



KEMENTERIAN
PENDIDIKAN
MALAYSIA

KURIKULUM STANDARD SEKOLAH MENENGAH

Fizik

Dokumen Standard Kurikulum dan Pentaksiran

Tingkatan 4 dan 5
(EDISI BAHASA INGGERIS)



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Bahagian Pembangunan Kurikulum
MEI 2019

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rukun Negara

BAHAWASANYA Negara kita Malaysia mendukung cita-cita hendak:
Mencapai perpaduan yang lebih erat dalam kalangan seluruh masyarakatnya;
Memelihara satu cara hidup demokratik;
Mencipta satu masyarakat yang adil di mana kemakmuran negara akan dapat dinikmati bersama secara adil dan saksama;
Menjamin satu cara yang liberal terhadap tradisi-tradisi kebudayaannya yang kaya dan berbagai corak;
Membina satu masyarakat progresif yang akan menggunakan sains dan teknologi moden;

MAKA KAMI, rakyat Malaysia, berikrar akan menumpukan seluruh tenaga dan usaha kami untuk mencapai cita-cita tersebut berdasarkan atas prinsip-prinsip yang berikut:

**KEPERCAYAAN KEPADA TUHAN
KESETIAAN KEPADA RAJA DAN NEGARA
KELUHURAN PERLEMBAGAAN
KEDAULATAN UNDANG-UNDANG
KESOPANAN DAN KESUSILAAN**

FALSAFAH PENDIDIKAN KEBANGSAAN

“Pendidikan di Malaysia adalah suatu usaha berterusan ke arah lebih memperkembangkan potensi individu secara menyeluruh dan bersepadu untuk melahirkan insan yang seimbang dan harmonis dari segi intelek, rohani, emosi dan jasmani, berdasarkan kepercayaan dan kepatuhan kepada Tuhan. Usaha ini adalah bertujuan untuk melahirkan warganegara Malaysia yang berilmu pengetahuan, berketerampilan, berakhlak mulia, bertanggungjawab dan berkeupayaan mencapai kesejahteraan diri serta memberikan sumbangan terhadap keharmonian dan kemakmuran keluarga, masyarakat dan negara”

Sumber: Akta Pendidikan 1996 (Akta 550)

DEFINISI KURIKULUM KEBANGSAAN

3. Kurikulum Kebangsaan

(1) Kurikulum Kebangsaan ialah suatu program pendidikan yang termasuk kurikulum dan kegiatan kokurikulum yang merangkumi semua pengetahuan, kemahiran, norma, nilai, unsur kebudayaan dan kepercayaan untuk membantu perkembangan seseorang murid dengan sepenuhnya dari segi jasmani, rohani, mental dan emosi serta untuk menanam dan mempertingkatkan nilai moral yang diingini dan untuk menyampaikan pengetahuan.

Sumber: Peraturan-Peraturan Pendidikan (Kurikulum Kebangsaan) 1997

[PU(A)531/97.]

FALSAFAH PENDIDIKAN SAINS KEBANGSAAN

Selaras dengan Falsafah Pendidikan Kebangsaan, pendidikan sains di Malaysia memupuk budaya Sains dan Teknologi dengan memberi tumpuan kepada perkembangan individu yang kompetitif, dinamik, tangkas dan berdaya tahan serta dapat menguasai ilmu sains dan keterampilan teknologi.

Sumber: Kementerian Sains, Teknologi dan Inovasi (MOSTI)

KATA PENGANTAR

Kurikulum Standard Sekolah Menengah (KSSM) yang dilaksanakan secara berperingkat mulai tahun 2017 akan menggantikan Kurikulum Bersepadu Sekolah Menengah (KBSM) yang mula dilaksanakan pada tahun 1989. KSSM digubal bagi memenuhi keperluan dasar baharu di bawah Pelan Pembangunan Pendidikan Malaysia (PPPM) 2013-2025 agar kualiti kurikulum yang dilaksanakan di sekolah menengah setanding dengan standard antarabangsa. Kurikulum berasaskan standard yang menjadi amalan antarabangsa telah dijelmakan dalam KSSM menerusi penggubalan Dokumen Standard Kurikulum dan Pentaksiran (DSKP) untuk semua mata pelajaran yang terdiri daripada Standard Kandungan, Standard Pembelajaran dan Standard Prestasi.

Usaha memasukkan standard pentaksiran di dalam dokumen kurikulum telah mengubah lanskap sejarah sejak Kurikulum Kebangsaan dilaksanakan di bawah Sistem Pendidikan Kebangsaan. Menerusinya murid dapat ditaksir secara berterusan untuk mengenal pasti tahap penguasaan mereka dalam sesuatu mata pelajaran, serta membolehkan guru membuat tindakan susulan bagi mempertingkatkan pencapaian murid.

DSKP yang dihasilkan juga telah menyepadukan enam tunjang Kerangka KSSM, mengintegrasikan pengetahuan, kemahiran dan nilai, serta memasukkan secara eksplisit Kemahiran Abad Ke-21 dan Kemahiran Berfikir Aras Tinggi (KBAT). Penyepaduan tersebut dilakukan untuk melahirkan insan seimbang dan harmonis dari segi intelek, rohani, emosi dan jasmani sebagaimana tuntutan Falsafah Pendidikan Kebangsaan.

Bagi menjayakan pelaksanaan KSSM, pengajaran dan pembelajaran guru perlu memberi penekanan kepada KBAT dengan memberi fokus kepada pendekatan Pembelajaran Berasaskan Inkuiri dan Pembelajaran Berasaskan Projek, supaya murid dapat menguasai kemahiran yang diperlukan dalam abad ke-21.

Kementerian Pendidikan Malaysia merakamkan setinggi-tinggi penghargaan dan ucapan terima kasih kepada semua pihak yang terlibat dalam penggubalan KSSM. Semoga pelaksanaan KSSM akan mencapai hasrat dan matlamat Sistem Pendidikan Kebangsaan.

Dr. MOHAMED BIN ABU BAKAR
Pengarah
Bahagian Pembangunan Kurikulum
Kementerian Pendidikan Malaysia

INTRODUCTION

As articulated in the National Education Philosophy, education in Malaysia is an on-going effort towards nurturing the potential of individuals in a holistic and integrated manner, to develop individuals who are intellectually, spiritually, emotionally and physically balanced. The primary and secondary school curriculum standard and assessment for sciences are developed with the aim of fostering such individuals.

Moving towards a developed nation, Malaysia should create a scientific, progressive, inventive and visionary community as well as benefiting the latest technologies. This community must be able to contribute to the advancement of science and the sustainability of technological civilisation. To achieve this, we need to develop critical, creative, innovative and competent citizens who practice the culture of Science, Technology, Engineering and Mathematics (STEM).

The national science curriculum encompasses core science and elective science subjects. The core science subject is being offered in primary, lower secondary and upper secondary schools, while the elective sciences are being offered in upper secondary schools such as are Biology, Physics, Chemistry and Additional Science.

Secondary core science subject is designed to develop science literacy and high order thinking skills as well as the ability to apply science knowledge, in decision-making and solving real-life problems among pupils.

Elective science subjects are aspired to sharpen and reinforce pupil's knowledge and skills in STEM. These subjects enable pupils to pursue high education with lifelong learning skills. These pupils are anticipated to pursue career in STEM and be able to actively participate in community development and nation-building.

Pupils taking KSSM Physics will have the knowledge and skills to enable them to solve problems and make decisions in everyday life related to Physics based on scientific attitudes and values. They will also be able to further their studies and undertake physics related career. KSSM Physics intends to develop individuals who are dynamic, viable, fair, practice STEM culture and responsible towards community and environment.

AIMS

KSSM Physics aims to develop science-literate pupils through learning experiences in understanding the physics related concepts, developing skills, using various strategies and applying the knowledge and skills based on scientific attitudes and values as well as understanding the impact of science and technological developments in society. These pupils can communicate, make decisions based on scientific evidences, and able to further their education and careers in the STEM field.

OBJECTIVES

The KSSM Physics enables pupils to achieve the following objectives:

1. Strengthen interest and passion for physics.
2. Reinforce and enrich scientific knowledge, skills, attitudes and values in physics through scientific investigation.
3. Enhance the ability to think logically, rationally, critically and creatively through processes of understanding and applying physics in decision-making and problems solving.
4. Acknowledge that the knowledge of physics is temporary and evolving.
5. Practise the usage of physics language and symbols and equip pupils with skills in delivering physics related ideas in the relevant context.
6. Develop mindset about chemical concepts, theories and laws, open-mindedness, objectiveness and proactiveness.
7. Realize social, economic, environmental and technological implications in physics and caring for the environment and society.
8. Appreciate physics and its application in helping to explain phenomena and solve real world problems.

KSSM FRAMEWORK

KSSM Physics is built based on six pillars, which are Communication; Spiritual, Attitude and Value; Humanity; Personal Development; Chemistry Development and Aesthetic; and Science and Technology. The six pillars are the main domain that support each other and are integrated with critical, creative and innovative thinking.

This integration aimed at developing human capital who is knowledgeable, competent, creative, critical, innovative and embraces noble values based on religion as illustrated in Figure 1.

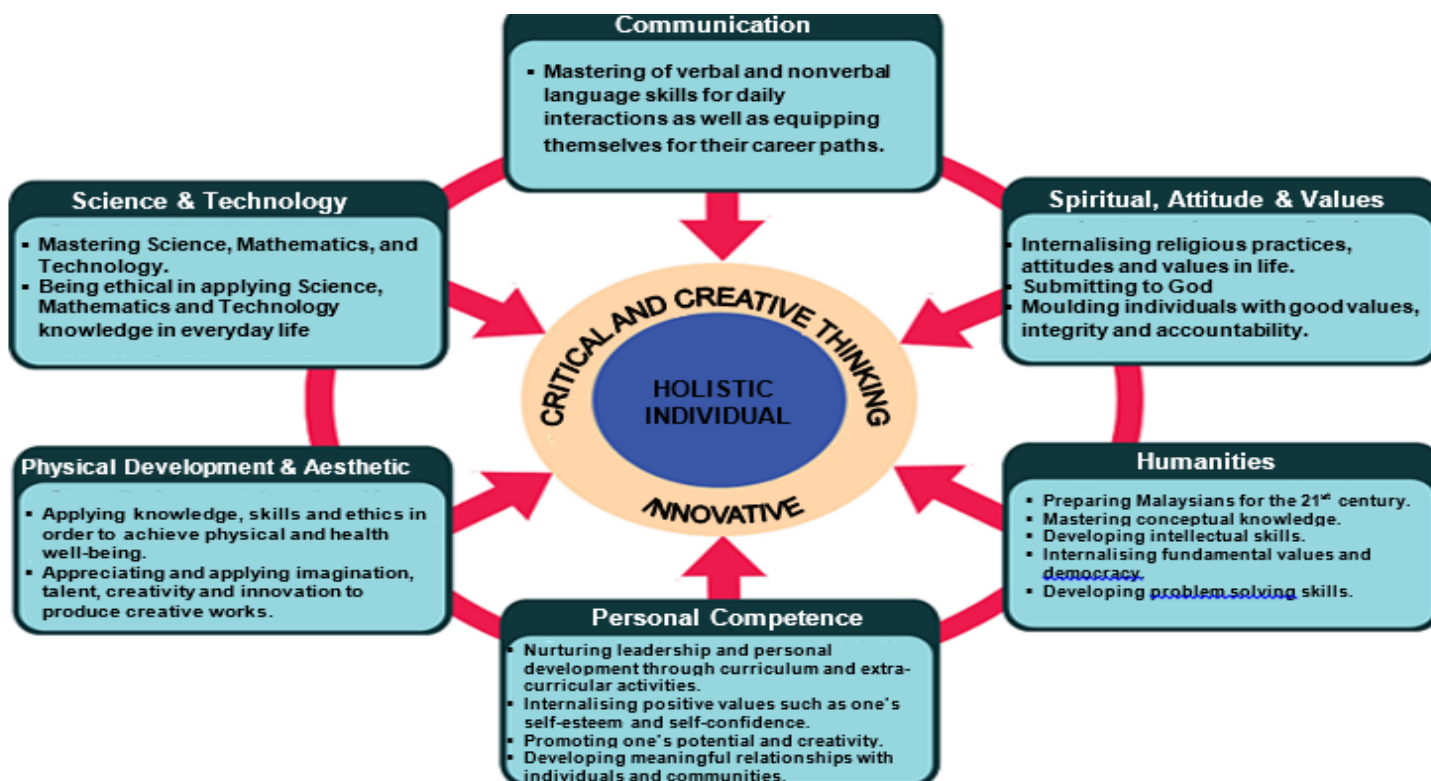


Figure 1: KSSM Framework

FOCUS

KSSM Physics focuses on thoughtful learning based on the three domains, which are knowledge, skills and values. The development of these domains will be experienced by pupils through inquiry method in order to nurture thoughtful science individual (Figure 2). The inquiry approach includes pupil-centred learning, constructivism, contextual learning, problem-based learning, mastery learning as well as related strategies and methods.

The curriculum also aims to prepare pupils to face rapid technological development and various challenges of the 21st century like The Industrial Revolution 4.0. The group of pupils that have gone through this curriculum will be the STEM human resource who will be able to contribute towards national development.

Thoughtful Science

According to Kamus Dewan (4th Edition), 'fikrah' or in English language 'thoughtful' means the ability to think and reflect. In the context of science curriculum, thoughtful science refers to the quality desired to be produced by the National Science Education System. Thoughtful science learners are those who can understand scientific ideas and are able to communicate in

scientific language; can evaluate and apply scientific knowledge and skills in science and technology contextually, responsibly and ethically. Thoughtful science also intends to produce creative and critical individuals that can communicate and collaborate to face the challenges of the 21st century demands, in which the country's progress is highly dependent upon the capacity and quality of its human resources.

Thoughtful Learning

Thoughtful learning is a process of acquiring and mastering skills and knowledge which can develop pupils mind to optimum level.

Thoughtful science can be achieved through thoughtful learning when pupils are actively engaged in the teaching and learning processes (T&L). In this process, the thoughtful learning activities designed by teachers are to dig the pupils' minds and encourage them to think, to conceptualize, solve problems and make wise decisions. Hence, thinking skills should be practised and cultured among pupils.

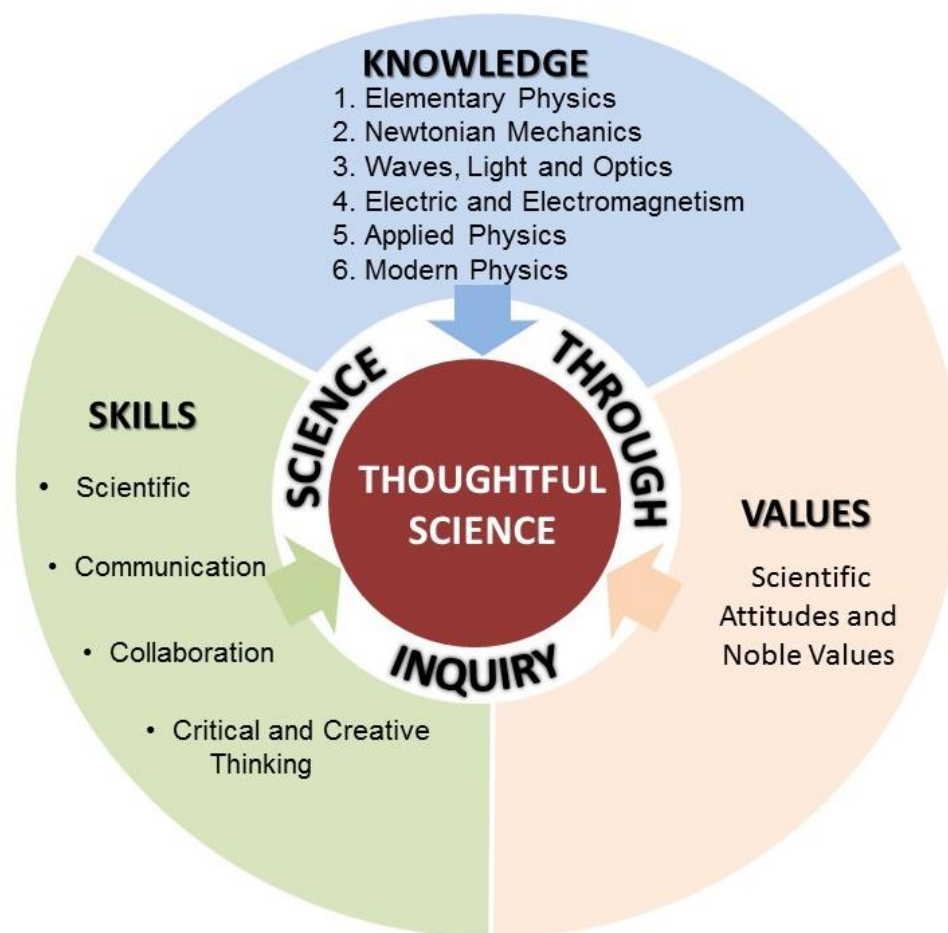


Figure 2: The Conceptual Framework for Physics Curriculum

Critical Thinking Skills

Critical thinking skills is the ability to evaluate an idea in a logical and rational manner to make reasonable judgement with justifications and reliable evidences.

A brief description of each critical thinking skills is as in Table 1:

Table 1: Critical Thinking Skills

CRITICAL THINKING SKILLS	DESCRIPTION
Attributing	Identifying characteristics, features, qualities and elements of a concept or an object.
Comparing and Contrasting	Finding similarities and differences based on criteria such as characteristics, features, qualities and elements of objects or events.
Grouping and Classifying	Separating and grouping objects or phenomena into groups based on certain criteria such as common characteristics or features.
Sequencing	Arranging objects and information in order based on the quality or quantity of common characteristics or features such as size, time, shape or number.

CRITICAL THINKING SKILLS	DESCRIPTION
Prioritising	Arranging objects or information in order based on their importance or urgency.
Analysing	Processing information by breaking it down into smaller parts in order to deeply and thoroughly understand them in details and their interrelationship.
Detecting Bias	Identify/ Investigate views or opinions that have the tendency to support or oppose something.
Evaluating	Assessing considerations and decisions using knowledge, experiences, skills, values and giving justification.
Making Conclusion	Making a statement about the outcomes of an investigation based on a hypothesis.

Creative Thinking Skills

Creative thinking skill is the ability to produce or create something new and valuable by using genuine imaginative skill and unconventional thinking. A brief description of each creative thinking skill is as in Table 2.

Table 2: Creative Thinking Skills

CREATIVE THINKING SKILLS	DESCRIPTION
Generating Ideas	Prompting thoughts or opinions related to something.
Relating	Making connections in certain situations or events to find relationship between a structure or pattern.
Making Inference	Making initial conclusion and explaining an event using data collection and past experiences.

CREATIVE THINKING SKILLS	DESCRIPTION
Predicting	Forecasting an event based on observations and previous experiences or collected data.
Making Generalisation	Making general statement about certain matter from a group of observations on samples or some information from that group.
Visualising	Forming perception or making mental images about a particular idea, concept, situation or vision.
Synthesising	Combining separate elements to produce an overall picture in the form of writing, drawing or artefact.
Developing Hypothesis	Making a general statement about the relationship between the manipulated variable and responding variable to explain an observation or event. This statement or

CREATIVE THINKING SKILLS	DESCRIPTION
	conjecture can be tested to determine its validity.
Developing Analogy	Forming an understanding about a complex or abstract concept by relating it to simple or concrete concept with similar characteristics.
Inventing	Producing something new or modifying something which is already in existence to overcome problems in a systematic manner.

Thinking Strategy

Thinking strategy is structured and focused high-level thinking which involves critical and creative thinking and reasoning skills in every steps taken to achieve the intended goal or solution to a problem. Description of each thinking strategy is as in Table 3.

Table 3: Thinking Strategy

THINKING STRATEGY	DESCRIPTION
Conceptualising	Making generalisations towards building a meaning, concept or model based on inter-related specific common characteristics.
Making Decision	Selecting the best solution from several alternatives based on specific criteria to achieve the intended aims.
Problem Solving	Finding the right solutions in a systematic manner for situations that are uncertain or challenging or unanticipated difficulties.

Table 3 shows an overall picture of the thinking skills and thinking strategies. Further information on thinking skills and thinking strategies (TSTS) can be found in *Buku Panduan Penerapan Kemahiran Berfikir dan Strategi Berfikir dalam Pengajaran dan Pembelajaran Sains* (Curriculum Development Centre, 1999).

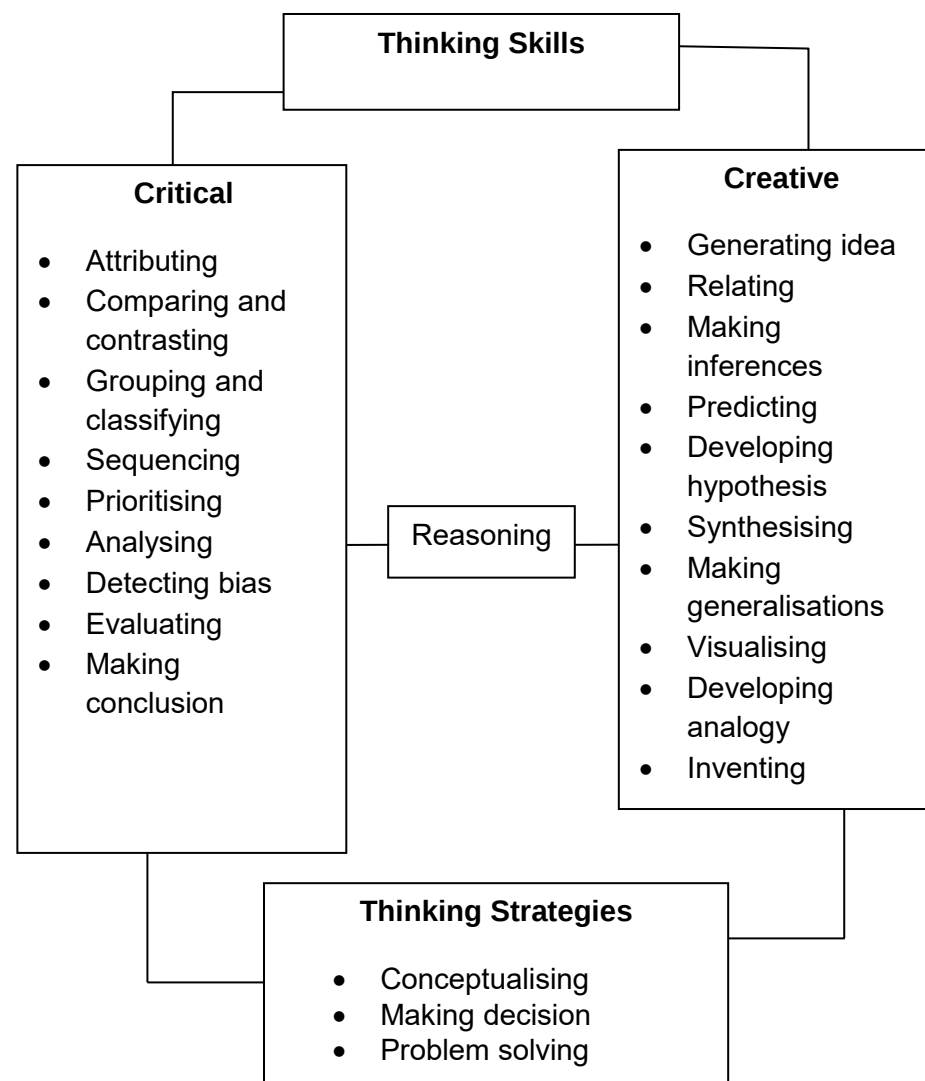


Figure 3: TSTS Model in KSSM Physics

Scientific Skills

KSSM Physics emphasizes on inquiry and problem solving. In the process of inquiry and solving problem, scientific skills and thinking skills are used. Scientific skills are important skills used during scientific activities such as conducting experiments and projects.

Scientific skills consist of science process skills and manipulative skills.

Science Process Skills

Science Process Skills (SPS) are skills required in the process of finding solutions to a problem or making decisions in a systematic manner. SPS are mental processes which promote critical, creative, analytical and systematic thinking. Mastery of SPS together with attitude and appropriate knowledge to guarantee the ability of pupils to think effectively. Thus, good command of SPS with positive attitude and sound knowledge will ensure effective thinking among pupils. Table 4 describes each of the SPS.

Table 4: Science Process Skills

SCIENCE PROCESS SKILLS	DESCRIPTION
Observing	Using the senses of sight, hearing, touch, taste or smell to gather information about objects and phenomena.
Classifying	Using observations to group objects or phenomena according to similarities and differences.
Measuring and Using Numbers	Making quantitative observations using numbers and tools with standard units to ensure an accurate measurement.
Inferring	Using collected data or past experiences to draw conclusions and make explanations of events.
Predicting	Making forecast about future events based on observations and previous experiences or collected data.

SCIENCE PROCESS SKILLS	DESCRIPTIONS
Communicating	Using words or graphic symbols such as tables, graphs, diagrams or models to explain actions, objects or events.
Using Space-Time Relationship	Describing changes in parameter such as location, direction, shape, size, volume, weight or mass with time.
Interpreting Data	Giving rational explanations about an object, event or pattern derived from collected data.
Defining Operationally	Giving meaning to a concept by describing what must be done and what should be observed.
Controlling Variables	Managing manipulated variable, responding variable and fixed variable. In a scientific investigation, the manipulated variable is changed to observe its relationship with the responding variable. At the same time, the other variables are kept the same.

SCIENCE PROCESS SKILLS	DESCRIPTIONS
Hypothesising	Making a general statement about the relationship between the manipulated and responding variable to explain an observation or event. This statement or conjecture can be tested to determine its validity.
Experimenting	Planning and conducting an investigation under controlled conditions to test a hypothesis, collecting and interpreting data until a conclusion can be obtained.

Manipulative Skills

Manipulative skills are psychomotor skills that enable pupils to carry out practical works in science. It involves the development of hand-eye coordination. These manipulative skills are:

- Use and handle science apparatus and substances correctly.
- Handle specimens correctly and carefully.
- Draw specimens, apparatus and substances accurately
- Clean science apparatus correctly
- Store science apparatus and substances correctly and safely.

Relationship between Science Process Skills and Thinking Skills

Accomplishment in Science Process Skills require pupils to master the related thinking skills. Table 5 shows these relationships.

Table 5: Relationship between Science Process Skills and Thinking Skills

SCIENCE PROCESS SKILLS	DESCRIPTION
Observing	Attributing Comparing and contrasting Relating
Classifying	Attributing Comparing and contrasting Grouping and classifying
Measuring and Using Numbers	Relating Comparing and contrasting

SCIENCE PROCESS SKILLS	DESCRIPTION
Making Inferences	Relating Comparing and contrasting Analysing Making Inferences
Predicting	Relating Visualising
Using Space - Time Relationship	Sequencing Prioritising
Interpreting data	Comparing and contrasting Analysing Detecting bias Making conclusion Making Generalisation Evaluating
Defining operationally	Relating Developing analogy Visualising Analysing

SCIENCE PROCESS SKILLS	DESCRIPTION
Controlling variables	Attributing Comparing and contrasting Relating Analysing
Hypothesising	Attributing Relating Comparing and contrasting Generating ideas Developing hypothesis Predicting Synthesising
Experimenting	All thinking skills
Communication	All thinking skills

Teaching and Learning based on Thinking Skills and Scientific Skills

KSSM Physics emphasizes thoughtful learning based on thinking skills and scientific skills. In this curriculum, the intended Learning Standard (LS) is written by integrating the aspired knowledge and skills for pupils to acquire and master. Teachers should emphasize on the acquisition and proficiency of pupils' knowledge and skills along with attitudes and scientific values in T&L.

The embedding of SPS in KSSM Physics has somewhat fulfills the aspirations of 21st century education and indirectly encourages and uplifts the development of pupils' high order thinking skills.

Science Process Skills Standard

The Science Process Skills Standard is a general recommended and specific accomplishment which must be met by pupils in each level of schooling. Each statement refers to the minimum standard of pupils achievement based on schooling levels and cognitive development.

The science process skills at level 1 and 2 stated in the Learning Standard which must be mastered as a basis for further study at the secondary level as shown in Table 6.

Table 6: Science Process Skills Standard

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
1	Observing	Use sensory organs involved to make observation about phenomena or changes that occur.	Use sensory organs to make observation qualitatively and quantitatively with appropriate tools to describe the phenomena or changes that occur.	- Make relevant and precise observation qualitatively and quantitatively to identify trends or sequences on objects or phenomena. - Use correct tools skillfully to make observations.	- Make observation qualitatively and quantitatively to make generalization based on trends or sequences. - Present advance findings analytically.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
2	Classifying	Collect/segregate evidences/data/objects /phenomena based on observed characteristics.	Compare/identify the similarities and differences based on given categories based on common characteristics.	Compare/identify the similarities and differences to determine the criteria of category for evidence/ data/ objects/ studied phenomena	Identify characteristics used to segregate, choose and explain in detail about objects or the studied phenomena.
3	Measuring and Using Numbers	Measure using correct tools and standard units.	Measure using correct techniques, tools with standard units.	- Measure using correct techniques and tools with standard units and record systematically and completely. - Convert basic quantity units correctly. - Use correct derived units.	- Show ways to measure using tools and standard units with correct techniques and record in tables systematically and completely. - Use complex derived units correctly.
4	Inferring	State a reasonable explanation for an observation.	Make reasonable pre-assumption for an observation using the information given.	Make more than one reasonable early conclusions for an incident or an	- Generate multiple possibilities to explain a complex situation. - Explain the relation and

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
				observation using information given.	trends between manipulated and responding variables in an investigation.
5	Predicting	Describe a possibility for an incident or data.	Make a reasonable prediction about an incident based on observations, past experiences or data.	Perform simple development or trend analysis based on obtained data to predict the future of an object or phenomena.	- Perform simple development or trend analysis based on obtained data to predict the future of an object or phenomena. - Test the prediction made.
6	Communicating	Record ideas or information in any form.	Record and present ideas and information systematically in suitable form.	Present experimental findings and observation data in various form such as simple graphics, pictures or tables.	Present experimental findings and observation data in various complex form using graphics, pictures or tables to show the relationship between the associated patterns.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
7	Using Space Time Relationship	(Not stated explicitly in the Learning Standard)	Arrange a phenomenon or incident chronologically.	- Arrange a phenomenon or incident chronologically. - Interpret and explain the meaning of mathematical relations.	Use, analyse and interpret numbers and numerical relationship efficiently when solving problems and conducting investigations.
8	Interpreting Data		Choose relevant ideas about objects, incidents or patterns in data to come up with an explanation.	Give rational explanations by interpolating and extrapolating the collected data.	- Analyse data and suggest ways to improve. - Detect and explain anomaly in collected sets of data.
9	Defining Operationally		Describes an interpretation by stating what is being done and observed in a specific aspects of a situation.	Describes the most appropriate interpretation of a concept by stating what is being done and observed in a situation.	Describe the interpretation made about the selection of tools or methods of what is being observed.

NO	SCIENCE PROCESS SKILLS	Level 1 (Year 1-3)	Level 2 (Year 4 – 6)	Level 3 (Form 1 – 3)	Level 4 (Form 4 – 5)
10	Controlling Variables	(Not stated explicitly in the Learning Standard)	Determine the responding and constant variables after the manipulated variable is determined in an investigation.	Determine all types of variable, which are responding variables, manipulated variables and fixed variables.	Change the fixed variable to the manipulated variable and state the new responding variable.
11	Hypothesising		Make a general statement that can be tested about the relationship between the variables in an investigation.	Make a relationship between the manipulated variable and the responding variable to build a hypothesis which can be tested.	Explain an expected result from the designed scientific investigation.
12	Experimenting		Carry out experiment, collect data, interpret data and make conclusions to test the hypothesis and write report.	Carry out experiment, build hypothesis, design methods and determine appropriate apparatus, collect data, analyse, summarise and write report.	Trigger new question and plan an experiment to test new hypothesis from the question.

Scientific Attitudes And Noble Values

Science learning experiences can inculcate scientific attitudes and noble values in pupils. These attitudes and values are instilled through the following:

1. Interest and curious about the environment.
 - Seek information from teachers, friends or other people.
 - Do own reading.
 - Collect materials or specimens for research purposes.
 - Carry out own research.
2. Honest and accurate in recording and validating data.
 - Describe and record real observations.
 - Record information objectively (not affected by feelings of illusions)
 - Explain information rationally.
 - Cite the sources of used information.
3. Flexible and open-minded.
 - Accept others' opinions.
 - Agree to cogent evidence.
 - Be open-minded.
4. Diligent and persistent when carrying out a task.
 - Preserve and determined.
 - Ready to repeat experiments.
 - Do the task wholeheartedly.
 - Ready to accept critics and challenges.
 - Strive to overcome problems and challenges.
5. Systematic, confident and ethical.
 - Conduct activities orderly and timely.
 - Arrange tools and materials in order.
 - Optimistic about the task.
 - Brave and ready to venture something new.
 - Dare to defend something done.
6. Collaborate.
 - Help friends and teachers.
 - Carry out activities and experiments together.
 - Selflessness.
 - Fair and equitable.

7. Be responsible for the safety of oneself, others, and the environment.

- Take care of oneself and friends' safety.
- Preserve and conserve the environment.

8. Compassionate.

- Love all living things.
- Be prudent and respectful.

9. Appreciate the contributions of science and technology.

- Use the creation of science and technology wisely.
- Utilise public facilities created by science and technology responsibly.

10. Thankful to God.

- Always be satisfied with the gift of God.
- Use the gift of God wisely.
- Be thankful to God.

11. Appreciate and practise clean and healthy living.

- Maintain cleanliness and good health.
- Always be conscious of personal hygiene and clean environment.

12. Realise that science as a means to understand nature.

- Express how science is used to solve problems.
- State the implications of using science to solve a problem or issue.
- Communicate through correct scientific language.

The inculcation of scientific attitudes and noble values generally occurs through the following stages:

- Aware and understand the importance and the need of scientific attitudes and noble values.
- Focus on these attitudes and noble values.
- Internalise and practise these scientific attitudes and noble values.

Sound lesson plan is required for effective inculcation of scientific attitudes and noble values during teaching and learning. Thus, before planning each lesson, teachers should examine the Learning Standard, including Performance Standard to foster scientific attitudes and noble values in the lesson.

21st CENTURY SKILLS

One of the aspirations in KSSM is to develop pupils with 21st century skills, while focusing on thinking skills as well as life and career skills strongly rooted in noble values and practices. 21st century skills aim to prepare pupils with the characteristics specified in Table 7: Pupils' Profile. These features enable them to compete globally. Achieving CS and LS in KSSM Physics contributes to the acquisition of 21st century skills among pupils.

Table 7: Pupils' Profile

PUPILS' PROFILE	DESCRIPTION
Resilient	Able to face and overcome difficulties and challenges with wisdom, confidence, tolerance and empathy.
Communicator	Able to voice out and express their thoughts, ideas and information confidently and creatively in verbal and written, using multi-media and technology.
Thinker	Able to think critically, creatively and innovatively; solve complex problems

PUPILS' PROFILE	DESCRIPTION
	and make ethical decisions. Think about learning and about being learners themselves. Generate questions and are receptive towards perspective, values and individual traditions and society. Confident and creative in handling new learning areas.
Team Player	Cooperate effectively and harmoniously with others. Share collective responsibility while respecting and appreciating the contributions of each member in the team. Acquire interpersonal skills through collaborative activities, which in turn mould pupils into better leaders and team members.
Curious	Develop natural curiosity to explore strategies and new ideas. Learn skills that are needed to carry out inquiry and research, as well as display

PUPILS' PROFILE	DESCRIPTION
	independent learning traits. Enjoy continuous life-long learning experiences.
Principled	Honest and have integrity, equity with just and respect for individuals, groups and community. Responsible for their actions, and as well as the consequences.
Informative	Knowledgeable, have wide, deep and balanced understanding across various disciplines. Explore and gain knowledge on local and global issues effectively and efficiently. Understand ethical issues/ laws related to the information gained.
Caring/ Concern	Show empathy, compassion and respect towards the needs and feelings of others. Committed to serve the society and ensure sustainability of the environments.
Patriotic	Portray love, support and respect towards the country.

HIGHER ORDER THINKING SKILLS

Higher Order Thinking Skills (HOTS) is explicitly stated in the curriculum to encourage teachers to incorporate them in teaching and learning, hence stimulating structured and focused thinking among pupils. Descriptions of the focused four levels of HOTS are shown in Table 8.

Table 8: Thinking Levels in HOTS

THINKING LEVEL	DESCRIPTIONS
Applying	Using knowledge, skills and values to take actions in different situations.
Analysing	Breaking down information into smaller parts to enhance understanding and make relationship between the parts.
Evaluating	Making considerations and decisions using knowledge, skills, values and experiences as well as justifications.
Creating	Generating ideas, products or methods and innovatively.

HOTS are the ability to apply knowledge, skills and values in reasoning and reflecting to solve problems, make decisions, to innovate and create something. HOTS include critical thinking, creative thinking, reasoning and thinking strategy.

Critical thinking skill is the ability to evaluate an idea in a logical and rational manner to make a reasonable judgement with justifications and reliable evidences.

Creative thinking skill is the ability to produce or create something new and valuable by using genuine imaginative skill and unconventional thinking.

Reasoning skill is the ability of an individual to consider and evaluate logically and rationally.

Thinking strategy is a way of thinking that is structured and focused to solve problems.

HOTS can be applied in classrooms through activities in the form of reasoning, inquiry learning, problem solving and projects. Teachers and pupils need to use thinking tools such as thinking maps and mind maps, including high level questioning to stimulate thinking processes among pupils.

TEACHING AND LEARNING STRATEGIES

Teaching and learning strategies in KSSM Physics emphasise on thoughtful learning. Thoughtful learning is a process that helps pupils acquire knowledge and master skills which assist them to develop their minds to optimum level. Thoughtful learning can take place through various learning approaches such as inquiry, constructivism, science, technology and society, contextual learning and mastery learning space. Learning activities should therefore be geared towards activating pupils' critical and creative thinking skills and not be confined to routine methods. Pupils should be made explicitly aware of the thinking skills and thinking strategies which are employed in their learning.

More higher order questions and problems posed to pupils encourages them to enhance their critical and creative thinking skills. Pupils actively involved in the teaching and learning where the acquisition of knowledge, mastery of skills and inculcation of scientific attitudes and noble values are integrated.

The learning approaches that can be applied by teachers in the classroom are as follows:

Inquiry Approach

Inquiry approach emphasises learning through experiences. Inquiry generally means to find information, to question and to investigate a phenomenon. Discovery is the main characteristic of inquiry. Learning through discovery occurs when the main concepts and principles of science are investigated and discovered by pupils themselves. Through activities such as experiments, pupils investigate a phenomenon and draw conclusions by themselves. Teachers then lead pupils to understand the science concepts through the results of the inquiry. Thinking skills and scientific skills are thus developed further during the inquiry process. However, the inquiry approach may not be suitable for all teaching and learning situations. Sometimes, it may be more appropriate for teachers to present concepts and principles directly or through guided inquiry.

Constructivism

Constructivism is a learning theory which suggests that learners construct their own knowledge and understanding of the world through experiences and reflecting on those experiences. The important elements of constructivism are:

- Teachers have to consider pupils' prior knowledge.

- Learning is the result from pupils' own effort.
- Learning occurs when pupils restructure their ideas through relating original ideas to new ones.
- Pupils have the opportunities to cooperate, share ideas and experiences and reflect on their learning.

Contextual Learning

Contextual learning is a method of instruction that enables pupils to apply new knowledge and skills to real-life situations. In this context pupils do not just obtain knowledge theoretically, but allowing pupils to make connections and make relevance of science learning with their lives. A contextual approach is used when pupils learn through investigation similar to inquiry approach.

Mastery Learning

Mastery learning ensures all pupils acquire and master the intended learning objectives. This approach is based on the principle that pupils are able to learn if given the opportunities. Pupils should be allowed to learn at their own pace, with the incorporation of remedial and enrichment activities as part of the teaching-learning process.

Problem/ Project Based Learning

Problem/ project based learning (PBL) is a student-centered pedagogy where pupils learn through prompting solving issues/ problems. The issues or problems are provided by teachers. Teachers can provide issues, problems or projects from various sources such as newspapers, magazines, journals, books, textbooks, and cartoons, videos, television, films and others to suit the teaching and learning.

Real world and relevant problem or project is used as a platform to encourage pupils to the intended the concepts and principles. PBL promotes the development of critical thinking skills, problem solving abilities, and communication skills.

PBL provides students the opportunity to work in a team, collaborate on inquiring and evaluating research materials, analysing data, justifying and making decision, and nurturing life-long learning among pupils.

For effective PBL, the provided issue of problem should;

- encourage pupils to understand the concept clearly an deeply.
- Require pupils to justify and support their decisions.
- meet the intended and previous related content/ learning standards.
- Be suitable to the capabilities of the pupils to ensure they can work together to complete the task.
- Be open and captivating enough to motivate and enhance pupils' interest.

STEM APPROACH

STEM approach is the teaching and learning (T&L) method which applies integrated knowledge, skills and values of STEM through inquiry, problem solving or project in the context of daily life, environmentand, as well as local and global community, as shown in Diagram 4.

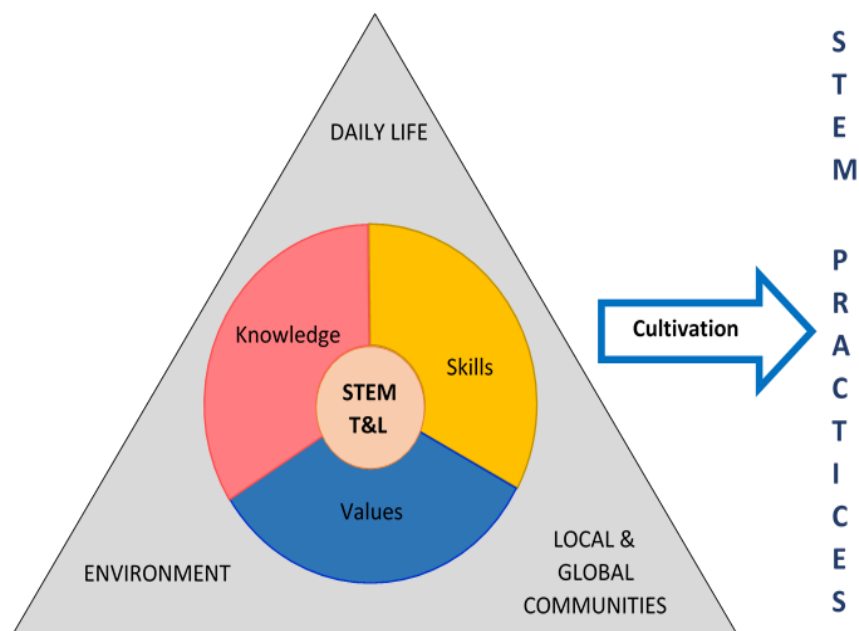


Diagram 4: STEM Teaching and Learning Approach

STEM T&L which is contextual and authentic can encourage in depth learning amongst pupils. Pupils can work in groups or individually based on the nature of the T&L activities. The STEM practices that are encouraged during STEM T&L are as follows:

1. Questioning and identifying problems,
2. Developing and using models,
3. Planning and carrying out investigations,
4. Analyzing and interpreting data,

5. Using mathematical thinking and computational thinking,
6. Developing explanations and designing solutions,
7. Engaging in debates and discussion based on evidence, and
8. Acquiring information, evaluating and communicating about the information.

Computational thinking is a cognitive process involved in formulating problems and solutions which can be represented in a form that can be effectively executed by humans and/ or computers. Computational thinking helps pupils to solve complex problems easily through organizing, analysing and presenting data or ideas in a logical and systematic way.

Varied T&L activities can elevate pupils' interest towards science. Interesting science lessons will motivate pupils to study which will then show favourable influence on their performance. The T&L activities should correspond to the intended curriculum content, pupils' ability and multiple intelligences, as well as resources and facilities available.

Some T&L activities encouraged in science are as follows:

Scientific Investigation/ Experiment

A scientific investigation/ experiment is commonly used in science lessons. The hypothesis is tested by pupils through an investigation to discover certain scientific concepts of principle. Carrying out scientific investigation/ experiment encourages pupils to cultivate thinking skills, science process skills and manipulative skills.

In general, the procedures to conduct a scientific investigation/ experiment are shown in Diagram 5.

With the introduction of KSSM Physics, pupils are given the opportunity to design scientific investigation/ experiments beside the usual teacher-guided scientific investigations/ experiments. Pupils are expected to plan and design the experiment, collect and analyse data, interpret and display results, and finally share and present their report and findings.

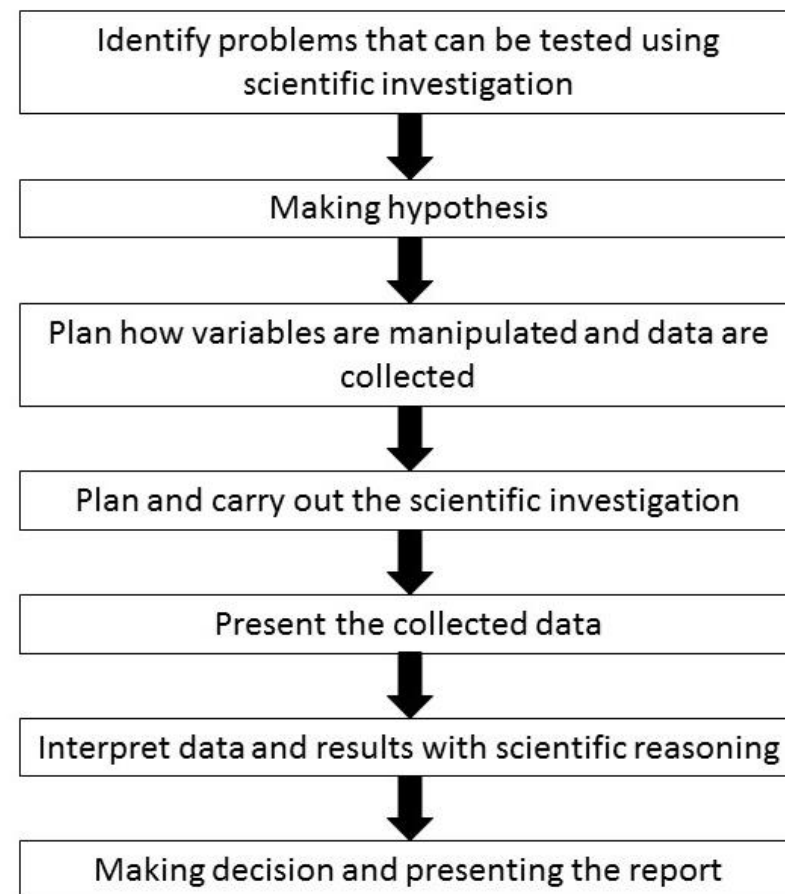


Diagram 5: Steps to carry out a scientific investigation/ experiment

Simulation

Simulation is an activity that imitates the real situation. Simulations can be carried out through role-play, games or using model. In role-playing, pupil act out a particular role spontaneously based on a certain pre-determined conditions. Whereas in gaming, pupils is required to follow procedures. Pupil plays games in order to learn a particular principle or to understand the process of decision making. While in modelling, an object/ replica is used to represent the real thing/ process. Pupils will be able to visualise the actual situation, thus understand the concepts and principles to be learned.

Project

Activities carried out by individuals or groups of students to achieve certain goals. Project takes a long time and usually reach out with the formal learning time. Pupils' reports, artifacts or other forms of project outcomes need to be presented to teachers and fellow pupils. Project work promotes problem solving skills, time management skills and self-study.

Visits and Use of External Resources

Science learning is not limited to schools only. Science learning can take place at the zoos, museums, science centers, research institutes, mangrove swamps and factories too. Visits to such places can make learning more effective, fun and meaningful. Learning through visits can be impacted by careful planning. To optimise learning, students must carry out activities or perform assignments during the visit and held discussion after the visit.

The Use of Technology

Technology is a highly effective and powerful tool to increase interest in science learning. Through the use of technologies such as television, radio, video, computers and the internet, science T&L can be more exciting and effective. Animation and computer simulation can be used as an effective tool to learn difficult and abstract science concepts. Computer simulations and animation can also be displayed in the form of courseware or through website. Software applications such as word processors, graphic presentation software and electronic spreadsheets are valuable tools that can be employed to analyse and present data.

The use of other technologies such as data loggers and computerized user interface in experiments and projects can be of effective assistants in science teaching and learning.

Good management of activities and two-ways interactions between teacher-pupils and pupils-pupils during T&L further liberate their thinking skills to a higher level.

ELEMENTS ACROSS THE CURRICULUM

Elements Across Curriculum is a set of value-added elements applied in the teaching and learning process other than those specified in the standard content. The application of these elements is aimed at strengthening the human capital skills and competency besides preparing pupils for the challenges of the present and the future. The elements are explained below:

1. Language

- Using correct instruction language in all subjects.
- Emphasising promunication correct sentences structure, grammar and terminologies in T&L in order to assist pupils to communicate effectively and organise their thoughts clearly and systematically.

2. Environmental Sustainability Awareness

- Developing awareness, nurturing the love and care for the environment through teaching and learning.
- Promoting knowledge and awareness on the importance of the environmental ethics and sustainability for pupils to appriciate.

3. Noble Values

- Instilling noble values in all subjects to ensure that pupils are aware of their importance and gradually practice them.
- Practising noble values which encompass the aspects of spirituality, humanity and citizenship in relation to pupils' daily life.

4. Science and Technology

- Raising the pupils' interest in the science and technology to improve scientific and technological literacy.
- Using technology in teaching and learning can contribute and assist efficient and effective learning.
- Integration of science and technology in the teaching and learning enhances knowledge, skills and values in all subjects for examples:
 - (i) knowledge of science and technology principles, concepts and facts related to science and technology;
 - (ii) Process skills (process of thought and specific manipulative skills);
 - (iii) Scientific attitudes and values
 - (iv) Technological knowledge and skills.

5. Patriotism

- Nurturing patriotism in all subjects, extracurricular activities and community services,
- Developing the spirit of love for the country as well as encouraging the feelings of 'truly proud to be Malaysians' amongst pupils.

6. Creativity and Innovation

- Giving time and opportunity in all subjects for pupils to be creative and innovative through extracting and generating or creating new/ original ideas.
- Exploiting and fostering pupils' creativity and innovativeness to see and realise their full potential.
- Integrating elements of creativity and innovation in teaching and learning to ensure human capital meet the challenges of 21st Century.

7. Entrepreneurship

- Incorporating the characteristics and practices of entrepreneurship, gradually shaping a culture amongst pupils,
- Fostering entrepreneured characteristics through activities which promote diligence, honesty, trustworthiness and responsibility as well as developing creative and innovative mindset to drive ideas into the economy.

8. Information and Communication Technology (ICT)

- Incorporating information and communication technology (ICT) in the lessons to ensure pupils have the ability to apply and strengthen their basic knowledge and skills in ICT,
- Utilizing ICT to motivate pupils to be creative, stimulates interesting and fun T&L and improve the quality of learning,
- Integrating ICT in teaching appropriate topics to further enhance pupils' understanding of the content subject.

9. Global Sustainability

- Discussing Global Sustainability directly or indirectly in related subjects, prompt and develop sustainable thinking (responsive towards the environment, being responsible, creative and resourceful) with the concept of living within global resources without damaging its present or future environment,
- Educating global sustainability prepares pupils to face challenges on complex interconnected global issues.

10. Financial Education

- Incorporating Financial Education to build future generations who are financial literate, capable of making wise financial decisions and practise ethical financial management and skills.
- Exploring financial management and skills directly or indirectly in T&L through topics related to finance e.g simple and compound interest, foreign exchange, budgeting credit-debit, saving and financial safety.
- Simulating financial management activities to prepare pupils with knowledge, skills and values which are relevant and useful to their living.

CLASSROOM ASSESSMENT

Classroom Assessment is the process of obtaining information on student development planned, implemented and reported by the teacher concerned. This process is ongoing to enable teachers to determine the Student Mastery Level.

Classroom Assessment can be implemented by teachers formatively and summatively. Assessment is formatively implemented at the same time with the T&L process, while summative assessments are implemented at the end of a learning unit, term, semester or year. Teachers should plan, construct valuation items or instruments, administer, examine, record and report levels of mastery based on DSKP.

In order to ensure that assessments help to improve the ability and mastery of the pupils, the teacher should implement the assessments that have the following characteristics:

- Use various assessment methods such as observation, oral and writing.
- Use various assessment strategies that can be implemented by teachers and pupils.

- Take into consideration the various levels of knowledge and skills learned.
- Allow pupils to show various learning capabilities.
- Assess the pupil's mastery level on Learning Standard and Performance Standards.
- Follow up actions for recovery and consolidation purposes.

Performance Standard of KSSM Physics

Classroom Assessment for KSSM Physics is evaluated from three main domains which are knowledge, skills and affective domains (for nobles values).

Knowledge and science process skills integrated in learning area are assessed based on the stated Performance Standards (PS). PS aims to gauge the achievement of students mastering the specific knowledge, skills and values. Assessment of scientific skills can be carried out continuously, periodically or in clusters throughout the year. Therefore, it is important for teachers to use professional judgment in determining the pupils' performance levels. There are 6 performance levels with their general descriptors shown in Table 9.

Table 9 : General Descriptors of Performance Level in Science subjects for KSSM Physics

PERFORMANCE LEVEL	DESCRIPTORS
1	Recall knowledge and basic skills of science.
2	Understand the knowledge and skills of science and explain the understanding.
3	Apply knowledge and science skills to carry out simple tasks.
4	Analyze information about knowledge and science skills in the context of problem solving.
5	Evaluate to make judgement about the science knowledge and skills in context problem solving and decision-making to carrying out a task.
6	Invent by applying the knowledge and skills in context problem solving and decision-making or carrying out an assignment in a new situation creatively and innovatively, giving due consideration to the social values/ economy/ culture of the community.

Teachers can refer to **Appendix** to view the relationship between the key verbs of each Performance Level in Performance Standards and verbs in the Learning Standard with examples of student activity that can be implemented.

All the investigations/ experiments/ activities listed in each theme in Table 10 are **COMPULSORY**. Investigations / experiments / activities are conducted using inquiry approach.

Table 10: List of Investigations/ Experiments/ Activities in each Theme

TEMA	EKSPERIMEN
ELEMENTARY PHYSICS	1.2.3 Carry out scientific investigation and write a complete report for the Simple Pendulum Experiment.
NEWTONIAN MECHANICS (FORM 4)	2.3.2 Experiment to determine the value of gravitational acceleration.
	2.4.2 Experiment to find the relationship between inertia and mass.
HEAT	4.2.3 Experiment to determine: (i) the specific heat capacity of water (ii) the specific heat capacity of aluminium
	4.3.3 Experiment to determine: (i) specific latent heat, ℓ_f of fusion of ice. (ii) specific latent heat of evaporation, ℓ_v of water

TEMA	EKSPERIMEN
HEAT	4.4.2 Experiment to determine the relationship between the pressure and volume of a fixed mass of gas at constant temperature.
	4.4.3 Experiment to determine the relationship between the volume and temperature of a fixed mass of gas at constant pressure.
	4.4.4 Experiment to determine the relationship between the pressure and temperature of a fixed mass of gas at constant volume.
WAVES, LIGHT AND OPTICS	6.1.4 Experiment to determine the refractive index, n for glass block or perspex.
	6.1.6 Experiment to determine refractive index of a medium using real depth and apparent depth.
	6.4.1 Experiment to: (i) Investigate the relationship between object distance, u and image distance, v for a convex lens. (ii) Determine the focal length of a thin lens using lens formula:

TEMA	EKSPERIMEN
	$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$
NEWTONIAN MECHANICS (FORM 5)	1.4.2 Experiment to investigate the relationship between force, F and extension of spring, x
	2.1.2 Experiment to investigate factors affecting pressure in liquids
	2.3.1 Determine gas pressure using a manometer
ELECTRIC AND ELECTROMAGNETISM	3.2.1 Compare and contrast ohmic and non-ohmic conductor
	3.2.4 Describe factors that affect resistance of a wire through experiments to conclude $R = \frac{\rho \ell}{A}$
	3.3.3 Conduct an experiment to determine e.m.f and internal resistance in a dry cell
	4.1.1 Describe the effect of a current-carrying conductor in a magnetic field

TEMA	EKSPERIMEN
	4.1.3 Explain factors that affect the magnitude of force on a current-carrying conductor in a magnetic field

Reporting on scientific skills assessments is done twice a year. Table 11 can be used as guidance on making professional judgment for the reporting.

Table 11: General Descriptions of Performance Level in Scientific Skills for KSSM Physics

PERFORMANCE LEVEL	DESCRIPTORS
1	- Poorly planned scientific investigation. - Inappropriate materials and apparatus used in the scientific investigation. - No data collected and recorded. - No or unclear explanation of the scientific investigation.
2	- Plan the correct strategy and procedure in the scientific investigation with guidance. - Use suitable material and apparatus. - Collect and record incomplete or irrelevant data. - Make an interpretation and conclusion not based on the collected data.

PERFORMANCE LEVEL	DESCRIPTORS
3	- Plan and carry out the correct strategy and procedure in the scientific investigation with guidance. - Use correct material and apparatus. - Collect and record relevant data. - Organize data in numerical or visual form with some error. - Make an interpretation and conclusion based on the collected data. - Write an incomplete scientific investigation report.
4	- Plan and carry out the correct strategy and procedure in the scientific investigation. - Handle and use the correct material and apparatus to get an accurate result. - Collect relevant data and record in a suitable format. - Organize the data in the numerical or visual form with no error. - Interpret the data and make an accurate conclusion based on the aim of the scientific investigation. - Write a complete report on the scientific investigation

PERFORMANCE LEVEL	DESCRIPTORS
5	- Carry out a scientific investigation and writing a complete report. - Collect, organize and present data in numerical or visual form well. - Interpret data and make conclusions accurately with scientific reasoning. - Identify the trend, pattern and relevant data.
6	- Justify the outcome of the scientific investigation relating to theory, principle and law of science in the reporting. - Evaluate and suggest ways to improve to the scientific investigation methods and further inquiry investigation if needed. - Discuss the validity of the data and suggest ways to improve the method of data collection.

Assessment of scientific attitudes and values can be implemented throughout the year. Table 12 can be used as guide for teachers in making a professional judgment.

Table 12: General Interpretation of the Performance Level in Scientific Attitudes and Values of KSSM Physics

PERFORMANCE LEVEL	DESCRIPTORS
1	Pupil is not able to: - state how science is used to solve problems. - state the implication of using science to solve problems or certain issues. - use scientific language to communicate - document the source of information used.
2	Pupil is less able to: - state how science is used to solve problems. - state the implication of using science to solve problems or certain issues. - use scientific language to communicate - document the source of information used.

PERFORMANCE LEVEL	DESCRIPTORS
3	Pupil is able to: • state how science is used to solve problems. • state the implication of using science to solve problems or certain issues. • use limited scientific language to communicate. • document a few sources of information used.
4	Pupil is able to: • determine how science is used to solve problems or certain issues. • determine the implication of using science to solve problems or certain issues. • always use sufficient scientific language to communicate. • document parts of the sources of information used.
5	Pupil is able to: • Summarise how science is used to solve specific problems or issues. • Summarise the implications of a particular problem or issue. • Always use scientific language to communicate well. • Document almost all sources of information used.

PERFORMANCE LEVEL	DESCRIPTORS
6	Pupil is able to: • Summarise how science is used to solve problems or certain issues. • Discuss and analyse the implication of using science to solve problems or certain issues. • Consistently use the correct scientific language to communicate clearly and accurately. • Document all the sources of information. • Become a role model to other pupils.

Overall Performance Level

Overall Performance Level of KSSM Physics is to be determined at the end of each year. This Overall Performance Level includes aspects of knowledge, skills and values. Teachers need to assess pupils collectively and holistically by looking at all aspects of the learning process. Teachers' professional judgment should be employed in all assessment processes, particularly in determining the overall performance level. Professional judgments can be made based on knowledge and experience of teachers, teacher-pupil interactions, and discussions with committee members of relevant departments. Table 13 shows the overall performance level descriptors of KSSM Physics.

Table 13: Descriptors of the overall performance level of KSSM Physics

PERFORMANCE LEVEL	DESCRIPTORS
1 (Know)	Pupils know basic knowledge, skills or values in Physics.
2 (Know and understand)	Pupils know and understand basic knowledge, skills and values in Physics.
3 (Know, understand and do)	Pupils know, understand and apply basic knowledge, skills and values in Physics.
4 (Know, understand and carry out in a civilised manner)	Pupils know, understand and apply knowledge, skills and values in a competent mannerly procedure in Physics.
5 (Know, understand and do with commendable praise)	Pupils know, understand and apply knowledge, skills and values in new situations with excellent commendable procedure in Physics.
6 (Know, understand and carry out in an exemplary manner)	Pupils know, understand and apply knowledge, skills and values in new situations with exceptional exemplary procedure in Physics.

CONTENT ORGANISATION

Form 4 and Form 5 Physics KSSM consist of seven themes: Elementary Physics, Newtonian Mechanics, Heat, Wave, Light and Optics, Electric and Electromagnetism, Applied Physics and Modern Physics. Each theme is divided into several areas of learning as shown in Table 14.

Table 14: Themes and Learning Areas in Physics

Themes	Learning Areas	
	Form 4	Form 5
Elementary Physics	1.0 Measurement	
Newtonian Mechanics	2.0 Force and Motion 3.0 Gravitation	1.0 Force and Motion II 2.0 Pressure
Heat	4.0 Heat	
Waves, Light and Optics	5.0 Waves 6.0 Light and Optics	
Electric and Electromagnetism		3.0 Electric 4.0 Electromagnetism
Applied Physics		5.0 Electronic
Modern Physics		6.0 Nuclear Physics 7.0 Quantum Physics

The recommended minimum teaching hours for KSSM Physics is 96 hours per year as stipulated in *Surat Pekeliling Ikhtisas Kementerian Pendidikan Malaysia Bilangan 9 Tahun 2016*.

The Learning Area in each theme describes the span of development, knowledge, skills and values through its Content Standard and Learning Standard. The Content Standard has one or more Learning Standards which collectively form a concept or idea based on the Learning Area.

T&L needs to be holistic and integrated in order to deliver the scientific concept or principle from a few Learning Standards to suit pupils' ability.

Teachers need to examine Content Standards, Learning Standards and Standard Performance during the intended T&L activities. Teachers need to prepare activities which would actively prompt pupils to exercise their analytical, critical, innovative and creative thinking.

The application of technology in activity, investigation or experimental-based T&L will promote and strengthen pupils' understanding.

KSSM Physics focuses on the mastery of knowledge, skills and values that are appropriate to the pupils' development. Each Learning Area contains Content Standard, Learning Standard and Standard Performance as described in Table 15.

The Remarks column gives additional information to the Content Standard and Learning Standard. It also includes suggestions on activities to be performed and/ or notes related to Learning Standard and sometimes limitations to the Learning Standard.

Table 15: Interpretation of Content Standard, Learning Standard and Performance Standard

CONTENT STANDARD	LEARNING STANDARD	PERFORMANCE STANDARD
Specific statements about what pupils should know and can do during the schooling period encompassing the knowledge, skills and values.	A predetermined criteria or indicator of the quality in learning and achievement that can be measured for each content standard.	A set of general criteria which reflects the levels of pupils' achievement that they should show as a sign that a certain topic has been mastered by pupils.

In providing learning environments and activities which are suitable and relevant to the pupils' abilities and interests, teachers need to use their creativity and wisdom. The list of proposed activities is not absolute. Teachers are advised to use various resources such as books and the internet in providing T&L activities suitable to their pupils' ability and interest.

Content Standard,
Learning Standard
and Performance Standard
Form 4

THEME

ELEMENTARY PHYSICS

LEARNING AREA

1.0 Measurement

Theme 1

ELEMENTARY PHYSICS

This theme aims to provide an understanding that physical quantities have magnitudes and units. Emphasis is given to base quantities and units, which are used to derive other physical quantities. Focus is given to the scientific method in terms of graph interpretation and scientific investigation.

Learning area

- 1.0 Measurement
 - 1.1 Physical Quantities
 - 1.2 Scientific Investigation

1.0 MEASUREMENT

CONTENT STANDARD	LEARNING STANDARD	NOTES
1.1 Physical Quantities	Pupils are able to: 1.1.1 Explain physical quantities. 1.1.2 Explain with examples base quantities and derived quantities.	Note: Physical quantities consist of base quantities and derived quantities. Physical quantities involve metric and imperial units. Examples of imperial unit: foot, inch, yard, mile, gallon, psi, etc. Note: Seven base quantities and their corresponding S.I units: • length, ℓ (m) • mass, m (kg) • time, t (s) • absolute temperature, T (K) • electric current, I (A) • luminous intensity, I_v (cd) • amount of substance, n (mol)

CONTENT STANDARD	LEARNING STANDARD	NOTES
	1.1.3 Describe derived quantities in terms of base quantities and their corresponding S.I. units. 1.1.4 Explain with examples, scalar quantities and vector quantities.	Suggested activity: Discuss derived quantities in terms of base quantities and their corresponding S.I. units. Note: Formulas are used to describe derived quantities in terms of base quantities and to determine their base S.I. units. Example: $\rho = \frac{m}{V} = \frac{m}{\ell \times \ell \times \ell}$ S.I. unit for $\rho = \text{kgm}^{-3}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
1.2 Scientific Investigation	Pupils are able to: 1.2.1 Interpret graph to determine the relationship between two physical quantities. 1.2.2 Analyse graph to summarise an investigation.	Suggested activity: Discuss different shape of graphs to show the relationship between two physical quantities such as: • directly proportional • increase linearly • decrease linearly • increase non-linearly • decrease non-linearly • inversely proportional Suggested activity: Plot a graph from given data to: • state the relationship between two given variables • determine the gradient that represents a physical quantity • determine the area under the graph that represents a physical quantity • determine the value of a physical quantity from interpolation • make predictions through extrapolation

CONTENT STANDARD	LEARNING STANDARD	NOTES
	1.2.3 Carry out a scientific investigation and write a complete report for the Simple Pendulum Experiment.	Suggested activity: Carry out a Simple Pendulum Experiment to investigate the relationship between the length of pendulum, ℓ and the period of oscillation, T from the graph: • T against ℓ • T^2 against ℓ The graphs plotted must: • have a suitable scale based on the range of data obtained • be drawn using the best fit line method The value of g is determined from the gradient of the graph of T^2 against ℓ using the formula: $T = 2\pi \sqrt{\frac{\ell}{g}}$ The value of g obtained from the experiment is compared to the standard value. The difference in the obtained value and the standard value has to be justified.

PERFORMANCE STANDARD

MEASUREMENT

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall knowledge and scientific skills on Measurement.
2	Understand Measurement, and able to comprehend the concept.
3	Apply knowledge of Measurement to explain the occurrences or phenomena of nature and perform simple tasks.
4	Analyse information about Measurement in daily life problem solving about natural phenomena.
5	Evaluate to make judgement about Measurement in daily life problem solving and decision making to carry out a task.
6	Invent by applying the knowledge and skills about Measurement in daily life problem solving or decision making to carry out activities/ assignments in a new situation creatively and innovatively; giving due consideration to the social/ economic/ cultural aspects.

THEME

NEWTONIAN MECHANICS

LEARNING AREA

2.0 Force and Motion I

3.0 Gravitation

Theme 2:

NEWTONIAN MECHANICS

This theme aims to introduce kinematics and mechanics as a branch of physics related to motion. The focus is on factors that cause a change in the state of motion of an object and subsequently Newton laws of linear motion are discussed. The focus is also on understanding the Newton's universal gravitational law and Kepler's laws.

Learning Area:

- 2.0 Force and Motion I
 - 2.1 Linear Motion
 - 2.2 Linear Motion Graphs
 - 2.3 Free Fall Motion
 - 2.4 Inertia
 - 2.5 Momentum
 - 2.6 Force
 - 2.7 Impulse and Impulsive Force
 - 2.8 Weight

- 3.0 Gravitation
 - 3.1 Law of Universal Gravitation
 - 3.2 Kepler's Law
 - 3.3 Man Made Satellite

2.0 FORCE AND MOTION I

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.1 Linear Motion	Pupils are able to: 2.1.1 Describe the type of linear motion of an object in the following states: (i) stationary (ii) uniform velocity (iii) non-uniform velocity 2.1.2 Determine: (i) distance and displacement (ii) speed and velocity (iii) acceleration/ deceleration 2.1.3 Solve problems involving linear motion using the following equations: (i) $v = u + at$ (ii) $s = \frac{1}{2}(u + v)t$ (iii) $s = ut + \frac{1}{2}at^2$ (iv) $v^2 = u^2 + 2as$	Note: Discuss motion in terms of its displacement, velocity and acceleration. Suggested activity: Carry out activities using a ticker timer and ticker tapes to determine the displacement, velocity, acceleration and deceleration for an object in linear motion. Introduce photogates and electronic timer to determine displacement, velocity, acceleration and deceleration with higher accuracy. Note: Derivation of the formulas is required. Problem solving involves linear motion with uniform acceleration only.

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.2 Linear Motion Graphs	Pupils are able to: 2.2.1 Interpret types of motion from the following: (i) displacement-time graph (ii) velocity-time graph (iii) acceleration-time graph 2.2.2 Analyse displacement-time graph to determine distance, displacement and velocity. 2.2.3 Analyse velocity-time graph to determine distance, displacement, velocity and acceleration. 2.2.4 Convert and sketch: (i) displacement-time graph to velocity-time graph and vice-versa (ii) velocity-time graph to acceleration-time graph and vice-versa. 2.2.5 Solve problems involving linear motion graphs.	Suggested activity: Pupils use "Data Logger" or appropriate smartphone applications such as "Tracker" to map the motion of an object in the form of the following: - displacement-time graph - velocity-time graph - acceleration-time graph Subsequently, analyse motion from the graphs. Note: Average speed and average velocity can be determined using displacement-time and velocity-time graph. Note: Problem-solving involves linear motion with uniform acceleration only.

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.3 Free Fall Motion	Pupils are able to: 2.3.1 Explain with examples free fall motion and gravitational acceleration. 2.3.2 Experiment to determine the value of gravitational acceleration. 2.3.3 Solve problems involving the Earth's gravitational acceleration for objects in free fall.	Suggested activity: Watch a video on free fall motion. Carry out an activity for an object falling with and without air resistance. Note: Qualitative explanation on the motion of an object falling in a uniform gravitational field. Suggested activity: Use photogates to determine gravitational acceleration, g. Compare the value of g obtained to the actual value of g at the Equator. Note: The value of g is approximately 9.78 m s^{-2} at the Equator and 9.83 m s^{-2} at the poles. Note: Value of g is positive when the object is moving downwards and negative when it is moving upwards.

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.4 Inertia	Pupils are able to: 2.4.1 Explain with examples the concept of inertia. 2.4.2 Experiment to find the relationship between inertia and mass. 2.4.3 Justify the effects of inertia in daily life.	Suggested activity: Carry out an activity to demonstrate the concept of inertia. Introduce Newton's first law of motion Note: Newton's First Law of motion states that an object will remain stationary or move with constant velocity if no external force acts on it. Inertia is not a physical quantity. Suggested activity: Carry out an experiment using an inertial balance to determine the relationship between mass and inertia. Discuss why an inertial balance can be used to measure mass in outer space. Suggested activity: Discuss: • Examples of situations in daily life involving inertia. • Positive and negative effects of inertia. • Methods of reducing the negative effects of inertia.

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.5 Momentum	Pupils are able to: 2.5.1 Explain momentum, p as the product of mass, m and velocity, v. $p = mv$ 2.5.2 Apply the Principle of Conservation of Momentum in collision and explosion.	Suggested activity: Carry out activities to investigate how the mass and velocity of an object influence the effect of stopping the object. Discuss the definition of momentum, the unit of momentum and momentum as a vector quantity. Discuss the applications of the concept of momentum in daily life . Suggested activity: Investigate situations involving the Principle of Conservation of Momentum in everyday life. Use the Dynamic Trolley Kit to investigate the Principle of Conservation of Momentum. Carry out project based learning: • Research on rocket launching technology, based on the Principle of Conservation of Momentum. • Design, build and launch water rockets. • Write a report on the application of the Principle of Conservation of Momentum in water rocket launching technology

CONTENT STANDARD	LEARNING STANDARD	NOTES
		Note: Discussion is restricted to collision and explosion in one dimension.
2.6 Force	Pupils are able to: 2.6.1 Define force as the rate of change of momentum. 2.6.2 Solve problems involving $F = ma$	Suggested activity: Carry out activities to generate ideas on the relationship between: • force and acceleration • mass and acceleration Introduce Newton's second law of motion. Note: Newton's second law of motion states that the rate of change of momentum is directly proportional to the force and acts in the direction of the force: $F \propto \frac{mv - mu}{t}$ $F \propto ma$ $F = kma; \text{ where } k = 1$ $F = ma$

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.7 Impulse and Impulsive Force	Pupils are able to: 2.7.1 Communicate to explain impulse and impulsive force. 2.7.2 Solve problems involving impulse and impulsive force.	Suggested activity: Carry out activities and discuss: - the effect of increasing or decreasing time of impact on the magnitude of impulsive force. - situations and applications involving impulse in daily life. - situations and applications involving impulsive force in the safety features in vehicles. Introducing Newton's third law of motion. Note: Newton's third law of motion states that for every action, there is an equal but opposite reaction. Impulse is the change of momentum: $\text{Impulse, } Ft = mv - mu$ Impulsive force is the rate of change of momentum in collisions that happen in a short period of time. $\text{Impulsive force, } F = \frac{mv - mu}{t}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.8 Weight	Pupils are ble to: 2.8.1 Describe weight as the gravitational force that acts on an object, $W = mg$	Note: Gravitational field strength, g is the force on a unit mass due to gravitational attraction. For an object on Earth, $g = 9.81 \text{ N kg}^{-1}$ Suggested Project: Design a model of a vehicle that applies Newton's laws of motion.

PERFORMANCE STANDARD

FORCE AND MOTION I

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall knowledge and scientific skills on Force and Motion.
2	Understand Force and Motion, and able to comprehend the concept.
3	Apply knowledge of Force and Motion to explain the occurrences or phenomena of nature and perform simple tasks.
4	Analyse information about Force and Motion in daily life problem solving about natural phenomena.
5	Evaluate to make judgement about Force and Motion in daily life problem solving and decision making to carry out a task.
6	Invent by applying the knowledge and skills about Force and Motion in daily life problem solving or decision making to carry out activities/ assignments in a new situation creatively and innovatively; giving due consideration to the social/ economic/ cultural aspects.

3.0 GRAVITATION

CONTENT STANDARD	LEARNING STANDARD	NOTES
3.1 Newton's Universal Law of Gravitation	Pupils are able to: 3.1.1 Explain Newton's Universal Law of Gravitation: $F = \frac{Gm_1m_2}{r^2}$	Suggested activity: Discuss that the gravitational force exists between two objects in the universe. Note: Gravitational force can be explained by Newton's universal law of gravitation. F is directly proportional to the product of mass of the objects and inversely proportional to the square of the distance between them. From the law: $F = \frac{Gm_1m_2}{r^2}$ where, F = gravitational force between two objects m_1 = mass of first object m_2 = mass of second object r = distance between the centre of the two objects G = universal gravitational constant ($G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$)

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.1.2 Solve problems involving Newton's Universal Law of Gravitation for: (i) two static objects on the Earth (ii) objects on the Earth's surface (iii) Earth and satellites (iv) Earth and Sun 3.1.3 Relate gravitational acceleration, g on the surface of the Earth with the universal gravitational constant, G	Note: Discuss the effects of mass and distance between two objects on the gravitational force. Note: Deriving gravitational acceleration, g from: • $F = mg$ • $F = G \frac{Mm}{r^2}$ Thus, the gravitational acceleration, g is: $g = \frac{GM}{r^2}$ M = mass of the Earth r = distance between the centre of the Earth and centre of an object ($r = R+h$) R = radius of the Earth h = height of an object from the surface of the Earth Discuss the variation of g with r using the graph g against r for: • $r < R$ • $r \geq R$

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.1.4 Justify the importance of knowing the values of gravitational acceleration of the planets in the Solar System.	Suggested activity: Compare the values of gravitational acceleration for the moon, the Sun and the planets in the solar system Discuss the importance of knowing the gravitational acceleration of planets in space exploration and sustainability of life. Carry out a multimedia presentation on the effects of gravity on human growth based on: • difference in density • bone fragility • size of lungs • blood circulation system and blood pressure
	3.1.5 Describe the centripetal force in the motion of satellites and planets system. Centripetal Force, $F = \frac{mv^2}{r}$	Suggested activity: Carry out activities to understand centripetal force using a Centripetal Force Kit. Note: Objects that orbit the Earth will experience free fall toward the centre of the Earth. Satellite and planetary motion systems are circular motions which are constantly experiencing a centripetal acceleration, a where:

CONTENT STANDARD	LEARNING STANDARD	NOTES
		$a = \frac{v^2}{r}$ v = linear velocity r = radius of orbit
	3.1.6 Determine the mass of the Earth and the Sun using Newton's universal law of gravitation and centripetal force.	Suggested activity: To determine the mass of the Earth and the Sun using: - Newton's universal law of gravitation $F = G \frac{mM_E}{r^2}$ - centripetal force: $F = \frac{mv^2}{r}$ - speed of the Earth orbiting the Sun: $v = \frac{2\pi r}{T}$ where, r = average radius of orbit T = period of the Earth orbiting the Sun

CONTENT STANDARD	LEARNING STANDARD	NOTES
3.2 Kepler's Laws	Pupils are able to: 3.2.1 Explain Kepler's Laws.	Suggested activity: Sketch an elliptical shape based on the elliptical dual-focus concept using thread and pencil. Discuss that the elliptical orbits of the planets in the solar system are almost circular. Note: Kepler's first law: All planets move in elliptical orbits, with the sun at one focus (Law of Orbits). Kepler's second law: A line that connects a planet to the sun sweeps out equal areas in equal times (Law of Areas). Kepler's third law: The square of the period of any planet is directly proportional to the cube of the radius of its orbit (Law of Periods).

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.2.2 Express Kepler's Third Law $T^2 \propto r^3$	Note: Derivation of the relationship is required. Kepler's third law, $T^2 \propto r^3$ can be derived from: - Centripetal Force, $F = \frac{mv^2}{r}$ - Gravitational Force, $F = G \frac{mM}{r^2}$ and, $v = \frac{2\pi r}{T}$ Thus, $T^2 = \left(\frac{4\pi^2}{GM}\right)r^3$ $T^2 = k r^3$ where the constant, $k = \frac{4\pi^2}{GM}$ Therefore, Kepler's third law is expressed as $T^2 \propto r^3$, where, - M is mass of the Sun; for the Sun and planetary system - M is mass of the Earth; for the Earth and satellite system

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.2.3 Solve problems using Kepler's Third Law	Note: From Kepler's third law: $\frac{T_1^2}{T_2^2} = \frac{r_1^3}{r_2^3}$ - For a planet that orbits the Sun; r = the distance between the center of the planet and the center of the Sun. - For satellites orbiting the Earth; r = R + h (distance between center of Earth and satellite center) R = Earth radius = 6370 km h = satellite elevation from Earth's surface

CONTENT STANDARD	LEARNING STANDARD	NOTES
3.3 Man-made Satellites	Pupils are able to: 3.3.1 Describe how an orbit of a satellite is maintained at a specific height by setting the necessary satellite's velocity. 3.3.2 Communicate on geostationary and non-geostationary satellites.	Suggested activity: Orbital velocity of satellite is derived and determined using centripetal force and Newton's universal law of gravitation. $v = \sqrt{\frac{GM}{r}}$ Orbital velocity is calculated for satellites, such as, ISS and Measat. Discuss the effect on the satellite if the satellite's velocity is less than its orbital velocity. Suggested activity: Search for information on geostationary and non-geostationary satellites in terms of its function and life span. Present ideas in the form of folios, multimedia presentation and others. Note: Examples of satellites : MEASAT, TiungSAT, RazakSAT, Pipit, ISS and others.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.3.3 Conceptualize escape velocity	Suggested activity: Describe the escape velocity of an object from the Earth's surface. Note: The escape velocity, v is the minimum velocity required by an object on the Earth surface to overcome gravitational force and escape to space. Escape velocity is achieved when the minimum kinetic energy supplied to the object overcomes gravitational potential energy. Gravitational Potential Energy + Minimum Kinetic Energy = 0 The gravitational potential energy, U gained by an object at a distance, r from the centre of the Earth is: $U = -\frac{GMm}{r}$ and Kinetic Energy $E_K = \frac{1}{2}mv^2$ Where m = mass of object M = mass of The Earth v = escape velocity Derivation of U is not required.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.3.4 Solve problems involving the escape velocity, v for a rocket from the Earth's surface, the Moon's surface, Mars' surface and the Sun's surface.	Formula of escape velocity of an object from the Earth's surface is derived using U and E_K: $v = \sqrt{\frac{2GM}{r}}$ Discuss why: • Earth can maintain its atmospheric surface • aeroplane cannot escape from the Earth based on the Earth's escape velocity. Escape velocity of the Earth = 11.2 km s^{-1} Suggested activity: Discuss escape velocity from the Earth's surface, the Moon's surface, Mars' surface and the Sun's surface.

PERFORMANCE STANDARD

GRAVITATION

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall knowledge and scientific skills on Gravitation.
2	Understand Gravitation, and able to comprehend the concept.
3	Apply knowledge of Gravitation to explain the occurrences or phenomena of nature and perform simple tasks.
4	Analyse information about Gravitation in daily life problem solving about natural phenomena.
5	Evaluate to make judgement about Gravitation in daily life problem solving and decision making to carry out a task.
6	Invent by applying the knowledge and skills about Gravitation in daily life problem solving or decision making to carry out activities/ assignments in a new situation creatively and innovatively; giving due consideration to the social/ economic/ cultural aspects.

THEME

HEAT

LEARNING AREA

4.0 Heat

Theme 3:

HEAT

This theme discusses concepts and laws related to heat energy and its applications in life. Discussions include energy changes and changes in gas properties. This theme involves discussions on the gas laws; Boyle's law, Charles' law and pressure law (Gay-Lussac)

Learning area:

- 4.0 Heat
 - 4.1 Thermal Equilibrium
 - 4.2 Specific Heat Capacity
 - 4.3 Specific Latent Heat
 - 4.4 Gas Laws

4.0 HEAT

CONTENT STANDARD	LEARNING STANDARD	NOTES
4.1 Thermal Equilibrium	Pupils are able to: 4.1.1 Explain with examples thermal equilibrium in daily life. 4.1.2 Calibrate a liquid-in-glass thermometer using two fixed points.	Suggested activity: Carry out an activity that shows thermal equilibrium between two bodies in thermal contact. Discuss situations and applications of thermal equilibrium in daily life. Suggested activity: Carry out an activity to calibrate a liquid-in-glass thermometer by using boiling point and melting point of distilled water for calibration.
4.2 Specific Heat Capacity	Pupils are able to: 4.2.1 Explain heat capacity, C. 4.2.2 Define specific heat capacity of a material, c $c = \frac{Q}{m(\Delta \theta)}$	Suggested activity: Discuss heat capacity and examples of daily life situations involving heat capacity. Suggested activity: Gather information to compare the specific heat capacity of different materials such as water, oil, aluminum, copper, and other materials.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.2.3 Experiment to determine: (i) the specific heat capacity of water (ii) the specific heat capacity of aluminum 4.2.4 Communicate to explain the applications of specific heat capacity in daily life, material engineering and natural phenomena.	Note: Specific heat capacity, $c = \frac{Q}{m(\Delta \theta)}$ c = specific heat capacity of a material (J kg⁻¹ °C⁻¹ atau J kg⁻¹ K⁻¹) Q = heat (J) m = mass (kg) $\Delta \theta$ = temperature change (°C atau K) Suggested activity: Gather information and report on the applications of specific heat capacity in daily life, material engineering and natural phenomena. Note: Examples of specific heat capacity application in daily life: • selection of traditional building materials in various climate zones • cooking utensils • car radiator system

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.2.5 Solve problems involving specific heat capacity using formula: $Q = mc\Delta\theta$	Examples of application of specific heat capacity in material engineering: • outer layer of a spacecraft • production of the latest materials in the construction of green buildings • cooking utensils Examples of natural phenomena involving specific heat capacity: • land breeze • sea breeze Note: Problem solving involving: $Q = mc\Delta\theta$ $Pt = mc\Delta\theta$ P = electric power (W) t = time (s) Assumptions made in problem solving should be explained. Carry out project-based learning: Build a model of a cluster home that can reduce the problem of extreme temperatures (refer to PdP STEM Physics Resources at www.bpk.moe.gov.my).

CONTENT STANDARD	LEARNING STANDARD	NOTES
4.3 Specific Latent Heat	Pupils are able to: 4.3.1 Explain latent heat. 4.3.2 Define: (i) specific latent heat, ℓ $\ell = \frac{Q}{m}$ (ii) specific latent heat of fusion, ℓ_f (iii) specific latent heat of evaporation, ℓ_v 4.3.3 Experiment to determine: (i) specific latent heat, ℓ_f of fusion of ice. (ii) specific latent heat of evaporation, ℓ_v of water	Suggested activity: Explain the concept of latent heat in terms of molecular bonding during melting and boiling. Suggested activity: Compare and discuss: - Specific latent heat of fusion of ice and wax - Specific latent heat of evaporation of water, oil and other substances Note: Specific latent heat, ℓ is the quantity of heat, Q absorbed or released during change of phase of 1 kg of a substance at constant temperature. Suggested activity: Compare and discuss the value of the - specific latent heat of fusion of ice, ℓ_f and specific latent heat of vaporization of water, ℓ_v - the values of ℓ_f and ℓ_v obtained from experiments with standard values.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.3.4 Communicate to explain the applications of specific latent heat in daily life. 4.3.5 Solve problems involving latent heat.	Suggested activity: Carry out an activity to show that evaporation causes cooling such as blowing air into alcohol. Discuss the applications of specific latent heat in daily life such as: • the cooling system in a refrigerator • sweat evaporation from certain fabrics • the steaming of food Note: The formula used is: $Q = m \ell$ $Pt = m \ell$ Assumptions made in problem solving should be stated.

CONTENT STANDARD	LEARNING STANDARD	NOTES
4.4 Gas Laws	Pupils are able to: 4.4.1 Explain pressure, temperature and volume of gas in terms of the behaviour of gas molecules based on the Kinetic Theory of Gas. 4.4.2 Experiment to determine the relationship between the pressure and volume of a fixed mass of gas at constant temperature.	Suggested activity: Observe computer simulations or models to understand the behaviour of gas molecules. Suggested activity: Deduce Boyle's law by discussing the experimental results based on the P-V graph. Note: Boyle's law states that for a fixed mass of gas, pressure is inversely proportional to volume at constant temperature. $\left(P \propto \frac{1}{V} \right).$ PV = k, k is a constant P = gas pressure (Pa) V = gas volume (m³)

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.4.3 Experiment to determine the relationship between the volume and temperature of a fixed mass of gas at constant pressure.	Suggested activity: Discuss the experimental results including: • extrapolation of V-θ graph, to show that when V=0, $\theta = -273\text{ }^{\circ}\text{C}$ • absolute zero temperature and Kelvin scale • V-T graph where T is absolute temperature • deduce Charles's law Note: Charles's law states that for a fixed mass of gas, volume is directly proportional to absolute temperature at constant pressure. $\frac{V}{T} = k, \text{ where } k \text{ is a constant}$ T = absolute temperature (K)
	4.4.4 Experiment to determine the relationship between the pressure and temperature of a fixed mass of gas at constant volume.	Suggested activity: Discuss experimental results that include: • extrapolation of p-θ graph to indicate when p=0, $\theta = -273\text{ }^{\circ}\text{C}$. • p-T graph, where T is absolute temperature • deduce Gay-Lussac law

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.4.5 Solve problems involving pressure, temperature and volume for a fixed mass of gas using Gas law formulas.	Note: Gay-Lussac's law states that for a fixed mass of gas, pressure is directly proportional to absolute temperature at constant volume ($p \propto T$). $\frac{P}{T} = k$, where k is a constant Note: The formulas used: • $P_1 V_1 = P_2 V_2$ • $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ • $\frac{P_1}{T_1} = \frac{P_2}{T_2}$

PERFORMANCE STANDARD

HEAT

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall knowledge and scientific skills on Heat.
2	Understand Heat, and able to comprehend the concept.
3	Apply knowledge of Heat to explain the occurrences or phenomena of nature and perform simple tasks.
4	Analyse information about Heat in daily life problem solving about natural phenomena.
5	Evaluate to make judgement about Heat in daily life problem solving and decision making to carry out a task.
6	Invent by applying the knowledge and skills about Heat in daily life problem solving or decision making to carry out activities/ assignments in a new situation creatively and innovatively; giving due consideration to the social/ economic/ cultural aspects.

THEME

WAVES, LIGHT AND OPTICS

LEARNING AREA

5.0 Waves

6.0 Light and Optics

Theme 4:

WAVES, LIGHT AND OPTICS

This theme provides an understanding of the concepts and phenomena of wave, light and optics, and its applications in life. This theme covers nature of the wave in terms of wave propagation, light characteristics and electromagnetic waves. The knowledge is applied in wireless communication, home appliances, medicine, industry and so on. Light-related experiments are focused on understanding the concepts and principles associated with geometrical optics and their applications in life.

Learning Area:

5.0 Waves

- 5.1 Fundamentals of Waves
- 5.2 Damping and Resonance
- 5.3 Reflection of Waves
- 5.4 Refraction of Waves
- 5.5 Diffraction of Waves
- 5.6 Wave Interference
- 5.7 Electromagnetic Waves

6.0 Light and Optics

- 6.1 Fundamentals of Light
- 6.2 Refraction of Light
- 6.3 Total Internal Reflection
- 6.4 Image Formation by Lens
- 6.5 Thin Lens Formula
- 6.6 Optical instruments
- 6.7 Image Formation by Spherical Mirrors

5.0 WAVES

CONTENT STANDARD	LEARNING STANDARD	NOTES
5.1 Fundamentals of Waves	Pupils are able to: 5.1.1 Describe waves. 5.1.2 State the types of waves.	Suggested activity: Carry out activities to investigate the production of waves through oscillating systems or vibrations. Carry out activities using ripple tank/ slinky/ computer simulations to generate the idea that wave transfers energy without transferring matter. Note: Two types of waves: • Progressive waves • Stationary waves Progressive waves are waves where the profile of the wave changes with time. Progressive waves consist of: • Transverse waves • Longitudinal waves Stationary waves are waves where the profile of the waves does not change with time.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.1.3 Compare transverse waves and longitudinal waves.	Examples of stationary waves are waves produced by musical instruments. Discussion on stationary waves is restricted to its meaning and shape only. Waves are categorized into • Mechanical waves • Electromagnetic waves For example: Mechanical waves – water and sound waves Electromagnetic waves – light and radio waves Suggested activity : Carry out activities using ripple tank/ slinky spring/ computer simulations to explain transverse waves and longitudinal waves. Give examples of transverse waves and longitudinal waves. Note: Examples of transverse waves are water waves, radio waves and light waves. An example of longitudinal wave is sound waves.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.1.4 Explain the characteristics of waves: (i) Amplitude (a) (ii) Period (T) (iii) Frequency (f) (iv) wavelength (λ) (v) wave speed (v)	Suggested activity: Define the following wave terms: • Amplitude (a) • Period (T) • Frequency (f) • wavelength (λ) • wave speed (v) Introduce the formula of wave speed $v = f \lambda$
	5.1.5 Sketch and interpret wave graphs: (i) displacement - time (ii) displacement - distance	Suggested activity: Determine the value of the following from the graph: • Amplitude (a) • Period (T) • Frequency (f) • wavelength (λ) • wave speed (v)
	5.1.6 Determine wavelength, λ , frequency, f and wave speed, v.	Suggested activity: Carry out an activity using ripple tank and digital xenon stroboscope to determine wavelength and frequency of a wave, and hence, calculate the wave speed using the wave formula, $v = f \lambda$.

CONTENT STANDARD		LEARNING STANDARD	NOTES
5.2	Damping and Resonance	Pupils are able to: 5.2.1 Describe damping and resonance for an oscillating/ vibrating system	Suggested activity: Observe the phenomenon of damping in an oscillating system such as a simple pendulum and sketch an amplitude–time graph. Discuss the cause and ways to overcome damping in an oscillating/ vibrating system. Carry out activities/ view computer simulations/ make observations using a Tuning Fork Kit and Barton’s pendulum to investigate how resonance occurs. Note: During damping, the oscillating frequency remains constant. For Barton’s pendulum, the pendulum in resonance oscillates with maximum amplitude.
		5.2.2 Justify the effects of resonance in our daily lives.	Suggested activity: View videos of an event or incident, for example the collapse of Tacoma Narrows Bridge, USA in 1940 and the tuning of musical instruments.

CONTENT STANDARD	LEARNING STANDARD	NOTES
5.3 Reflection of Waves	Pupils are able to: 5.3.1 Describe reflection of waves from the following aspects: (i) angle of incidence (i) (ii) angle of reflection (r) (iii) wavelength (λ), (iv) frequency (f), (v) speed (v) (vi) direction of propagation of waves.	Suggested activity: Carry out activities on the reflection of plane water waves in a ripple tank to determine: • angle of incidence (i) • angle of reflection (r) • wavelength (λ) • frequency (f) • speed (v) • direction of propagation of waves. Note: Wave fronts should be introduced.
	5.3.2 Draw a diagram to show the reflection of plane water waves by through a plane reflector.	
	5.3.3 Justify the application of reflection of waves in daily life.	Suggested activity: Discuss the applications of reflection of waves in the following fields: • Telecommunication • Medicine • Aquaculture • Oil exploration

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.3.4 Solve problems involving reflection of waves.	Note: Problem solving is limited to the reflection of water waves and sound waves.
5.4 Refraction of Waves	Pupils are able to: 5.4.1 Describe refraction of waves from the following aspects: (i) angle of incidence (i) (ii) angle of refraction (r) (iii) wavelength (λ) (iv) frequency (f) (v) speed (v) (vi) direction of propagation of waves. 5.4.2 Draw diagrams to show the refraction of waves for two different depths. 5.4.3 Explain natural phenomena of refraction of waves in daily life.	Suggested activity: Carry out activities on refraction of waves for plane water waves using a ripple tank. Discuss refraction of waves is due to the change of wave velocity propagating through two different densities or depths. Suggested activity: Discuss by drawing the refraction of plane water waves propagating at a particular incident angle at the boundary of two different depths. Suggested activity: Discuss natural phenomena of refraction waves such as: • sound is heard more clearly at night compared to during the day • wavefronts follow the shape of the shoreline as it moves towards the beach

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.4.4 Solve problems involving refraction of waves.	Note: Formula: $v = f\lambda$ $\frac{v_1}{\lambda_1} = \frac{v_2}{\lambda_2}$
5.5 Diffraction of Waves	Pupils are able to: 5.5.1 Describe diffraction of waves from the following aspects: (i) wavelength (λ) (ii) frequency (f) (iii) speed (v) (iv) direction of propagation of waves 5.5.2 Determine factors affecting diffraction of waves. 5.5.3 Draw diagrams to show the pattern of diffraction of water waves and the effect of diffraction of light waves.	Suggested activity: Carry out activities/ view computer stimulations to show diffraction of: - water waves - light waves, and - sound waves Suggested activity: Carry out activities of diffraction of plane water waves by changing: - width of the gap - wavelength Suggested activity: Draw a diagram to show the pattern of diffraction of plane water waves for different widths of gap and different wavelengths.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.5.4 Explain the applications of diffraction of waves in daily life.	Carry out an activity with red laser light ($\lambda = 700 \text{ nm}$) to observe and draw the effects of diffraction through a single slit and a pin hole. Suggested activity: Gather information and discuss situations on diffraction of water waves, light waves and sound waves in daily life.
5.6 Interference of Waves	5.6.1 Pupils are able to: Explain the principle of superposition of waves.	Suggested activity: Investigate superposition of waves using computer simulations/ transparency slides. Carry out activities to show the interference of waves with two coherent sources of waves for: • water waves • light waves • sound waves using an Audio Generator Kit. Discuss constructive (antinode) and destructive (node) interference using the superposition principle. Note: Two waves sources are coherent when: • both waves have the same frequency • their phase difference is constant

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.6.2 Describe the pattern of interference for: (i) water waves (ii) sound waves (iii) light waves	Suggested activity: Draw the pattern of interference of waves for different distance of separation of slits / sources and for different wavelengths.
	5.6.3 Relate λ , a, x and D for the wave interference pattern.	Suggested activity: Carry out activities to investigate the relationship between λ , a, x and D for the wave interference pattern of: • Water waves • Sound waves • Light waves (Young's double-slit experiment) Introduce $\lambda = \frac{ax}{D}$
	5.6.4 Solve problems involving interference of waves.	Note: Formula: $\lambda = \frac{ax}{D}$
	5.6.5 Communicate on the applications of interference of waves in daily life.	Suggested activity: Gather information on the applications of interference of waves in daily life.

CONTENT STANDARD	LEARNING STANDARD	NOTES
		For example : non-reflective glasses, design of theater hall involving seating arrangement and other related examples.
5.7 Electromagnetic Waves	Pupils are able to: 5.7.1 Characterise electromagnetic waves 5.7.2 State the components of the electromagnetic spectrum according to wavelengths and frequencies. 5.7.3 Communicate to explain about the applications of each component in the electromagnetic spectrum in daily life.	Suggested activity: Gather information on the properties of electromagnetic waves. Note: Electromagnetic waves are formed from magnetic and electric fields oscillating perpendicularly to each other. Suggested activity: Gather information on the daily life applications of components of the electromagnetic spectrum, such as: - radio waves, example: radio communication, television and communication devices - micro waves, example : microwave oven, cellular telephone, wifi, Bluetooth, zigBee, z-wave and satellite television. - Infrared, example : remote control, infrared camera and infrared binocular

CONTENT STANDARD	LEARNING STANDARD	NOTES
		• visible light, example : laser technology, photography and optical devices • ultraviolet rays, example : counterfeit note detection, and sterilisation • X-ray, example: security at airports, forensics and medicine • Gamma rays, example : industrial, medical and other applications

PERFORMANCE STANDARD

WAVES

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall knowledge and scientific skills on Waves.
2	Understand Waves, and able to comprehend the concept.
3	Apply knowledge of Waves to explain the occurrences or phenomena of nature and perform simple tasks.
4	Analyse information about Waves in daily life problem solving about natural phenomena.
5	Evaluate to make judgement about Waves in daily life problem solving and decision making to carry out a task.
6	Invent by applying the knowledge and skills about Waves in daily life problem solving or decision making to carry out activities/ assignments in a new situation creatively and innovatively; giving due consideration to the social/ economic/ cultural aspects.

6.0 LIGHT AND OPTICS

CONTENT STANDARD	LEARNING STANDARD	NOTES
6.1 Refraction of Light	Pupils are able to: 6.1.1 Describe refraction of light 6.1.2 Explain refractive index, n.	Note: Refraction of light occurs due to the change in velocity of light when traversing through mediums of different optical density. Suggested activity: Compare the refractive index of different materials such as air, water, oil, glass and diamond. Relate the refractive index of a material to its optical density. Note: Refractive index, n is the degree to which light bends when traversing from vacuum to a medium. Refractive index is defined as the ratio of speed of light in vacuum to speed of light in the medium: $n = \frac{\text{speed of light in vacuum}}{\text{speed of light in medium}} = \frac{c}{v}$ where $c = 3.0 \times 10^8 \text{ ms}^{-1}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.1.3 Conceptualize Snell's Law	Note: Law of refraction of light states that for light traversing between two mediums: - The incident ray, refractive ray and normal line meet at a point and lies in the same plane. - Snell's Law: $n_1 \sin \theta_1 = n_2 \sin \theta_2$ therefore, $\frac{n_2}{n_1} = \frac{\sin \theta_1}{\sin \theta_2}$ where, n_1 = refractive index of medium 1 n_2 = refractive index of medium 2 θ_1 = incident angle θ_2 = refracted angle If medium 1 is air ($n_1=1$), $n = \frac{\sin i}{\sin r}$ n = refractive index of particular medium i = incident angle in the air r = refracted angle in the particular medium

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.1.4 Experiment to determine the refractive index, n for glass block or perspex.	Suggested activity: Carry out an experiment to determine the refractive index, n for glass block/ perspex using laser beam/ ray box and semicircular glass/ perspex block.
	6.1.5 Explain real depth and apparent depth.	Suggested activity: Draw a ray diagram to show real depth, H and apparent depth, h. Note: The relationship between refractive index, n with real depth, H and apparent depth, h is: $n = \frac{\text{real depth}}{\text{apparent depth}} = \frac{H}{h}$
	6.1.6 Experiment to determine refractive index of a medium using real depth and apparent depth.	Suggested Activity: Carry out an activity to determine the refractive index of water by using real depth and apparent depth using a non-parallax method.
	6.1.7 Solve problems related to refraction of light.	Note: Problem solving is limited to light traversing between two different mediums.

CONTENT STANDARD	LEARNING STANDARD	NOTES
6.2 Total Internal Reflection	Pupils are able to: 6.2.1 Describe critical angle and total internal reflection. 6.2.2 Relate critical angle with refractive index, n, $n = \frac{1}{\sin c}$ 6.2.3 Communicate to explain natural phenomena and applications of total internal reflection in daily life.	Suggested Activity: Carry out activities to observe the phenomenon of total internal reflection. Suggested Activity: Discuss the relationship between critical angle and refractive index using Snell's Law with the aid of a ray diagram. Suggested activity: Gather information and discuss natural phenomena that involve total internal reflection. Carry out activities to observe total internal reflection in a water stream or optical fibre kit. Note: Example of natural phenomena: • Formation of rainbow • Mirage Example of application: • Prism periscope • Optical fibre • Cat's eye reflector

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.2.4 Solve problems involving total internal reflection.	
6.3 Image Formation by Lenses	Pupils are able to: 6.3.1 Identify convex lenses as converging lenses and concave lenses as diverging lenses 6.3.2 Estimate focal length for a convex lens using distant object.	Suggested Activity: Carry out activities with Optical Ray Kit to show convex lens as converging lens and concave lens as diverging lens. Introduce terms used in optics: • principle axis • lens axis • optical centre, O • focal point, F • object distance, u • image distance, v • focal length, f Suggested Activity: Carry out activities to observe real images and estimate the focal length of a convex lens using distant objects.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.3.3 Determine the position and features of images formed by : (i) convex lens (ii) concave lens	Suggested Activity: Carry out activities and draw ray diagrams to determine features of images formed by convex lens and concave lens for different object distance: • $u > 2f$ • $u = 2f$ • $f < u < 2f$ • $u = f$ • $u < f$ Note: Virtual image is an image that cannot be formed on the screen.
	6.3.4 Explain linear magnification, m as: $m = \frac{v}{u}$	Suggested Activity: Carry out activities or observe computer simulations to generate ideas about image magnification with the aid of a ray diagram. Note: Linear magnification can also be: $m = \frac{h_i}{h_o} = \frac{v}{u}$ where : h_i = height of the image h_o = height of the object v = image distance u = object distance

CONTENT STANDARD	LEARNING STANDARD	NOTES
6.4 Thin Lens Formula	Pupils are able to: 6.4.1 Experiment to: (i) Investigate the relationship between object distance, u and image distance, v for a convex lens. (ii) Determine the focal length of a thin lens using lens formula: $\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$ 6.4.2 Solve problems using lens formula for convex and concave lens.	Note: Focal length, f of a convex lens is determined from the graph of $\frac{1}{v}$ against $\frac{1}{u}$. Note: The value of f for convex lens is always positive and concave lens is always negative.
6.5 Optical Instruments	Pupil are able to: 6.5.1 Justify the usage of lenses in optical instruments such as magnifying lens, telescope and microscope.	Suggested Activity: Carry out 'hands on' activities, active reading and/ or internet search to justify the usage of lenses in optical instruments.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.5.2 Design and build a compound microscope and astronomical telescope.	Suggested Activity: Carry out project-based learning: • Gather information about compound microscope and astronomical telescope. • Draw ray diagrams to show image formation in compound microscope and astronomical telescope. • Design and build compound microscope and astronomical telescope using convex lenses.
	6.5.3 Communicate application of small lenses in optical instrument technology.	Suggested Activity: Discuss about small lens application in optical instruments such as cameras in smart phone and CCTV. Discuss about the limitation to the thickness of a smart phone due to the thickness of the camera's lens.
6.6 Image Formation by Spherical Mirror	Pupils are able to: 6.6.1 Determine position and features of image formed by: (i) concave mirror (ii) convex mirror	Suggested Activity: Introduce terms used in optics: • principal axis • focal point, F • object distance, u • image distance, v • focal length, f • centre of curvature, C • radius of curvature, r

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.6.2 Explain the applications of concave and convex mirrors in life.	Draw ray diagrams to determine the position and features of image formed by: • concave mirror • convex mirror Carry out activities and draw ray diagrams to determine the features of images formed by concave and convex mirrors for different object distances: • $u > 2f$ • $u = 2f$ • $f < u < 2f$ • $u = f$ • $u < f$ Note: The radius of curvature of a mirror is twice the focal length: $r = 2f$ Suggested activity: Gather information to justify the use of concave and convex mirrors in life.

PERFORMANCE STANDARD

LIGHT AND OPTICS

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall knowledge and scientific skills on Light and Optics.
2	Understand Light and Optics, and able to comprehend the concept.
3	Apply knowledge of Light and Optics to explain the occurrences or phenomena of nature and perform simple tasks.
4	Analyse information about Light and Optics in daily life problem solving about natural phenomena.
5	Evaluate to make judgement about Light and Optics in daily life problem solving and decision making to carry out a task.
6	Invent by applying the knowledge and skills about Light and Optics in daily life problem solving or decision making to carry out activities/ assignments in a new situation creatively and innovatively; giving due consideration to the social/ economic/ cultural aspects.

Content Standard,
Learning Standard
and Performance Standard
Form 5

THEME

NEWTONIAN MECHANICS

LEARNING AREA

1.0 FORCE AND MOTION II

2.0 PRESSURE

Theme 1: NEWTONIAN MECHANICS

This theme introduces the concept of resultant force, resolution of forces and forces in equilibrium in order to explain the motion of an object. Focus is given on the concept of elasticity and pressure that is related to force. Emphasis is also given on problem solving as well as the contextual applications of forces in daily life.

Learning Area:	1.0	Force and Motion II
	1.1	Resultant Force
	1.2	Resolution of Forces
	1.3	Forces in Equilibrium
	1.4	Elasticity
	2.0	Pressure
	2.1	Pressure in Liquids
	2.2	Atmospheric Pressure
	2.3	Gas Pressure
	2.4	Pascal's Principle
	2.5	Archimedes' Principle
	2.6	Bernoulli's Principle

1.0 FORCE AND MOTION II

CONTENT STANDARD	LEARNING STANDARD	NOTES
1.1 Resultant Force	Pupils are able to: 1.1.1 Describe resultant force 1.1.2 Determine the resultant force	Suggested activity: Use two spring balance to pull a block to generate an idea of resultant force and determine its direction. Suggested activity: Calculate the resultant force of two forces that act upon an object on a plane : • in the same direction • in the opposite direction • perpendicular to each other • when the two forces are acting at an angle (using scale diagrams of the triangle and parallelogram methods) A Vector Force Table Kit is used to determine the resultant force.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	1.1.3 Communicate about resultant force, F when an object is : (i) stationary, $F = 0 \text{ N}$ (ii) moving with constant velocity, $F = 0 \text{ N}$ (iii) moving with constant acceleration, $F \neq 0 \text{ N}$ 1.1.4 Solve problems involving resultant force, mass and acceleration of an object	Suggested activity: Discuss resultant force that acts on an object using free body diagrams. Relate resultant force to Newton's laws of motion. Suggested activity: Solve problems involving resultant force that acts on: • an object that is moving horizontally or vertically • a person in the elevator • an object that is pulled using a pulley

CONTENT STANDARD	LEARNING STANDARD	NOTES
1.2 Resolution of Forces	Pupils are able to: 1.2.1 Describe resolution of forces 1.2.2 Solve problems involving resultant force and resolution of forces	Suggested activity : Resolve a force into two components when the object does not move in the direction of the force, such as : • pulled or pushed at an inclined angle • slides on an inclined plane due to its weight
1.3 Forces in Equilibrium	Pupils are able to : 1.3.1 Explain forces in equilibrium 1.3.2 Sketch a triangle of forces in equilibrium	Suggested activity: Sketch a triangle of forces in equilibrium for: • a stationary object on an inclined plane • a hanging picture frame • a ship pulled by two tugboats at constant velocity

CONTENT STANDARD	LEARNING STANDARD	NOTES
	1.3.3 Solve problems involving forces in equilibrium	A Vector Force Table Kit is used to demonstrate the forces in equilibrium. Note: The direction of forces in the triangle of forces must be in sequence. Suggested activity: Solve problems involving forces in equilibrium using these methods: • resolution of forces • drawing scale diagrams of triangle of forces Note: Sine and cosine rules can be used to solve problems involving forces in equilibrium.

CONTENT STANDARD	LEARNING STANDARD	NOTES
1.4 Elasticity	Pupils are able to : 1.4.1 Describe elasticity 1.4.2 Experiment to investigate the relationship between force, F and extension of spring, x 1.4.3 Communicate about the law related to force, F and extension of spring, x	Suggested activity: Conduct activities to generate ideas on elasticity using objects such as spring, sponge and rubber band. Suggested activity: Plan and conduct an experiment to determine the relationship between force and extension of spring. Introduce Hooke's law, $F = kx$ Suggested activity: Analyse the graph of F against x to determine: (i) value of spring constant, k from the gradient of graph (ii) elastic potential energy from the area under the graph: $E_p = \frac{1}{2}Fx$ $E_p = \frac{1}{2}kx^2$

CONTENT STANDARD	LEARNING STANDARD	NOTES
	1.4.4 Solve problems involving force and extension of spring	Discuss factors that affect the value of spring constant, k : • length • diameter • thickness • type of material Suggested activity: Solve problems involving combinations of series and parallel springs.

PERFORMANCE STANDARD

FORCE AND MOTION II

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Force and Motion II.
2	Understand concepts of Force and Motion II and able to comprehend them.
3	Apply concept of Force and Motion II to explain occurrences of natural phenomenon and perform simple tasks.
4	Analyse information and draw connections on Force and Motion II in the context of problem solving on occurrences of natural phenomenon.
5	Evaluate to make judgement on Force and Motion II in the context of problem solving and decision making to complete a task.
6	Create new or original work on Force and Motion II in the context of problem solving and decision making to complete activities / assignments creatively and innovatively in a new situation; taking into consideration the social / economic / cultural values of society.

2.0 PRESSURE

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.1 Pressure in Liquids	Pupils are able to : 2.1.1 Communicate about the concept of pressure in liquids $P = h\rho g$ 2.1.2 Experiment to investigate factors affecting pressure in liquids	Suggested activity: Derive formula $P = h\rho g$ from: $P = \frac{F}{A} \text{ and } \rho = \frac{m}{V}$ Suggested activity: Carry out experiments to investigate factors affecting pressure in liquids: • depth • density Carry out an activity to show that cross sectional area and shape of container do not affect pressure in liquids. Discuss : • pressure in liquids at a point acts in all directions • points at the same level have the same pressure Determine the density of an unknown liquid using a liquid with known density and a U-tube ($h_1\rho_1g = h_2\rho_2g$).

CONTENT STANDARD	LEARNING STANDARD	NOTES
	2.1.3 Solve problems involving pressure in liquids	Note: Atmospheric pressure should be considered when calculating the actual pressure on an object in liquids.
	2.1.4 Communicate about applications of pressure in liquids in daily life	Suggested activity: Discuss applications of pressure in liquids such as : • position of water tank • position of intravenous liquid which is higher than a patient's body • construction of a dam (thickness of the wall and position of penstock) • use of siphon Conduct a study to determine the highest transfer rate of fluid using a siphon based on factors such as: • diameter of tube • length of tube • relative height of containers Implement STEM project related to pressure in liquids (Source: <i>Bahan Sumber PdP STEM Fizik</i>), www.bpk.moe.gov.my

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.2 Atmospheric Pressure	Pupils are able to: 2.2.1 Describe atmospheric pressure 2.2.2 Communicate about the value of atmospheric pressure 2.2.3 Solve problems in daily life involving various pressure units	Suggested activity: Discuss atmospheric pressure based on the weight of the air column that acts on an object on the surface of the earth. Suggested activity: Discuss how the value of atmospheric pressure is determined using the height of a mercury column supported by atmospheric pressure (Torricelli experiment / mercury barometer). $P_{\text{atm}} = 760 \text{ mm Hg}$ Describe pressure measuring tools such as Fortin barometer and aneroid barometer. Note: Pressure units such as: • Pascal, Pa • mm Hg • m H₂O • milibar

CONTENT STANDARD	LEARNING STANDARD	NOTES
	2.2.4 Describe the effects of atmospheric pressure on objects at high altitude and underwater	Suggested activity: Discuss the pressure that acts at: • high altitudes such as on mountain climbers, planes and astronauts • extreme depths such as on divers and submarine
2.3 Gas Pressure	Pupils are able to: 2.3.1 Determine gas pressure using a manometer 2.3.2 Solve problems involving gas pressure in daily life	Suggested activity: Carry out an activity to determine gas pressure in a container using a water manometer Suggested activity: Calculate gas pressure in a container using a mercury manometer in mm Hg and Pa.
2.4 Pascal's Principle	Pupils are able to: 2.4.1 Describe the principle of pressure transmission in an enclosed fluid	Suggested activity: Make an observation using Pascal's piston to generate an idea that pressure acting on an enclosed liquid is uniformly transmitted in all directions. State Pascal's principle.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	2.4.2 Communicate about hydraulic system as a force multiplier	Suggested activity: Carry out activities using a simple hydraulic system and hydraulic press. Derive a force multiplier formula from Pascal's principle: $\frac{F_1}{A_1} = \frac{F_2}{A_2}$ therefore, $F_2 = \frac{A_2}{A_1} F_1$ whereby, F_1 = force acting on surface area A_1 F_2 = force acting on surface area A_2
	2.4.3 Communicate about applications of Pascal's principle	Suggested activity: Discuss applications of Pascal's principle in: - hydraulic brake - hydraulic jack
	2.4.4 Solve problems involving Pascal's principle in daily life	

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.5 Archimedes' Principles	Pupils are able to: 2.5.1 Describe the relationship between buoyant force and the difference in liquid pressure at different depths for a submerged object	Suggested activity: Discuss buoyant force as a result of the difference in liquid pressure between two levels of depth for a submerged object. Derive buoyant force, $F_B = \rho Vg$ whereby, ρ = density of liquid V = volume of liquid displaced g = gravitational acceleration State Archimedes' principle. Carry out an experiment to determine the relationship between buoyant force and weight of liquid displaced.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	2.5.2 Relate the balance of forces with the state of floatation of an object in a fluid	Suggested activity: Discuss the state of floatation of an object in a fluid: - weight of object, $W =$ buoyant force, object floats at a constant level - weight of object, $W >$ buoyant force, object moves downward with an acceleration - weight of object, $W <$ buoyant force, object moves upward with an acceleration
	2.5.3 Communicate about applications of Archimedes' principle in daily life	Suggested activity: Carry out activities to determine the density of various liquids using hydrometer. Build a Cartesian diver to understand the principle of ballast tanks in a submarine. Research and report on applications of Archimedes' principle such as: - ship and Plimsoll line - submarine - hot air balloon and weather balloon
	2.5.4 Solve problems involving Archimedes' principle and buoyancy	

CONTENT STANDARD	LEARNING STANDARD	NOTES
2.6 Bernoulli's Principle	Pupils are able to: 2.6.1 Describe the effect of fluid velocity on pressure 2.6.2 Explain lift as a result of the difference in pressure due to different velocity of fluids	Suggested activity: Carry out activities to generate an idea that fluid at high velocity creates a low pressure area such as: • blowing on the top surface of a piece of paper • using straw to blow air in between two balloons hung with thread • using Venturi tube to observe the flow of water or air State Bernoulli's principle. Suggested activity: Carry out activities to investigate the effects of lift using: • a filter funnel with ping pong ball • an aerofoil kit

CONTENT STANDARD	LEARNING STANDARD	NOTES
	2.6.3 Communicate about applications of Bernoulli's principle in daily life	Explain lift on an aerofoil by applying Bernoulli's principle and Newton's third law : - Bernoulli's principle: lift, $F = (P_2 - P_1)A$ whereby, $P_2 - P_1$ = difference in pressure A = surface area - Newton's third law: aerofoil's angle of attack contributes to lift. Note: The direction of force produced is from high to low pressure areas. Suggested activity: Research and report on Bernoulli's principle in daily life such as Bunsen burners, racing cars, sports and aeronautics. Proposed STEM project: design a paper plane capable of flying at a distance by applying Bernoulli's principle and Newton's third law of motion.

PERFORMANCE STANDARD

PRESSURE

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Pressure.
2	Understand concepts of Pressure, and able to comprehend them.
3	Apply concept of Pressure to explain occurrences of natural phenomenon and perform simple tasks.
4	Analyse information and draw connections on Pressure in the context of problem solving on the occurrences of natural phenomenon.
5	Evaluate to make judgement on Pressure in the context of problem solving and decision making to complete a task.
6	Create new or original work on Pressure in the context of problem solving and decision making to complete activities/assignments creatively and innovatively in a new situation; taking into consideration the social / economic / cultural values of society.

THEME

ELECTRICITY AND ELECTROMAGNETISM

LEARNING AREA

3.0 Electricity

4.0 Electromagnetism

Theme 2:**ELECTRICITY AND ELECTROMAGNETISM**

This theme provides an understanding of electric field and its effects on electric charge. Focus is given on current, potential difference, electromotive force (e.m.f) and internal resistance as well as their applications in simple circuits. Magnetic field generated from current establishes the relationship between electricity and magnetism. Emphasis is also given to the phenomenon of induced current due to the change in magnetic field. These concepts will be used in generation, transmission and distribution of electricity.

Learning area:

- 3.0 Electricity
 - 3.1 Current and Potential Difference
 - 3.2 Resistance
 - 3.3 Electromotive Force (e.m.f) and Internal Resistance
 - 3.4 Electrical Energy and Power

- 4.0 Electromagnetism
 - 4.1 Force on a Current-carrying Conductor in a Magnetic Field
 - 4.2 Electromagnetic Induction
 - 4.3 Transformer

3.0 ELECTRICITY

CONTENT STANDARD	LEARNING STANDARD	NOTES
3.1 Current and Potential Difference	Pupils are able to: 3.1.1 Explain electric field 3.1.2 Define strength of electric field, E	Suggested activity: Define electric field as a region where an electric charge experiences a force. Carry out activities to explain electric field using an electric field kit. Draw electric field lines from: • two spherical charged electrodes • a spherical electrode and a plane charged plate • two parallel plane charged plates Suggested activity: Define strength of electric field, E as force acting on a unit positive charge in electric field: $E = \frac{F}{q}$ whereby, E = strength of electric field (N C⁻¹) F = electric force (N) q = quantity of electric charge (C)

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.1.3 Explain behaviour of charged particles in an electric field	Discussion is limited to two parallel charged plates where the strength of electric field, E is: $E = \frac{V}{d}$ whereby, V = potential difference between two parallel plates d = distance between two parallel plates in meter Unit for E is V m⁻¹. Note: Direction of electric field is given by direction of force acting on a positive test charge. Electric field between two parallel charged plates is constant. Suggested activity: Carry out activities to explain effects of electric field on : • candle flame • metal coated polystyrene ball

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.1.4 Define electric current	Note: Current, I is the rate of flow of electric charge, Q in a conductor: $I = \frac{Q}{t}$ Charge of an electron, $e = 1.6 \times 10^{-19} \text{ C}$ Quantity of charge, $Q = ne$ whereby, n = number of electron e = charge of an electron
	3.1.5 Define potential difference, V	Note: The potential difference, V between two points, is defined as a work done, W to move one coulomb of charge, Q between two points in an electric field: $V = \frac{W}{Q}$ $1 \text{ V} = 1 \text{ J C}^{-1}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
3.2 Resistance	Pupils are able to: 3.2.1 Compare and contrast ohmic and non-ohmic conductor 3.2.2 Solve problems involving combination of series and parallel circuits 3.2.3 Define resistivity of wire, ρ 3.2.4 Describe factors that affect resistance of a wire through experiments to conclude $R = \frac{\rho \ell}{A}$	Suggested activity: Conduct experiments to compare V-I graphs for: - constantan wire (ohmic conductor) - filament bulb (non-ohmic conductor) Suggested activity: Calculate current, potential difference and effective resistance for combination of series and parallel circuits. Note: Define resistivity of wire, ρ and state its unit ($\Omega \text{ m}$). Suggested activity: Conduct experiments to study factors that affect resistance. The factors are limited to : - length of wire, ℓ - cross-sectional area of wire, A - resistivity of wire, ρ Assumption: temperature of conductor is constant throughout the experiment.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.2.5 Communicate about applications of resistivity of wire in daily life	Note: The value of s.w.g (<i>standard wire gauge</i>) represents diameter of the wire. Suggested activities: Research and explain applications of wire resistivity for : • heating element • electrical wiring at home Research and report on resistivity of conductors, insulators, semiconductors and superconductors. Research and report on studies of superconductors such as : • resistance-thermodynamic temperature graph • critical temperature (T_c) • latest research about T_c
	3.2.6 Solve problems involving the formula of wire resistance, $R = \frac{\rho \ell}{A}$	

CONTENT STANDARD	LEARNING STANDARD	NOTES
3.3 Electromotive Force (e.m.f) and Internal Resistance	Pupils are able to:	
	3.3.1 Define electromotive force, $\mathcal{E}$	Suggested activity: Carry out an activity to compare e.m.f and potential difference. Note: e.m.f is work done by an electrical source to move one coulomb of charge in a closed circuit.
	3.3.2 Explain internal resistance, r	Suggested activity: Carry out an activity to study the effect of internal resistance on voltage drop, Ir. Note: $Ir = \mathcal{E} - V$
	3.3.3 Conduct an experiment to determine e.m.f and internal resistance in a dry cell	Suggested activity: Determine r and $\mathcal{E}$ from the V-I graph using linear equation. $V = -Ir + \mathcal{E}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
	3.3.4 Solve problems involving e.m.f and internal resistance in a dry cell	Suggested activity: Carry out an activity to compare the magnitude of current when batteries are connected in series and parallel arrangements. Investigate : • internal resistance of battery • the effect of connecting batteries in series or parallel arrangement that affects effective internal resistance to provide maximum current in the circuit. Discuss the connections of solar cell and batteries to start the engine of an electric car that requires high current.
3.4 Electrical Energy and Power	Pupils are able to: 3.4.1 Formulate relationship between electrical energy (E), voltage (V), current (I) and time (t) 3.4.2 Formulate relationship between power (P), voltage (V), and current (I)	Suggested activity: Derive formula $E = VIt$ from the definition of potential difference and current. Suggested activity: Derive formula $P = VI$ from $E = VIt$ Then, use Ohm's law, $R = V/I$ to derive formula:

CONTENT STANDARD	LEARNING STANDARD	NOTES
		• $P = \frac{V^2}{R}$ This formula is used to calculate the resistance of an electrical appliances based on its power rating when it is functioning optimally. • $P = I^2R$ This formula is used to calculate power loss in an electrical wiring system.
	3.4.3 Solve problems involving electrical energy and power in daily life	
	3.4.4 Compare power and rate of energy consumptions in various electrical appliances	Suggested activity: Perform an energy audit on the consumption of electrical energy based on power rating in electrical appliances at home such as rice cooker, television, electrical oven, light, fan and air-conditioner.
	3.4.5 Suggest ways to save usage of electrical energy in household	

PERFORMANCE STANDARD

ELECTRICITY

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Electricity.
2	Understand concepts of Electricity and able to comprehend them.
3	Apply concept of Electricity to explain occurrences of natural phenomenon and perform simple tasks.
4	Analyse information and draw connections on Electricity in the context of problem solving on occurrences of natural phenomenon.
5	Evaluate to make judgement on Electricity in the context of problem solving and decision making to complete a task.
6	Create new or original work on Electricity in the context of problem solving and decision making to complete activities/ assignments creatively and innovatively in a new situation; taking into consideration the social/ economic/ cultural values of society.

4.0 ELECTROMAGNETISM

CONTENT STANDARD	LEARNING STANDARD	NOTES
4.1 Force on a Current-carrying Conductor in a Magnetic Field	Pupils are able to:	
	4.1.1 Describe the effect of a current-carrying conductor in a magnetic field	Suggested activity: Carry out an activity to study the effect of a current-carrying conductor in a magnetic field. Observe the direction of force due to the changes in : • direction of the current • direction of the magnetic field
	4.1.2 Draw the pattern of the combined magnetic field (catapult field) to indicate the direction of force on a current-carrying conductor in a magnetic field	Suggested activity: View computer simulation to show the pattern of the combined magnetic field. Use Fleming's Left Hand Rule.
	4.1.3 Explain factors that affect the magnitude of force on a current-carrying conductor in a magnetic field	Suggested activity: Carry out activities to show factors that affect the magnitude of force on a current-carrying conductor in a magnetic field.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.1.4 Describe the effect of a current-carrying coil in a magnetic field 4.1.5 Describe the working principle of a direct current motor 4.1.6 Describe factors that affect the speed of rotation in an electric motor	Suggested activity: View video/computer simulation to show the turning effect on a current-carrying coil in a magnetic field. Gather information related to the working principle of a direct current motor. Carry out activities to identify factors that affect the speed of rotation in an electric motor. Study the electric motor of used electrical appliances to identify the arrangement of coil and commutator. Research and report the advantages of brushless motor compared to brushed motor. Suggested STEM project: Design a model of simple homopolar motor using: • neodymium magnet • AA size battery • copper wire (swg 18-22) Discuss methods on how to build an efficient motor at low cost.

CONTENT STANDARD	LEARNING STANDARD	NOTES
4.2 Electromagnetic Induction	Pupils are able to:	
	4.2.1 Describe electromagnetic induction in : (i) straight wire (ii) solenoid	Suggested activity: Carry out activities to produce induced current in a straight wire and solenoid. Discuss electromagnetic induction as the production of emf in a conductor when there is relative motion of the conductor in a magnetic field.
	4.2.2 Explain factors that affect magnitude of induced emf	Suggested activity: Carry out activities to study factors that affect magnitude of induced emf Explain Faraday's law.
	4.2.3 Determine the direction of induced current in : (i) straight wire (ii) solenoid	Suggested activity: Carry out activities to study the direction of induced current in: • straight wire • solenoid Introduce Lenz's law and Fleming's right-hand rule.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.2.4 Design a direct current and alternating current generator	Suggested activity: Gather information on the structure and working principle of a direct current or alternating current generator. Suggested STEM project: Design a functional current generator (dynamo) prototype by: • modifying electric motor to function as dynamo • studying the method to convert the function of a motor to dynamo
4.3 Transformer	Pupils are able to: 4.3.1 Describe the working principle of a simple transformer	Suggested activity: Gather information related to the principle of a simple transformer.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.3.2 Describe an ideal transformer	Note: Efficiency of a transformer, η: $\eta = \frac{\text{output power}}{\text{input power}} \times 100\%$ For an ideal transformer there is no energy loss, therefore, $\eta = 100\%$, $\text{Input power} = \text{Output power}$ $V_P I_P = V_S I_S$
	4.3.3 Describe energy loss and ways to increase the efficiency of a transformer	Suggested activity: Gather information and discuss factors that cause energy loss in a transformer such as: • resistance • eddy current • hysteresis • flux leakage Discuss ways to increase the efficiency of a transformer.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	4.3.4 Communicate about the use of transformers in daily life	Note: Induction cooker produces eddy currents in a cooking pot causing it to heat up quickly. Gather information on the use of transformers in daily life in: • electrical appliances • transmission and distribution of electrical energy

PERFORMANCE STANDARD

ELECTROMAGNETISM

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Electromagnetism.
2	Understand concepts of Electromagnetism and able to comprehend them.
3	Apply concept of Electromagnetism to explain occurrences of natural phenomenon and perform simple tasks.
4	Analyse information and draw connections on Electromagnetism in the context of problem solving on occurrences of natural phenomenon.
5	Evaluate to make judgement on Electromagnetism in the context of problem solving and decision making to complete a task.
6	Create new or original work on Electromagnetism in the context of problem solving and decision making to complete activities/assignments creatively and innovatively in a new situation; taking into consideration the social/economic/cultural values of society.

THEME

APPLIED PHYSICS

LEARNING AREA

5.0 Electronics

Theme 3:**APPLIED PHYSICS**

This theme introduces basic electronics for the purpose of understanding electron characteristics, the use of diodes as rectifiers and the function of transistors as a current amplifier and an automatic switch.

Learning Area:

- 5.0 Electronics
 - 5.1 Electron
 - 5.2 Semiconductor Diode
 - 5.3 Transistor

5.0 ELECTRONICS

CONTENT STANDARD	LEARNING STANDARD	NOTES
5.1 Electron	Pupils are able to : 5.1.1 Describe thermionic emission and cathode rays 5.1.2 Describe effects of electric and magnetic fields on cathode rays	Suggested activity: View video/computer simulation on thermionic emission. Discuss production of cathode rays in vacuum tube using extra high tension power supply (EHT). Suggested activity: Carry out an activity or view computer simulation to observe the effect of electric field on cathode rays using apparatus such as deflection tube. Carry out an activity or view computer simulation to observe the effect of magnetic field on cathode rays using apparatus such as Maltese cross tube. Note: Characteristics of cathode rays: • negatively charged • can be deflected by electric and magnetic fields • produces fluorescent effect • can be stopped by thin metal

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.1.3 Determine velocity of an electron in cathode ray tube	Suggested activity: Calculate maximum velocity of an electron in cathode ray tube using the formula: Electric Potential Energy = Maximum Kinetic Energy $eV = \frac{1}{2}mv_{\max}^2$ Note: Electric potential energy of an electron, eV converts into maximum kinetic energy: Electric Potential Energy = Maximum Kinetic Energy $eV = \frac{1}{2}mv_{\max}^2$ e = charge of an electron (1.6×10^{-19} C) m = mass of an electron (9.1×10^{-31} kg) V = potential difference between anode and cathode $v_{\max}$ = maximum velocity obtained by an electron before hitting the anode

CONTENT STANDARD	LEARNING STANDARD	NOTES
5.2 Semiconductor Diode	Pupils are able to : 5.2.1 Describe the function of semiconductor diode 5.2.2 Communicate about the function of semiconductor diode and capacitor as a rectifier	Suggested activity: Discuss the function of semiconductor diode as an electronic component that allows current to flow in one direction. Carry out activities using dry cell, diode and bulb to observe the effect of a diode in: • forward biased circuit • reverse biased circuit Draw a simple circuit for forward and reverse biased diodes. Suggested activity: Carry out activities to build rectification circuits or use rectification kit for: • half-wave rectification using one diode • full-wave rectification using four diodes and observe the display on a cathode-ray oscilloscope (CRO). Discuss current flow in rectification circuits. Research and discuss the function of capacitor as a current smoother in a rectification circuit.

CONTENT STANDARD	LEARNING STANDARD	NOTES
5.3 Transistor	Pupils are able to : 5.3.1 Explain the function and use of a transistor as a current amplifier	Suggested activity : Research and discuss on: • terminals of a transistor; base (B), collector (C) and emitter (E). • npn and pnp transistors Discuss characteristics of a transistor circuit: • consists of a common base circuit and a common collector circuit • turns on when a minimum voltage is achieved in the common base circuit • needs a high resistance in the common base circuit, R_b to limit the base current Discuss connections of npn and pnp transistor in a circuit. Calculate minimum voltage for common base circuit that is required to turn on the transistor using the potential divider method.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	5.3.2 Describe circuits that consist of a transistor as an automatic switch	Carry out an activity using transistor kit to study the use of a transistor as a current amplifier. Calculate amplification factor of an amplifier, β : $\beta = \frac{I_c}{I_b}$ Note: Minimum voltage, V_{be} to turn on a silicon and germanium transistor are 0.7 V and 0.3 V respectively. Suggested activity : Carry out an activity with transistor kits to show the function of transistor as an automatic switch. Discuss transistor circuits as an automatic switch using: • light dependent resistor (LDR) in a light controlled switch • thermistor in a heat controlled switch The discussion of current flow mechanism in a transistor is not necessary.

PERFORMANCE STANDARD

ELECTRONIC

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Electronic.
2	Understand concepts of Electronic and able to comprehend it.
3	Apply concept of Electronic to explain occurrences of natural phenomenon and perform simple tasks.
4	Analyse information and draw connections on Electronic in the context of problem solving on occurrences of natural phenomenon.
5	Evaluate to make judgement on Electronic in the context of problem solving and decision making to complete a task.
6	Create new or original work on Electronic in the context of problem solving and decision making to complete activities/ assignments creatively and innovatively in a new situation; taking into consideration the social/ economic/ cultural values of society.

THEME

MODERN PHYSICS

LEARNING AREA

6.0 Nuclear Physics

7.0 Quantum Physics

Theme 4:**Modern Physics**

This theme involves understanding the characteristics of radioactivity emitted by unstable nuclei. Focus is given on nuclear reactions; fission and fusion. Fission reaction is required in the understanding of nuclear energy generation in a reactor while fusion explains the clean energy from the Sun. Einstein's equation, $E = mc^2$ is used to calculate nuclear energy produced from fission and fusion.

This theme also studies quantum physics which explains the behaviour of matter and energy at atomic and sub-atomic level that cannot be explained using classical physics.

Learning Area:

- 6.0 Nuclear Physics
 - 6.1 Radioactive Decay
 - 6.2 Nuclear Energy
- 7.0 Quantum Physics
 - 7.1 Quantum Theory of Light
 - 7.2 Photoelectric Effect
 - 7.3 Einstein's Photoelectric Theory

6.0 NUCLEAR PHYSICS

CONTENT STANDARD	LEARNING STANDARD	NOTES
6.1 Radioactive Decay	Pupils are able to: 6.1.1 Explain with examples decay equations: (i) α decay (ii) β decay (iii) γ decay 6.1.2 Explain half-life through examples	Suggested activity: Discuss changes in nucleus composition after decay using the decay equation. Suggested activity: View an animation to gain ideas about half-life. Discuss the radioactive decay series of a radioactive source such as uranium considering the elements produced, types of radiation emitted and period of decay. Explain qualitatively the importance of the uranium decay series in determining the age of various stones and earth.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.1.3 Determine half-life of radioactive sources from decay curve	Suggested activity: Carry out an activity using dice to plot decay curve. Introduce decay series and half-life equation: $N_0 \xrightarrow{T_{\frac{1}{2}}} \left(\frac{N_0}{2}\right) \xrightarrow{T_{\frac{1}{2}}} \left(\frac{N_0}{4}\right) \xrightarrow{T_{\frac{1}{2}}} \left(\frac{N_0}{8}\right) \xrightarrow{T_{\frac{1}{2}}} \dots$ Number of undecayed nuclei, N $N = \left(\frac{1}{2}\right)^n N_0$ whereby, N_0 = initial number of undecayed nucleus n = number of half-life (limited to positive integer) $T_{\frac{1}{2}}$ = half-life of radioactive substances
	6.1.4 Solve problems involving half-life in daily life	Suggested activity: Solve problems involving: - radioactive decay curve - half-life equation

CONTENT STANDARD	LEARNING STANDARD	NOTES
6.2 Nuclear Energy	Pupils are able to: 6.2.1 Communicate about nuclear reactions: (i) nuclear fission (ii) nuclear fusion 6.2.2 Describe relationship between energy released during nuclear reaction and mass defect: $E = mc^2$	Suggested activity: View videos on: • nuclear fission • nuclear fusion Compare nuclear fission to nuclear fusion. Note: The source of energy in the Sun is the result of nuclear fusion of hydrogen nuclei. Suggested activity: Discuss atomic mass unit (amu) using mass of 1 atom Carbon-12 and the Avogadro number. (1 amu is also known as 1 u) $1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.2.3 Solve problems involving nuclear energy due to radioactive decay and nuclear reactions	Note: Nuclear energy, $E = mc^2$ whereby, m = mass defect (kg) E = nuclear energy (J) c = speed of light ($m\ s^{-1}$) Nuclear energy can be stated in electron-volt (eV): $1\ eV = 1.6 \times 10^{-19}\ J$ Suggested activity: Solve problems involving: - radioactive decay - nuclear fission - nuclear fusion

CONTENT STANDARD	LEARNING STANDARD	NOTES
	6.2.4 Describe generation of electrical energy in nuclear reactor	Suggested activity: Search for information on generation of electrical energy in nuclear reactor. Discuss chain reaction in nuclear reactor. Discuss ways to control energy produced from chain reaction in nuclear reactor.
	6.2.5 Justify the use of nuclear energy as an alternative energy to generate electrical energy	Suggested activity: Search for information to make comparisons on generation of electrical energy from power station that uses coal, hydropower and nuclear energy. Aspects that can be considered: • cost (construction, operation and maintenance) • location of power station • effects on ecosystem and carbon footprint • health and safety issues • use of technology and expertise • waste management issues Discuss the suitability of building a nuclear power plant in Malaysia.

PERFORMANCE STANDARD

NUCLEAR PHYSICS

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Nuclear Physics
2	Understand concepts of Nuclear Physics and able to comprehend them
3	Apply concept of Nuclear Physics to explain the occurrences of natural phenomenon and perform simple tasks
4	Analyse information and draw connections on Nuclear Physics in the context of problem solving on occurrences of natural phenomenon.
5	Evaluate to make judgement on Nuclear Physics in the context of problem solving and decision making to complete a task
6	Create new or original work on Nuclear Physics in the context of problem solving and decision making to complete activities/ assignments creatively and innovatively in a new situation; taking into consideration the social/ economic/ cultural values of society

7.0 QUANTUM PHYSICS

CONTENT STANDARD	LEARNING STANDARD	NOTES
7.1 Quantum Theory of Light	Pupils are able to: 7.1.1 Explain the initiation of the quantum theory	Suggested activity: Research and report on development of quantum theory and classical theory incorporating findings from physicists: • Isaac Newton • Thomas Young • John Dalton • J.J. Thomson • Max Planck • Albert Einstein • Niels Bohr • Louis de Broglie Discuss the blackbody radiation phenomenon which could not be explained by classical theory, thus initiating the idea of quantum physics. Note: Blackbody is an ideal absorber and emitter of electromagnetic radiation (including light and heat).

CONTENT STANDARD	LEARNING STANDARD	NOTES
		The characteristics of blackbody radiation can be investigated by sketching the graph of radiation intensity against wavelength. Classical theory explains that light behaves as a wave with continuous energy. It cannot explain the graph at a shorter range of wavelength (ultraviolet). Planck introduces the idea of quanta (discrete packet of energy) which explains the part of the graph that could not be explained by classical theory. Einstein further expanded Planck's theory by stating that light exists in quanta known as photon. de Broglie introduces a hypothesis that particles also show wave behaviour. Einstein and de Broglie's ideas led to wave-particle duality.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.1.2 Describe quantum of energy	Suggested activity: Gather information to compare the concept of continuous energy and discrete energy using observed spectrum (continuous energy) and line spectrum from mercury lamp (discrete energy). Explain quantum of energy as a discrete packet of energy which is dependant on frequency. Note: Energy, E is directly proportional to frequency, f, $E \propto f$ Therefore, $E = hf$, whereby h is Planck's constant. $h = 6.63 \times 10^{-34} \text{ J s}$

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.1.3 Explain wave-particle duality	Suggested activity: Introduce de Broglie's hypothesis to explain wave behaviour of particles using the relationship between momentum, p (particle behaviour) and wavelength, λ (wave behaviour): $p = mv$ $p = \frac{h}{\lambda}$ whereby λ is known as de Broglie's wavelength. Based on a computer simulation, conclude how de Broglie's wavelength changes with: • mass of particles • velocity of particles Discuss application of wave behaviour of an electron in the operation of an electron microscope based on de Broglie's wavelength. Compare images produced by electron microscope and light microscope.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.1.4 Explain concept of photon	Note: The value of h is extremely small, therefore de Broglie's wavelength is too small for objects with greater mass (more than mass of an atom), hence the characteristics of wave cannot be observed. Only small mass particles such as electron shows observable wave characteristics. Suggested activity: Discuss that light shows wave and particle behaviour using computer/video simulation. Discuss photon energy, $E = hf$ whereby, $f = \frac{c}{\lambda}$ therefore, $E = \frac{hc}{\lambda}$ Note: Photon is quanta of light

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.1.5 Solve problems using : (i) photon energy, $E=hf$ (ii) power, $P=nhf$; n is number of photon emitted per second.	Note: Number of photons emitted per second by 50 W lamp for red light ($\lambda = 7.0 \times 10^{-7} \text{ m}$) is 1.77×10^{20} .
7.2 Photoelectric Effect	Pupils are able to: 7.2.1 Explain photoelectric effect	Suggested activity: View computer simulation about photoelectric effect. Carry out an activity to determine the value of Planck's constant using the Planck's constant kit.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.2.2 Identify four characteristics of photoelectric effect that cannot be explained using wave theory	Suggested activity: Research and report on four characteristics of photoelectric effect that cannot be explained using wave theory such as: • the effect of frequency on photoelectric effect • existence of threshold frequency • kinetic energy of electron does not depend on light intensity • photoelectron is emitted instantly when light shines on a specific material
7.3 Einstein's Photoelectric Theory	Pupils are able to: 7.3.1 State minimum work function needed by a metal to emit an electron using Einstein's equation 7.3.2 Explain threshold frequency, f_0 and work function, W	Suggested activity: Describe relationship between the kinetic energy of photoelectron and frequency of light using graph of kinetic energy against frequency. Suggested activity: View computer simulation on violet, blue, green, yellow, orange and red light to obtain an idea that metals have different threshold frequency.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.3.3 Determine work function of metal, $W=hf_0$	Suggested activity: Determine work function of metal such as zinc, aluminium and steel using the threshold frequency of that metal. Note: Threshold frequency, f_0 is the minimum frequency to produce photoelectric effect on metal. Work function, W is the minimum energy required to emit photoelectron.
	7.3.4 Solve problems involving Einstein's equation for photoelectric effect. $hf = W + \frac{1}{2}mv^2$	Suggested activity: Determine the maximum kinetic energy of photoelectron from graph or formula.
	7.3.5 Explain production of photoelectric current in a photocell circuit	Suggested activity: View computer simulation of caesium or lithium coated photocell to observe the production of photoelectric current.

CONTENT STANDARD	LEARNING STANDARD	NOTES
	7.3.6 Describe applications of photoelectric effect	Suggested activity: Research and report on the applications of photoelectric effect such as : • photocell • light sensor on automatic door • image sensor • solar panels on the International Space Station (ISS)

PERFORMANCE STANDARD

QUANTUM PHYSICS

PERFORMANCE LEVEL	DESCRIPTOR
1	Recall facts, concepts and scientific skills on Quantum Physics.
2	Understand concepts of Quantum Physics and able to comprehend them.
3	Apply concept of Quantum Physics to explain occurrences of natural phenomenon and perform simple tasks.
4	Analyse information and draw connections on Quantum Physics in the context of problem solving on occurrences of natural phenomenon.
5	Evaluate to make judgement on Quantum Physics in the context of problem solving and decision making to complete a task.
6	Create new or original work on Quantum Physics in the context of problem solving and decision making to complete activities/assignments creatively and innovatively in a new situation; taking into consideration the social/economic/cultural values of society.

Appendix 1

**RELATIONSHIP BETWEEN VERBS IN EACH PERFORMANCE LEVEL IN STANDARD PERFORMANCE AND VERBS IN
STANDARD OF LEARNING WITH EXAMPLES OF PUPIL'S ACTIVITIES**

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
1	Recall (Recall or identify specific information)	Recognise Recall List Identify Name State Tell etc.	Quiz Definition Fact Worksheet Work Test Label List Workbook Reproduce
2	Understand (Translate material or ideas from one form to another; interpret material or ideas, estimate trends)	Elaborate Give examples Summarise Translate Choose Explain etc.	Memorisation Summary Collection Explanation Show and explain Example Quiz Label List Framework

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
3	Apply (Using knowledge, skills, and values in different situations to carry out things)	Show Adjust Use Illustrate Build Complete Check Classify Demonstrate Draw Sketch Predict Prepare Produce Reuse Execute Role play etc.	Illustration Simulation Carve Demonstration Performance Interview Show Diary Journal
4	Analyse (Break down the information to small sections to understand in depth as well as to interrelate between the relevant section)	Break down Differentiate Examine Compare Detect Investigate Categorise	Questionnaire Data Abstract Report Graph Checklist Chart

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
		Display Evaluate Test Predict Making inference Interpret etc.	Guidelines
5	Evaluate (Make judgments and decisions using knowledge, experience, skills and values as well as justification)	Consider Choose Make decisions Give reasons Argue Confirm Suggest Assess Make conclusion Defend Support Determine priorities Predict Make justification etc.	Debate Forum Report Evaluation Investigation Decision Conclusion Speech

KEY VERBS PERFORMANCE STANDARD		PERFORMANCE STANDARD VERBS	EXAMPLES OF PUPILS' ACTIVITIES
PERFORMANCE LEVEL	VERB		
6	Invent (Generate creative and innovative ideas, products or methods)	Upgrade Change Plan Build Suggest Generate Develop Prepare Rearrange Combine Assemble Summarise Produce Invent Sketch etc.	Film Story Project Plan Games Song Media Advertisement Drawing

Note: A verb can be categorized at different Performance Level based on the context of the determination Learning Standard.

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