliability	✓ Using scientific notation, significant figures and ratio for expressing and comparing scientific data

D3 Graphical presentation of relationships and functions

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Select appropriate variables for the x- and y-axes based on the nature of the independent and dependent variables • Choose suitable scales and units, axis labels, and graph titles for clear and accurate graphical representation • Plot data accurately (by hand and/or using digital tools) to construct appropriate line graphs or scatter graphs, or other suitable graph types • Recognise and represent common mathematical relationships graphically	✓ Using tables and graphs for data analysis

D4 Data analysis and interpretation

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Perform data analyses to identify patterns, trends or relationships in the collected data • Draw appropriate best-fit lines or curves from graphical data, and use them to interpret trends, interpolate/extrapolate values or determine slopes/intercepts • Interpret graphical representations to identify patterns, relationships, anomalies, or limitations in the data • Relate graphical and numerical results to underlying scientific principles • Evaluate limitations of data and suggest improvements	✓ Using tables and graphs for data analysis ✓ Identifying outliers and handling data from repeated measurements to assess the uncertainty incurred

3. Scientific Reasoning skills

Scientific reasoning skills involve deductive, inductive and abductive reasoning as foundational processes, these are applied in the use, evaluation, and revision of scientific models and argumentations. Through such reasoning, students interpret empirical evidence, construct coherent scientific explanations, and critically evaluate claims and models. Progressively developed from the Science (S1-3) curriculum, these higher-order cognitive skills are central to scientific literacy as articulated in the Science Education Key Learning Area. In senior secondary Biology, Chemistry, and Physics, students apply scientific reasoning when analysing experimental data, evaluating the validity of conclusions, applying concepts to novel situations, and examining Science, Technology, Society and the Environment-related issues using evidence-based judgement.

The following **scientific reasoning skills** are commonly articulated across the three subjects, with clear progression from the junior secondary level:

R1 Scientific reasoning: deduction, induction and abduction
R2 Application of reasoning: scientific modelling and argumentation

R1 Scientific reasoning: deduction, induction and abduction

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Draw logical inferences from observations, experimental data or scientific information • Examine evidence and apply logical reasoning to draw valid conclusions • Make informed judgements when outcomes involve uncertainty or probability • Use inductive reasoning to generalise from specific observations or data to broader trends, patterns, conclusions or models • Apply deductive reasoning to predict specific outcomes from a set of general observations or data and established laws, principles, theories, models, or established trends • Apply abductive reasoning to infer the most plausible explanation consistent with available evidence when multiple interpretations are	✓ Using specific data to induce a general trend, conclusion or model ✓ Using a set of general observations, trend or model to deduce a specific result ✓ Making inference to the best possible explanation to the observed phenomenon ✓ Making informed decision based on the probability of phenomenon to be occurred

possible • Recognise the appropriate contexts, strengths, and limitations of inductive, deductive and abductive reasoning in scientific inquiry	

R2 Application of reasoning: scientific modelling and argumentation

Students studying Biology, Chemistry or Physics should be able to	Articulation with Science (S1-3) curriculum
• Apply appropriate scientific models to explain phenomena, interpret data, and predict outcomes in familiar and novel contexts • Evaluate the strengths, limitations, assumptions, and tentative nature of scientific models • Construct and present reasoned scientific arguments supported by empirical evidence, logical reasoning, and relevant scientific principles • Engage in scientific argumentation as a systematic process to analyse, explain, critique, or defend explanations of natural phenomena • Integrate new concepts or evidence into existing knowledge frameworks and apply them critically to new situations • Appreciate the evolutionary nature of scientific knowledge, where models and explanations are subject to revision based on accumulating evidence	✓ Using specific data to induce a general trend, conclusion or model ✓ Using a set of general observations, trend or model to deduce a specific result ✓ Making inference to the best possible explanation to the observed phenomenon ✓ Making informed decision based on the probability of phenomenon to be occurred

Related subject contents across Biology (S4-6), Chemistry (S4-6) and Physics (S4-6) curricula

Biology, Chemistry, and Physics are offered as distinct elective subjects at the senior secondary level. Nevertheless, they share many fundamental concepts and principles. Students who concurrently study two or three science subjects gain significant advantages in developing a more comprehensive and interconnected understanding of the unified nature of science. By exploring the common fundamental concepts, such as matter, energy and interactions governing the physical world from subatomic to universe scales, through different disciplinary perspectives, students reinforce and deepen their mastery across subjects, enabling them to apply knowledge flexibly in novel or real-life contexts. For example, understanding conservation of energy in Physics strengthens interpretation of enthalpy changes in Chemistry and energy flow in biological ecosystems, fostering more sophisticated and transferable conceptual understanding.

Furthermore, studying multiple science subjects promotes fluency in shared language and conventions. Students become more proficient in precise scientific terminology (e.g. mole, potential difference, activation energy), symbolic representations (e.g. equations, graphs, structural formulae), and quantitative tools (e.g. significant figures, unit conversions, error estimation). This shared use of scientific language, notation, and representational practices reduces barriers between subjects, enhances communication of science ideas, and strengthens students' overall scientific literacy.

Making these cross-disciplinary connections explicit enables students to develop a more integrated and coherent understanding of scientific phenomena. More specifically, students taking two or three science electives will recognise that concepts encountered in one science subject often provide explanatory frameworks for understanding phenomena in another, thereby deepening conceptual understanding and promoting the application of knowledge across contexts.

The following table provides examples of related contents of Biology, Chemistry and Physics curricula, illustrating how core ideas, such as energy transformations, the structure of matter, particle interactions, radiation, and the relationship between structure and function, are developed and applied in different disciplinary contexts.

Examples of related subject contents of Biology, Chemistry and Physics:

Physics	**Chemistry**	**Biology**
Temperature, heat and internal energy; Change of state; Law of conservation of energy in a closed system	Enthalpy changes in chemical reaction	Energy flow in ecosystems; energy transformations in cellular respiration and photosynthesis; Regulation of body temperature
Gas laws	Mole concept; Avogadro's Law; Molar volume	Gas exchange in humans and plants
Kinetic theory	Rate of reaction	Factors affecting rate of enzymatic reactions; Diffusion and osmosis across cell membranes
EM spectrum; Intensity	IR spectroscopy; Colorimetry	Effects of light intensity on photosynthesis; Light absorption in photosynthetic pigments
Electric circuit	Chemical cells; Electrolysis	Nerve impulse transmission
Electrostatics; Scalars and vectors	Bond polarity; Intermolecular forces	Enzyme-substrate binding; water properties
Atomic model; Radioactive decay; Isotopes	Atomic structure; Subatomic particles; Isotopes	Structure and chemical bonding in biomolecules (e.g. DNA nucleotides, proteins)
Energy sources	Fossil fuels and carbon compounds	Use of resources in ecosystems

Mathematical skills across Biology (S4-6), Chemistry (S4-6) and Physics (S4-6) curricula

A strong foundation in mathematics is essential for the study of Biology, Chemistry, and Physics at senior secondary level, as many mathematical skills are shared or closely related across the three disciplines. These include algebraic manipulation and formula application, data handling and graphical analysis, as well as application of geometry and trigonometry. Examples of related mathematical skills of Biology, Chemistry and Physics are tabulated below for reference:

Mathematical skills	Contexts in Science Subjects (Examples)
Manipulation of equations and functions	Biology • Apply equations related to microscopy (e.g. magnification = image size / actual size). Chemistry • Solve algebraic equations (e.g. rate = k[reactant1]^x[reactant2]^y) • Perform calculations involving logarithms (e.g. pH = -log[H^+], Arrhenius equation) Physics • Derive and apply equations to solve problems for topics such as mechanics, electricity and magnetism, and quantum physics
Handling data and use of units	Biology • Convert between metric units (e.g. millimeters to micrometers) when calculating the sizes of sub-cellular structures • Apply appropriate measurement units when quantifying environmental conditions Chemistry • Express physical quantities (e.g. molecular mass, concentration) using appropriate units and how they can be inter-converted • Calculate a mean titre Physics • Perform dimensional analysis by converting and matching SI units • Apply the concept of order of magnitude and significant figures in experimental measurements
Use and interconversions of ratios, fractions and percentages	Biology • Calculate percentages to determine the efficiency of energy transfer between trophic levels Chemistry

	• Determine empirical formulae and molecular formulae from compositions by mass and molar masses Physics • Find the efficiency of transformer, electrical appliance and machines
Constructing and interpreting graphs	Biology • Plot graphs to determine physical properties of biological tissues • Interpret curves to deduce physiological changes over time or distance Chemistry • Determine the activation energy of a chemical reaction • Calculate enthalpy changes from experimental results Physics • Plot and analyse graphs for physical laws • Interpret the physical meaning of slope, intercepts and area under graph
Application of geometry and trigonometry	Biology • Understand three-dimensional structures of biomolecules Chemistry • Predict and draw three-dimensional diagrams to represent molecular shapes Physics • Apply addition of vector to find resultant vector and resolve a vector into components (e.g. acceleration, force) • Apply dot product and cross product in mechanics (e.g. work done) and electricity and magnetism (e.g. magnetic force)

Students who study two or three science subjects benefit significantly as they can reinforce these common mathematical skills, leading to deeper conceptual understanding and greater fluency in applying mathematics to solve scientific problems. This advantage is further amplified when students also take Mathematics Extended Part (Module 1 or 2) alongside the science subjects, as the study of extended mathematics enables them to engage with more advanced science topics at a deeper level. For example, knowledge of calculus from Module 1 or 2 equips students with a stronger grasp of concepts such as rate of change and the relationship between the area under a curve and physical quantities in the kinematics topic in Physics. Such synergy not only supports but also extends learning across all three subjects.

Summary of proposed updates in contents of the Physics curriculum

Direction of Update	Suggested Revision on the Curriculum Content	Rationale
Revisions to the Structure and Content of the Curriculum:		
Refinement of vertical articulation with junior secondary Science	• Removed "Geometrical Optics" from "Waves" and "Heat Transfer Processes" from "Heat and Gases", relevant learning contents have been incorporated into the updated Science (S1-3) Curriculum Units: Unit 12 "Light and Sound" and Unit 7 "Matter and Energy" respectively.	• Streamlined physics-related learning elements in the Science (S1-3) Curriculum to enhance the interface between junior and senior secondary learning stages
Integration of Compulsory and Elective Parts	• Elements from "Astronomy and Space Science" including structure of the universe, stellar luminosity, and the Doppler effect are incorporated into "Astrophysics and Relativity"; Orbital motion under gravity is incorporated into "Physics and Engineering" • Elements from "Atomic World" including Rutherford's atomic model, the photoelectric effect, Bohr's model of the hydrogen atom, and particles or waves are incorporated into "Quantum Physics" • Elements from "Energy and Use of Energy" including renewable and non-renewable energy sources, and the environmental impact of energy consumption are incorporated into "Physics and Society" • Elements from "Medical Physics" including ultrasonic range-measurement and medical imaging applications of radioisotopes are incorporated into "Waves" and "Physics and Society" respectively	• Integrate the Compulsory and Elective parts to provide students with a more solid foundation in modern physics knowledge

Direction of Update	Suggested Revision on the Curriculum Content	Rationale
Adjustment of selected content and re-organisation of the sequence of topics and sub-topics	Deletion of the following sub-topics/learning outcomes: • Heat and Gases - Thermometers - Transfer processes - Microscopic and macroscopic relationship for ideal gases $PV=\frac{1}{3}\ Nmc^2$ - Real gases • Wave Motion - present information of longitudinal waves on displacement-time and displacement-distance graphs for travelling waves - Geometrical optics, including ray diagrams for reflection, refraction, and total internal reflection of light, formation of image by lenses, and the lens formula - Noise • Electricity and Magnetism - Variation of current with applied potential difference for different materials, effect of temperature on the resistance of metals and semiconductors - Effect of resistance of ammeters and voltmeters on measurements - Root-mean-square value of alternating current • Radioactivity and Nuclear Energy - Exponential law of decay	• Create space for integrating compulsory and elective parts

Direction of Update	Suggested Revision on the Curriculum Content	Rationale
	- Transmutation • Astronomy and Space Science - Astronomy through history, including heliocentric and geocentric models, Galileo's astronomical discoveries, describe planetary motion using Kepler's laws - Kepler's third law for orbital motions under gravity - Stellar magnitudes, apparent and absolute magnitude, major spectral classes OBAFGKM, and using radial velocity curves to determine orbital radius, speed and period • Atomic World - Postulates of Bohr's model of hydrogen atom, including quantisation of angular momentum of an electron around a hydrogen nucleus - Probing into nano scale, including physical properties of materials in nano scale, working principle of transmission electron microscopes, and recent developments in nanotechnology • Energy and use of energy - Electricity at home, including energy consuming appliances at home, lighting, cooking without fire, moving heat around and Energy Efficiency Labelling Scheme - Energy efficiency in building and transportation, including building materials used to improve the energy efficiency and electric vehicles • Medical Physics - Making sense of the eye and the ear	

Direction of Update	Suggested Revision on the Curriculum Content	Rationale
	- Medical imaging using non-ionizing radiation - Medical imaging using ionizing radiation	
	Reorganisation of the sequence of topics and sub-topics: • Classical Physics is reorganised as "Mechanics", "Thermal Physics", "Waves", and "Electricity and Magnetism", aligning with the historical development of physics • Domestic electricity, electromagnetic induction, alternating currents, transformer and high voltage transmission of electrical energy are incorporated into "Physics and Engineering" • Concepts related to intensity from "Astronomy and Space Science", "Atomic World", and "Energy and Use of Energy " are integrated and incorporated into "Waves"	• Learning content is aligned with the historical development of physics to reinforce the nature of science • Incorporation of electricity and magnetism, and aerospace applications into "Physics and Engineering" highlights the application of physics in daily life • Facilitating a progressive approach to learning and applying the concept of intensity and related calculations across different topics
	Adjustments to learning outcomes of topics and sub-topics: • "Thermal Physics": Maxwell-Boltzmann distribution • "Electricity and Magnetism": Kirchhoff's laws • "Physics and Engineering": Applications of sensors • "Physics and Society": Sustainable development and carbon neutrality, physics-related careers, physics and innovation and technology • "Astrophysics and Relativity": Astronomical observations	• Making existing learning objectives and outcomes more clear • Aligning with recent developments in science and technology • Incorporating learning outcomes based on prior knowledge to strengthen student understanding and consolidate learning

Direction of Update	Suggested Revision on the Curriculum Content	Rationale
	Enrichment of the following sub-topics/learning outcomes: • Kinematics of simple harmonic motion - Variation of displacement, velocity, and acceleration with time - Forced oscillation, damping, and resonance • Polarisation of light as an evidence for light as transverse • Aircraft in fluid - derive continuity equation and solve related problems - recognise the role of Bernoulli's principle and Coanda effect in generating lifting force for aircraft - apply the Bernoulli's equation to solve problems related to aircraft, including pitot tube • Quantum Physics - probabilistic nature of quantum particles - Quantum superposition - Heisenberg's uncertainty principle • Relativity - Frames of reference - Principle of invariant light speed - Time dilation and length contraction - Spacetime diagram	• Aligning with the national 15th Five-Year Plan, including aerospace technology, quantum technology, etc. • Aligning with recent developments in science and technology • Benchmarking against high school physics curricula and examinations of major economies worldwide

Direction of Update	Suggested Revision on the Curriculum Content	Rationale
Strengthening scientific inquiry skills	• A new topic, "Scientific Inquiry in Physics", is introduced to replace the existing "Investigative Study". This topic specifies the key learning elements of scientific inquiry and engineering design, from which teachers can select and integrate into practical activities across different topics. Key practical tasks for each topic are also included in the suggested learning and teaching activities and computational physics activities for teachers' reference	• Providing students with ample learning experiences in scientific inquiry and strengthening their scientific inquiry abilities

Membership of the Working Group on the Review of the Physics Curriculum and Assessment

(From November 2023 to February 2025)

Chairperson:	Prof YEUNG Chi-ho
Members:	Mr CHOI Wai-kit
	Mr CHUNG Sai-chak
	Mr HONG Chun-yin
	Dr JIM Kwok-lung, Michael
	Mr KONG Maverick Chapman
	Dr LEUNG Po-kin
	Ms LIN Chi-wan
	Mr PANG King-fai
	Mr TAM Kai-hang
	Mr TSANG Shi-hon
	Mr TSUI Kin-chung
	Mr WAN Kwok-tung
	Mr WONG Wai-keung
Ex-officio Members:	Mr LEUNG Yat-yin, Leon (EDB)
	Mr SZETO Yuk-tong (HKEAA)
Secretary:	Mr LO Kam-hung, Leo (EDB)

Membership of the CDC-HKEAA Committee on Physics

(From September 2023 to August 2025)

Chairperson:	Prof LAW Kam-tuen
Members:	Dr CHOI Tat-shing
	Dr JIM Kwok-lung, Michael
	Mr KONG Maverick Chapman
	Mr LEE Cheuk-wa
	Dr LEUNG Kin-yi (until Apr 2024)
	Dr LEUNG Po-kin (from May 2024)
	Prof LING Chi-chung
	Mr PANG King-fai
	Mr TSANG Shi-hon
	Mr TSUI Kin-chung
	Mr WAN Kwok-tung
	Mr WONG Wai-keung
Ex-officio Members:	Dr LAM Wai-lim William (EDB) (until June 2025)
	Mr LO Kam-hung, Leo (EDB) (from July 2025)
	Mr SZETO Yuk-tong (HKEAA) (until Feb 2025)
	Mr LING Chi-yeung (HKEAA) (from Mar 2025)
Secretary:	Mr LO Kam-hung, Leo (until June 2025)
	Mr LEUNG Yat-yin, Leon (from July 2025)

Membership of the CDC-HKEAA Committee on Physics

(From September 2025 to August 2027)

Chairperson:	Prof LAW Kam-tuen
Members:	Mr CHEUNG Fung
	Dr CHOI Tat-shing
	Dr CHOY Siu-hong
	Ms CHUN Tsz-ching Jorcylene
	Mr KONG Maverick Chapman
	Mr LEE Cheuk-wa
	Dr LEUNG Po-kin
	Prof LING Chi-chung
	Mr NG Ki-fung
	Mr NG Kwok-fung
	Mr TSANG Shi-hon
Ex-officio Members:	Mr LO Kam-hung, Leo (EDB)
	Mr LING Chi-yeung (HKEAA)
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