ISBN: 978-9982-00-945-2

Printed by
Zambia Educational Publishing House

Republic of Zambia

Ministry of Education

PHYSICS SYLLABUS

SECONDARY EDUCATION ORDINARY LEVEL
FORM 1 - 4

DEVELOPED BY THE CURRICULUM DEVELOPMENT CENTRE
LUSAKA
2024

Republic of Zambia

MINISTRY OF EDUCATION

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First Published 2024 by
Zambia Educational Publishing House
Light Industrial Area
Chishango Road
P. O. Box 32708
Lusaka, Zambia

Printed by:
Zambia Educational Publishing House (ZEPH)

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VISION

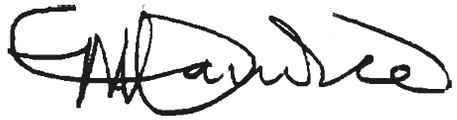
Quality, life long education for all which is accessible, inclusive and relevant to individual, national and global needs

PREFACE

The **Physics Syllabus** for Form 1 to 4 is designed to equip learners with a comprehensive understanding of Physics concepts, fostering a deep appreciation for the role of Physics in everyday life and its applications in various fields. This syllabus aims to develop a solid foundation in Physics and cultivate critical thinking, analytical skills, and problem-solving skills. Subsequently, it will help link Physics concepts to real-world problems and emerging technologies through the engagement of learners in hands-on, hearts-on and minds-on practical activities and simulations to reinforce theoretical understanding.

In addition, the syllabus intends to create a stimulating and supportive learning environment where learners can develop a profound understanding of the subject. By fostering curiosity, critical thinking, and practical skills, the syllabus will prepare learners for further education and careers in Science, Technology, Engineering and Mathematics (STEM), thereby contributing to their overall intellectual and personal growth.

It is hoped that the syllabus will inspire learners to explore the fascinating world of Physics and appreciate its significance in shaping the future.



Joel Kamoko (Mr.)
Permanent Secretary- Educational Services
MINISTRY OF EDUCATION

ACKNOWLEDGEMENT

This syllabus is designed to provide the topics for Physics considered necessary to be offered at Ordinary Secondary Education Level. This is with a view to provide guidance to the teaching and learning of this unique, yet exiting blend of concepts from Physics for teachers and other experts in the field.

Many thanks go to individuals, institutions and organizations that provided the technical and financial input to the successful development of this syllabus. These include; teachers, lecturers from colleges, public universities in Zambia. Sincere gratitude also goes to the Directorate of Secondary Education and National Science Centre in the Ministry of Education for their support and collaboration during the consultation period.

Last but not the least, the commitment and hard work of all the staff at the Curriculum Development Centre in ensuring that this syllabus comes to reality is recognised.

Charles Ndakala (Dr.)
Director – Curriculum Development
MINISTRY OF EDUCATION

INTRODUCTION

The O-level Physics syllabus covers the introductory part of the fundamental principles and concepts of Physics. This syllabus aims at developing an understanding of the natural world, fostering critical thinking, problem-solving, and analytical skills. It provides a solid foundation for further studies in Physics and related subjects. This syllabus is committed to providing an enriching and supportive educational environment where learners can advance a lifelong interest in the subject. By promoting inquiry, curiosity, and a passion for science, the syllabus aims to prepare learners not only for academic success, but also for their future roles as informed and responsible citizens in a scientifically advanced society.

It is expected that this Physics syllabus, once implemented successfully, will inspire and empower learners to achieve their full potential, equipping them with the knowledge and skills necessary to navigate and contribute to the world around them. The syllabus is designed to ensure learners develop a deep understanding of physics principles while equipping them with the practical skills and competencies needed for further education and careers in science. This O-level syllabus incorporates an interdisciplinary approach that integrates Science, Technology, Engineering, and Mathematics (STEM) to develop innovative solutions and critical thinking. The STEM aspect of Physics composed of:

Scientific: Understanding the natural world through observation, experimentation, and evidence-based reasoning.

- Observing and measuring physical phenomena
- Formulating hypotheses and theories
- Testing and validating models through experimentation
- Analysing and interpreting data

Technological: Applying physics principles to develop innovative solutions, tools, and technologies.

- Applying physics principles to develop innovative solutions
- Designing and building instruments, devices, and systems
- Using computational tools and simulations
- Developing new materials and technologies

Engineering: Designing, optimising, and troubleshooting systems, structures, and processes using physics-based models and simulations.

- Designing, optimising, and troubleshooting systems
- Applying physics-based models and simulations
- Developing and testing prototypes

- Ensuring safety, efficiency, and effectiveness

Mathematical: Use mathematical contexts to describe, analyse, and predict physical phenomena, from classical mechanics to quantum mechanics.

- Developing and applying mathematical contexts
- Describing and analysing physical systems using equations
- Modeling and simulating complex phenomena
- Interpreting and predicting results

These STEM aspects of Physics drive innovation, from medical imaging to space exploration, and continue to shape our understanding of the world around us.

STRUCTURE OF THE SYLLABUS

The syllabus is organised into four levels, corresponding to Forms 1 to 4, with each level building upon the knowledge and skills acquired in the previous year. The content is divided into topics, each focusing on specific concepts of Physics.

- **Form 1**: Introduction to Physics, General Physics, Elementary Astronomy, Geophysics, Mechanics I
- **Form 2:** Mechanics II, Thermal Physics, Wave Motion and Sound
- **Form 3:** Light, Static Electricity, Current Electricity, Magnetism, Electromagnetism, Electromagnetic Induction
- **Form 4:** Basic Electronics, Electronic Communication Systems, Atomic Physics, Renewable Energy

SUGGESTED TEACHING METHODOLOGY

The effective teaching methodologies in STEM physics include:

- **Conducting experiments:** Demonstrate key principles and encourage curiosity among learners
- **Collaborative learning:** Pair learners to work together, promoting peer-to-peer teaching, discussion, and problem-solving.
- **Conceptual learning:** Connect science concepts to everyday life, industry, or current events, making learning relevant and meaningful.
- **Differentiated instructions:** Tailor teaching to meet diverse learning styles, abilities, and interests of different learners.
- **Feedback and Reflection:** Encourage learners to reflect on their learning, providing constructive feedback to guide improvement.
- **Inquiry-based learning:** encourage learners to explore, investigate, and discover Physics concepts through hands-on experiments and activities.

- **Integration of Technology:** Use digital tools, simulations, and visualisations to enhance engagement, understanding, and analysis.
- **Problem-based learning:** Present real-world problems or case studies, requiring students to apply Physics principles to develop solutions.
- **Project-based learning:** Assign open-ended projects, allowing learners to design, conduct, and present research or applications of Physics concepts.

By implementing these methodologies, a teacher can create an engaging, inclusive, and effective STEM Physics learning environment.

TIME ALLOCATION

The standard minimum teacher-learner contact time for Physics at Ordinary Secondary School Level is 4 hours per week, translating into Six (6) periods. The duration for a single period is 40 minutes. The contact time is planned in such a way as to give ample time for practical activities.

ASSESSMENT

The assessment shall include a variety of methods to evaluate the competences of learners in terms of knowledge, skills, and general understanding of scientific concepts. The assessment will involve both formative and summative. Summative assessment will be used to evaluate learners' learning at the end of the Ordinary level Physics course through Final Examinations. On the other hand, formative assessment will be used to track learner progress in terms of knowledge, skills, values and attitudes throughout the teaching and learning process.

Both formative and summative assessments shall follow the following pattern:

- School Based Assessment (SBA) shall comprise of assignments, projects, practical work, research and end of term tests during the period of study and as guided by the Examinations Council of Zambia (ECZ). This shall carry **30%** of the total marks.
- Summative assessment shall carry **70%** of the total marks.

The Examinations Council of Zambia (ECZ) shall prepare detailed guidelines on how SBA will be conducted by the teachers and the management of the assessment results. The standardised national examination shall be administered at the end of Form 4 by the Examinations Council of Zambia.

KEY COMPETENCES

In Physics the following key competences are the fundamental abilities and qualities that will enable individual leaners to:

- Manage their own learning and knowledge
- Interact with others and solve problems
- Contribute to society and the economy
- Adapt to change and navigate through emerging issues in the environment

KEY COMPETENCES TO BE DEVELOPED

COMPETENCE	DESCRIPTORS
Analytical Thinking	• Identify patterns • Compile data, create mental images and address issues • Evaluate solutions
Collaboration	• Solving puzzle in groups • Play with peers to build relationships • Participate in and express themselves through play activities
Communication	• Use mathematical/scientific language in different situations • Express oneself using different media and symbols • Ask for feedback
Critical Thinking	• Ask and answer simple questions • Classify objects according to their attributes • Manipulate different objects • Solve simple problems in life • Match different things according attributes • Arrange objects according to attributes • Compare similarities or differences between objects • Explore the environment • Differentiate good from bad • Recognize and name items in the environment
Environmental Sustainability	• Dispose trash in the designated place. • Adhere to best practices in environmental management. • Identify a clean environment. • Identify types of waste in local environment
Problem Solving	• Make connections/link with the inner world or social environment • Use numeracy patterns and relations to solve problems • Manipulate numbers, shapes and symbols to complete a task

FORM 1

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
1.1 INTRODUCTION TO PHYSICS	**1.1.1 Safety Rules** (Laboratory Safety)	1.1.1.1 Practise laboratory safety rules	• Practising laboratory safety protocols (*using safety protocol simulation or role play, solving laboratory safety related puzzles to escape within certain time limits…*) • Identifying potential hazards and taking necessary precautions *(scavenger hunt*) • Using personal protective equipment (PPE) • Creating posters to communicate safety information • Demonstrating emergency response skills • Administering first aid	• Safety laboratory rules practised correctly
	1.1.2 Waste Management	1.1.2.1 Practise waste management principles	• Identifying waste materials in the Physics laboratory • Classifying waste materials according to physical state, properties, source and material type	• Principles of waste management practised correctly
	1.1.3 Apparatus in Physics	1.1.3.1 Use apparatus in Physics	• Identifying apparatus in Physics • Using apparatus in Physics • Improvising apparatus in Physics	• Apparatus in Physics used correctly
	1.1.4 Fundamental Concepts of Physics	1.1.4.1 Demonstrate curiosity and inquiry when exploring fundamental concepts of physics	• Recognising what physics is and its fundamental concepts such as motion, forces, energy, momentum, work and efficiency, waves and vibrations, and electricity and magnetism... • Classifying branches of Physics (*mechanics, thermodynamics, electricity and magnetism, atomic physics, electronics, geophysics…)* • Exploring the scientific methods of learning Physics (*observation,*	• Curiosity and inquiry when exploring the fundamental concepts of Physics demonstrated correctly.

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			experimentation, data analysis, interpretation, scientific reporting and presentation…)	
	1.1.5 Application of Physics	1.1.5.1 Relate the concepts of physics to everyday life	• Identifying applications of Physics in everyday life (*engineering, medicine, agriculture…)* • Demonstrating the application of Physics in everyday life *measuring mass, charging the phone*…)	• Concepts of physics related to everyday life accordingly
1.2 GENERAL PHYSICS	**1.2.1 Basic Principles of Scientific Investigations**	1.2.1.1 Apply principles of scientific investigations	• Designing an experiment that involves basic scientific principles (*Observation, Measurement, Data analysis, Report writing, Experimentation, Objectivity, Curiosity…)* • Writing scientific reports to disseminate scientific ideas	• Basic principles of scientific investigation applied appropriately
	1.2.2 Physical Quantities	1.2.2.1 Classify physical quantities as basic and derived	• Identifying basic quantities and their units *(including SI units*) • Discussing derived quantities and their units (*including SI units)* • Applying prefixes, multiples, submultiples on basic and derived units • Using scientific notations • Using significant figures in numerical problems • Converting basic and derived units (*converting from higher unit to lower or vice versa*)	• Physical quantities classified as basic and derived correctly
	1.2.3 Precision and Accuracy	1.2.3.1 Demonstrate precision and accuracy in measurements	• Measuring length with precision and accuracy using appropriate instruments (*metre rule, calipers and micrometer screw gauge…)* • Determining the area with precision and accuracy using appropriate apparatus and instruments	• Precision and accuracy in measurements demonstrated correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Measuring volume of liquids, regular and irregular solids with precision and accuracy using appropriate instruments • Measuring mass of gases, liquids and solids with precision and accuracy using appropriate instruments • Determining density of gases, liquids and solids with precision and accuracy using appropriate instruments • Measuring time with precision and accuracy (*using stop watches, simple pendulum ...*) • Experimenting on the factors that affect the period of the simple pendulum • Measuring weight with precision and accuracy using a spring balance • Carrying out experiments on measurements to demonstrate precision errors (*random, instrumental, methodical*) and accuracy errors (*systematic, gross, instrumental and relative*)	
	1.2.4 Equilibrium	1.2.4.1 Apply equilibrium concepts to design systems to solve real world problems	• Locating the center of mass • Designing systems in equilibrium to demonstrate stable, unstable and neutral equilibrium • Analysing equilibrium in real world situations (*structures such us bridges, cars, furniture ...)*	• Equilibrium concepts in daily life applied correctly
1.3 ELEMENTARY ASTRONOMY	**1.3.1 The Universe**	1.3.1.1 Construct astronomical models to demonstrate conceptual understanding of elementary astronomy	• Creating a scale model or diagram of planets and their relative sizes and positions • Simulating astronomical events like eclipse or planetary motion using	• Astronomical models to demonstrate conceptual understanding of elementary astronomy

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			computer software • Simulating space exploration using virtual reality • Using astronomical tools (*binoculars, telescopes, drones, spectroscope, and satellites…)* to view the solar system, planets or celestial bodies	constructed accordingly
1.4 GEOPHYSICS	**1.4.1 Structure and Composition of the Earth**	1.4.1.1 Demonstrate an understanding of the Earth	• Exploring the structure and composition of the earth to layered structure, density and gravity seismic waves, thermal gradient, magnetic fields, temperature gradient and radiative transfer • Collecting and analyzing rock samples to understand the earths' composition • Constructing a scale model of the earth's layers including the crust, mantle, outer and inner core	• Understanding of the Earth demonstrated accordingly
	1.4.2 Structure and Composition of the Earth's Atmosphere	1.4.2.1 Analyse the structure and composition of the earth's atmosphere	• Analysing the structure and composition of the earth's atmosphere in relation to humidity and phase transition thermal gradient, temperature and altitude gradient, and radiative transfer • Making a scale model of the atmospheric layers including the troposphere, stratosphere, mesosphere, thermosphere and exosphere	• The structure and composition of the earth's atmosphere analysed accordingly
1.5 MECHANICS 1	**1.5.1 Scalar and Vector Quantities**	1.5.1.1 Apply the concepts of scalar and vector quantities in everyday life	• Distinguishing scalar from vector quantities • Analysing scalar from vector quantities • Constructing vector diagrams representing physical quantities and	• Concepts of scalar and vector quantities in daily life applied correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			relationships • Determining resultant vectors using mathematical operation such as addition, subtraction, Pythagoras and Parallelogram rule: ($F_R = F_1 + F_2$, $F_R = F_1 - F_2$ and $F_R = \sqrt{F_1^2 + F_2^2}$) • Applying graphical methods to determine resultant vectors in everyday life	
	1.5.2 Linear Motion	1.5.2.1 Apply concepts of linear motion in real life situations	• Distinguish the terms used in mechanics such as distance, displacement, speed, velocity, and acceleration • Determining distance, displacement, time, speed, velocity and acceleration of moving objects using tools like rulers, sensors, ticker tape and stopwatches • Deriving the basic equations of uniformly accelerated motion; $v = u + at$ $v^2 = u^2 + 2as$ $s = ut + \frac{1}{2}at^2$ $s = \left(\frac{u+v}{2}\right)t$ • Using the equations of uniformly accelerated motion to solve numerical problems • Plotting linear motion graphs (*distance-time, velocity-time, acceleration-time*) • Calculating thinking distance, breaking	• Concepts of linear motion applied in real life situations accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			distance, and reaction time on different real-life scenarios	
		1.5.2.2 Apply concepts of falling bodies in real life situations	• Experimenting the motion of falling bodies in a uniform gravitational field with and without air resistance (qualitatively including terminal velocity) • Determining the numerical value of **'g'** experimentally • Solving problems on free fall using equations: $v = u + gt$ $v^2 = u^2 + 2gs$ $s = ut + \frac{1}{2}gt^2$	• Concepts of falling bodies in real life situation applied
	1.5.3 Forces	1.5.3.1 Apply force-body interaction concepts	• Investigating the effect of a force on a body (*shape and size, motion, and direction*) • Describing the inertia law • Describing the relationship between force and acceleration • Demonstrating the effect of friction on the motion of a body • Demonstrating the relationship between mass and acceleration • Solving problems involving force (F= ma) • Verifying Hooke's law using an experiment $(F \propto e)$	• Force-body interaction concepts applied accordingly
	1.5.4 Circular Motion	1.5.4.1 Apply circular motion concepts to solve problems and make predictions	• Describing motion in a circular path due to centripetal force • Showing that $F = m\left(\frac{v^2}{r}\right)$ Is derived from F=ma$_c$ where ac=	• Circular motion concepts applied to solve problems and make predictions correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			centripetal acceleration $\left(\frac{v^2}{r}\right)$ • Solving problems involving circular motion (*centripetal and centrifugal force*) • Demonstrating how circular motion is applied in real life situations (*satellite orbits, banked roads….)*	
	1.5.5 Moment of a Force	1.5.5.1 Create a tool that applies moment of a force in solving problems in everyday life.	• Demonstrating the concept of moment of a force using a lever • Exploring how forces and distance affect moment of force $M = Fd$ • Solving real life problems involving moment of a force. • Designing tools that apply moment of a force (*a lever,* …)	• A tool that applies moment of a force in solving problems in everyday life created accordingly
	1.5.6 Equilibrium	1.5.6.1 Apply equilibrium concepts to solve real world problems	• Locating the center of mass • Applying principle of moments as a condition for equilibrium (*for a system to be in equilibrium the sum of the clockwise moments about a point is equal* to the sum of the anticlockwise moment about the same point • Designing systems in equilibrium to demonstrate *stable, unstable and neutral equilibrium* • Analysing equilibrium in real world situations (*structures such us bridges, cars, furniture …)*	• Equilibrium concept to solve real world problems applied accordingly

FORM 2

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
2.1 MECHANICS 2	**2.1.1 Work, Energy, and Power**	2.1.1.1 Create a system that applies work, energy, and power concepts	• Developing a system that maximises the mechanical energy (*a simple pendulum, inclined plane, and water tank…)* • Determining the work done on an object by a force • Investigating the relationship between force and displacement through experimenting $W = Fs$ • Conducting experiments to measure and calculate mechanical energy (kinetic and potential) in different systems $E_p = mgh$ $E_K = \frac{1}{2}mv^2$ • Demonstrating the law of conservation of energy in mechanical energy • Exploring how machines can change the amount of mechanical energy required to perform a task, such as cranes • Calculating the efficiency of energy conversion using the appropriate formula $\eta = \frac{energy\ output}{energy\ input} \times 100\%$ • Solving mathematical problems involving power developed by mechanical energy systems • Calculating the efficiency of power using the appropriate formula $\eta = \frac{power\ output}{power\ input} \times 100\%$	• A system that applies work, energy, and power concepts created accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
	2.1.2 Linear Momentum	2.1.2.1 Apply the principle of linear momentum in everyday life	• Exploring linear momentum in real world scenarios *(sport, transportation, car accidents analyses, safety features built in cars and engineering…)* • Exploring the concept of momentum • Solving numerical problems involving linear momentum $P = m_1u_1 + m_2u_2$ • Demonstrating the law of conservation of momentum (*elastic and inelastic collision)* $m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$ • Demonstrating an understanding the effects and consequences of excessive speeding	• The principle of linear momentum in everyday life applied correctly
	2.1.3 Simple Machines	2.1.3.1 Build simple machines to solve real life problems	• Building simple machines to solve real life problems • Demonstrating the application of the various types of simple machines (*lever, pulley, inclined plane/wedge, screw, wheel and axle, and gears)* • Determining Mechanical Advantage (MA), and Velocity Ratio (VR) of a simple machine; $MA = \frac{load}{effort}$ $VR = \frac{distance\ moved\ by\ effort}{distance\ moved\ by\ load}$ • Deriving the formula for efficiency of a simple machine as $\eta = \frac{MA}{VR} \times 100\%$.	• Simple machines built to solve real life problems accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
	2.1.4 Pressure	2.1.4.1 Apply the principles of pressure to solve real-life problems	• Describing pressure and assigning its associated units • Establishing the relationship between force and area • Measuring pressure using pressure sensors (*manometer, barometer and other appropriate instruments*) • Determining pressure using the relationship between force and area $P = \frac{F}{A}$ • Deriving the equation for pressure in fluids (Pascal's Law); $p = \rho hg$ • Calculating pressure in liquids and gas $P = \rho gh$ • Exploring factors affecting pressure in liquids (*density (ρ), height (h) and gravity (g))* • Conducting an experiment to demonstrate principles of up thrust and floatation (*Archimedes principle*) • Conducting an experiment to demonstrate principles of up thrust and floatation (*Archimedes principle*) • Creating a model that uses the principle of pressure (*hydraulic press/brake and car jack, simple manometer, a mercury barometer...)*	The principles of pressure to solve real-life problems applied accordingly
2.2 THERMAL PHYSICS	**2.2.1 Simple Kinetic Theory of Matter**	2.2.1.1 Analyse the impact of simple kinetic theory of matter on technological innovations	• Describing the kinetic theory of matter • Exploring the molecular model of matter • Demonstrating kinetic theory of matter such as Brownian motion, diffusion, evaporation, cooling effect of evaporation • Developing an innovation on simple kinetic theory of matter to solve a real-	• The impact of simple kinetic theory of matter on technological innovation analysed correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			world problem *(gas leak detector, thermal insulators, refrigeration system…)*	
	2.2.2 Measurement of Temperature	2.2.2.1 Measure temperature using appropriate instruments	• Measuring temperature using appropriate instruments • Interpreting temperature data from various sources (*experiments...)* • Recognising various types of thermometers: (*liquid in glass, thermocouple, thermo scanners (infrared scanners)* • Determining the boiling and melting points of different substances • Experimenting on the effects of pressure and impurities on the boiling and melting points of substances • Calibrating unmarked thermometer • Experimenting on the physical properties that change with temperature *(volume, density, electrical resistance, gas pressure…)* • Experimenting on suitability of alcohol and mercury for use in liquid-in-glass thermometers • Exploring the relationship between Celsius and kelvin scales	• Temperature measured using appropriate instruments accordingly
	2.2.3 Expansion of Solids, Liquids and Gases	2.2.3.1 Demonstrate expansion of solids, liquids and gases	• Demonstrating thermal expansion of solids, liquids (*including anomalous expansion of water*) and gases • Demonstrating that various solids, liquids and gasses expand at different rates • Determining the boiling and melting points of different substances • Experimenting on the effects of pressure and impurities on the boiling and melting points of substances	• Expansion of solids, liquids and gases demonstrated correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Demonstrating the use of equations on gas laws to solve numerical problems (Boyle's Law, Charles' Law and Gay Lussac's and Ideal gas equation $P_1V_1 = P_2V_2$ $\frac{V_1}{T_1} = \frac{V_2}{T_2}$ $\frac{P_1V_1}{T_1} = \frac{P_2V_2}{T_2}$	
	2.2.4 The Internal Combustion Engine	2.2.4.1 Demonstrate how various internal combustion engines operate (four stroke engine)	• Recognising different types of internal combustion engines in terms of spark ignition, compression ignition, rotary….. • Exploring the operation of the internal combustion engine • Creating a model of an internal combustion engine • Comparing efficiency of diesel and petrol engine • Exploring emerging engine technologies such as hybrid, homogeneous charge compression ignition……	• The operations of various internal combustion engine demonstrated correctly
	2.2.5 Heat Transfer	2.2.5.1 Apply the concepts of heat transfer	• Describing heat transfer • Demonstrating heat transfer by conduction, convection and radiation • Applying heat transfer in everyday life such as food warmers, flasks, textile industry, refrigerators, sea and land breeze, heating elements, car radiators... • Exploring the relationship between kinetic theory and heat transfer • Demonstrating the use of bad and good conductors of heat • Distinguishing good from bad	• The concepts of heat transfer applied created accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			absorbers/emitters of radiant energy • Demonstrating greenhouse effects	
	2.2.6 Measurement of Heat	**2.2.6.1** Solve practical and numerical problems involving measurement of heat	• Exploring terms used in the measurement of heat (*heat capacity, specific heat capacity, latent heat of fusion/vaporisation…)* • Solving practical and numerical problems involving measurement of heat in everyday life • Exploring the differences between temperature and heat energy • Measuring heat capacity $\left(c = \frac{H}{\Delta T}\right)$ and specific heat capacity $\left(c = \frac{H}{m\Delta T}\right)$ of solids and liquids • Determining the latent heat of fusion $\left(H = mL_f\right)$ and latent heat of vaporisation $\left(H = mL_v\right)$ of substances	• Practical and numerical problems involving measurement of heat solved correctly
2.3 WAVE MOTION	**2.3.1 Longitudinal and Transverse Waves**	2.3.1.1 Solve practical and numerical problems involving wave motion	• Describing the terms associated with waves (amplitude (A), wavelength, period (T), frequency (f), wave front... • Distinguishing between longitudinal and transverse waves • Solving numerical problems involving wave motion • Creating a device that generates waves to demonstrate longitudinal and transverse waves	• Practical and numerical problems involving wave motion solved accordingly
	2.3.2 Electromagnetic Spectrum	2.3.2.1 Interpret information related to electromagnetic waves	• Describing the electromagnetic spectrum • Illustrating an electromagnetic spectrum with all types of electromagnetic waves • Exploring properties of electromagnetic waves • Exploring the sources, and uses of electromagnetic waves	• Information related to electromagnetic waves interpreted correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Recognising the methods of detection of each of the components of the electromagnetic spectrum • Exploring the harmful effects of each of the electromagnetic waves • Practising safety precautions against harmful effects of each of the electromagnetic waves	
2.4 SOUND	**2.4.1 Properties and Application of Sound**	2.4.1.1 Manipulate devices to demonstrate fundamental properties of sound	• Identifying vibrating parts in the production of sound by various sources (*guitar, xylophone, tuning fork, piano, whistle, drums, ruler ...)* • Experimenting on the transmission of sound in solids, liquids and gasses • Measuring sound using different instruments (*oscilloscope, sound level meter…)* • Demonstrating rarefaction and compression in sound waves using slinky spring • Conducting experiments to determine the speed of sound in air (*direct, echo, computer based)* • Discussing properties of sound (*frequency, wavelength, period, speed, amplitude, timbre, pitch, loudness intensity, reflection, refraction, interference, diffraction*) • Simulating the properties of sound using software *(refer to timbre, pitch, intensity, reflection, refraction, interference, diffraction)* • Explaining factors that influence quality of sound *(overtones and wave form of a note)* • Categorising types of sound based on; (*frequency, source, medium of*	• Devices to demonstrate fundamental properties of sound manipulated accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			transmission, perception, physical properties, directionality…) • Discussing application of sound (*music and entertainment, communication, ultrasound, technology, infrasonic, sonar technology for navigation, industrial application, non-destructive testing…)* • Researching the health and environmental impact of sound pollution and intervention measure	

FORM 3

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
3.1 LIGHT	**3.1.1 Rectilinear Propagation of Light**	3.1.1.1 Apply the concept of rectilinear propagation of light	• Demonstrating rectilinear propagation of light using a source of light (*laser, mirrors, screen*) to trace the path of light rays • Analyzing shadows (*eclipses*) using various light sources and objects • Exploring the behavior of rectilinear propagation of light using software or applications • Researching on the application of rectilinear propagation of light *(optical instrument, medical imaging and laser surgery)* • Creating a pinhole camera to show how light travels in a straight line	• The concept of rectilinear propagation of light applied accordingly
	3.1.2 Reflection of Light	3.1.2.1 Apply the concept of reflection of light.	• Describing the concepts of reflection of light and its associated terms • Creating a mirror maze to explore reflection and optical illusion • Exploring images of plane, concave, and convex mirrors, and other reflecting surfaces (*regular and irregular)* • Carrying out experiments to verify the laws of reflection • Utilising simulation or applications to model reflection to adjust angles and observe changes • Solving problems involving reflection, including mirror arrangement and image formation: • Using formula: (a) Law of reflection $\hat{i} = \hat{r}$	• The concept of reflection of light applied accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			(b) Mirror equation $\frac{1}{f}=\frac{1}{v}+\frac{1}{u}$ (c) Magnification equation $M=\frac{v}{u}$ (d) Number of images when two mirrors are at an angle. $n=\left[\frac{360^0}{\theta}-1\right]$ • Designing and building a periscope using mirrors and tubes • Creating a kaleidoscope to demonstrate reflection symmetry	
	3.1.3 Refraction of Light	3.1.3.1 Apply the concept of refraction of light	• Describing the concept of refraction of light and its associated terms • Creating optical illusions (*mirage, apparent depth using refraction…)* • Carrying out an experiment to verify the laws of refraction (*Snell's law*) using glass block, optical pins or laser beam, water and air $n=\frac{sine\ \hat{i}}{sine\ \hat{r}}$ • Investigating dispersion and refraction using a prism • Demonstrating critical angle and total internal reflection using prisms and glass blocks • Solving numerical problems on critical angle using the formula $\sin C=\frac{1}{n}$	• The concept of refraction of light applied accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Exploring how the concept of refraction is applied *(refer to; telescopes, optical fibre, cameras, microscopes, endoscope...)*	
	3.1.4 Lenses	3.1.4.1 Demonstrate understanding of lenses	• Describing lenses and their associated terms • Investigating the action of converging and diverging thin lenses • Exploring thin lenses and light sources to create ray diagrams, demonstrating image formation • Applying the lens equation to calculate focal length, image distance, object distance and power of the lens. Formula $\frac{1}{f}=\frac{1}{u}+\frac{1}{v}$, $P=\frac{1}{f}$ • Designing systems of thin lenses such as telescope and microscope and test its performance • Exploring how lenses create real and virtual images, and calculating magnification using the formula $M=\frac{v}{u}$ • Exploring computer simulations on thin lenses • Researching on thin lenses and applications in everyday life such as in correcting defects in vision, LCD, cameras …	• Understanding of lenses demonstrated accordingly
3.2 STATIC ELECTRICITY	**3.2.1 Introduction to Static Electricity**	3.2.1.1 Design experiments to investigate static electricity	• Carrying out experiments with suitable materials (*Perspex, polythene...) to verify the law of static electricity* • Generating static electricity by rubbing (*friction, triboelectrification*), induction and conduction (*contact*)	• Experiments to investigate static electricity designed accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Investigating how heat causes static electricity using a heat gun or a lamp • Investigating how humidity causes static electricity • Demonstrating how an object can be charged or discharged by induction. • Discussing how lightning is formed • Testing how different materials conduct or insulate static electricity • Creating a patterns of static electric field lines around a charged object • Exploring how distance affects the strength of electrostatic forces • Demonstrating how contact and separation of materials can transfer electrons and create static electricity • Researching on real world application of charging and discharging methods • Simulating charging and discharging methods using software or application	
		3.2.1.2 Install a lightning arrester	• Describing a lightning arrester/conductor • Simulating the danger of static electricity • Discussing the importance of grounding and earthling • Proposing safety procedures for working with electrostatic charge • Analysing real world cases of electrostatic accidents	• A lightning arrestor installed correctly
3.3 CURRENT ELECTRICITY	**3.3.1 Electric Charge, Current and Potential Difference**	3.3.1.1 Construct a simple electric circuit	• Describing the terms associated with current electricity (*charge, current, potential difference…*) • Constructing a simple electric circuit and use it to explain electric charge, current, and potential difference	• A simple electric circuit constructed accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Distinguishing between direction of flow of electrons and conventional current • Measuring voltage (V), and current (I) in series and parallel electric circuits • Calculating effective resistance (R) in series ($R_T = R_1 + R_2 + R_3 + - - R_N$) and parallel ($\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + - - + \frac{1}{R_N}$) electric circuits. • Investigating factors that affect resistance of a wire such as (temperature (T), cross section area (A), length (l) and type of material • Calculating resistivity (ρ) $R = \rho \frac{l}{A}$	
	3.3.2 Electric Cells	3.2.1.1 Apply electric cell technology to solve problems	• Developing a sustainable energy solution • Exploring the structure of electric cells • Exploring electric cells as a fundamental component of energy storage systems • Demonstrating charging and discharging of accumulators (*batteries, capacitors…)* • Investigating internal resistance (r) of a cell $E = IR + Ir \text{ or } E = V + V_r$ • Exploring environmental implications that electric cells bring about such as battery disposal and energy consumption	• Electric cell technology to solve problems applied accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
	3.3.3 Ohm's Law	3.3.3.1 Construct an electrical circuit system to apply the concept of ohms' law	• Investigating the relationship between voltage and current • Creating an electrical circuit system where the concept of ohms' law is applied • Verifying Ohm's law using Ohmic conductors • Analysing the properties of non-Ohmic conductors • Solving numerical problems involving Ohm's Law ($V = IR$)	• An electrical circuit system to apply the concept of ohms' law constructed correctly
	3.3.4 Electric Energy and Power	3.3.4.1 Solve practical and numerical problems involving electrical energy and power	• Describing electric power and energy and its associated units • Construc**ting** electrical energy efficient systems (*inductor stove…*) • Calculating power $P = VI$ and energy $E = VIt$ consumption • Costing electrical energy in kilowatt-hour (kWh)	• Electrical energy efficient systems constructed accordingly
	3.3.5 Electric Safety	3.3.5.1 Develop a domestic electric circuit, considering safety and efficiency	• Developing a domestic electric circuit, considering safety and efficiency • Demonstrating uses of fuse and circuit breakers to automatically interrupt the circuit in case of over current or short circuit • Insulating to prevent accidental contact with live wires or components • Exploring the importance of earthing metal cases and double insulation • Demonstrating how surge protectors protect electrical devices against voltage surges and sparks • Demonstrating adherence to set safety guidelines and regulations on electrical appliances	• A domestic electric circuit, considering safety and efficiency developed accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
3.4 MAGNETISM	**3.4.1 Phenomenon of Magnetism**	3.4.1.1 Demonstrate understanding of the phenomenon of magnetism	• Demonstrating the properties of magnets • Exploring the domain theory • Demonstrating induced magnetism in steel and iron • Carrying out experiments with suitable materials to plot magnetic field lines • Creating permanent and temporary magnets by stroking (touching) and using electricity • Demagnetising a magnet using electrical, heating or mechanical method • Demonstrating the use of magnetic keepers and magnetic screening • Designing an innovation that demonstrates the use of magnets	• Understanding of the phenomenon of magnetism demonstrated accordingly
3.5 LECTROMAGNETISM	**3.5.1 Magnetic effect of Electric-Current**	3.5.1.1 Apply magnetic effect of electric current to solve problems	• Demonstrating the magnetic field patterns of electric currents including the direction (*refer to; the right-hand grip rule, Corkscrew rule …*) • Creating a system that uses the magnetic effect of an electric current (*electric bell, relay switches …)* • Demonstrating the behaviour of an electric current in a magnetic field (*apply Fleming's left-hand rule*) • Demonstrating the nature of forces between parallel currents • Investigating the effects of magnetic fields on human health and environment • Designing innovative solutions to real-world problems involving the magnetic effect of electric that uses the application of current-carrying conductor placed in the magnetic field (*DC motor, galvanometers, ammeters …)*	• Magnetic effect of electric current applied to solve problems accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
3.6 ELECTROMAGNETIC INDUCTION	**3.6.1 Introduction to Electromagnetic Induction**	3.6.1.1 Create a system that applies Faraday's law of electromagnetic induction	• Demonstrating Faraday's law of electromagnetic induction • Demonstrating factors that affect the magnitude of induced current • Demonstrating the direction of the induced current using Lenz's and Fleming's right hand rules	• A system that applies Faraday's law of electromagnetic induction created correctly
	3.6.2 The Simple AC and DC Generators	3.6.2.1 Create simple AC and DC generators	• Creating a simple generator using a magnet, coil • Researching on how Electric Vehicles (EVs) apply electromagnetic induction. • Exploring the benefits of EVs compared to traditional fossil fuel propelled vehicles • Researching on the efficiency of EVs compared to traditional fossil fuel propelled vehicles	• Simple AC and DC generators created accordingly
	3.6.3 Transformers	3.6.3.1 Solve practical and numeric problems involving transformers	• Demonstrating mutual induction • Demonstrating the operation of an iron core transformer • Solving problems involving transformers $\frac{V_P}{V_S} = \frac{N_P}{N_S}$ $V_P I_P = V_S I_S$ (for ideal transformer) • Calculating the efficiency of a transformer $\eta = \frac{power\ output}{power\ input} \times 100\%$ • Demonstrating the effects of improper management of transformers • Building a simple and efficient iron core transformer	• Practical and numerical problems involving transformers solved correctly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
	3.6.4 Electrical Energy Transmission	3.6.4.1 Explore the transmission of electrical energy	• Discussing electric energy transmission considering factors such as voltage, current and distance • Exploring the structure and function of transmission lines • Investigating different types of transmission systems and technologies (overhead, underground, submarine…)	• Transmission of electrical energy explored accordingly

FORM 4

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
4.1 BASIC ELECTRONICS	**4.1.1 Introduction to Basic Electronics**	4.1.1.1 Construct a system that applies the concept of thermionic emission	• Demonstrating thermionic emission • Investigating properties of cathode rays • Distinguishing between direction of flow of electrons and conventional current • Exploring the application of electron beams *in cathode ray tubes, x-ray machines…* • Describing the basic structure and action of the cathode ray oscilloscope (CRO) • Solving numerical problems on CRO (*voltage, period and frequency*) • Constructing a system that applies the concept of thermionic emission	• A system that applies the concept of thermionic emission in its operations constructed accordingly
	4.1.2 Circuit Components	4.1.2.1 Design an electronic circuit	• Identifying circuit components (*resistors, capacitors, thermistors, diodes, transistors, reed switches, relay switches, inductor, integrated circuits...)* • Determining resistor values using standard colour codes • Demonstrating the action and application of a variable potential divider • Demonstrating the process of rectification (*forward and reverse bias of a diode*) • Demonstrating the action of electronic switching: Light sensitive switch (*light dependant resistor, temperature sensitive switch…*)	• Electronic circuit designed accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Investigating the charging and discharging of capacitors and their roles in electronic equipment • Designing an electronic circuit (*robot system: traffic control lights…*)	
	4.1.3 Digital Electronic System	4.1.3.1 Create an electronic system	• Making circuits to demonstrate the operation of the logic gates • Demonstrating the action of a bipolar transistor • Discussing types of logic gates (*AND, OR, NOT, NOR, and NAND*) • Deriving truth tables of logic gates • Describing the use of bistable and astable circuits • Creating an electronic system using breadboards, printed circuits boards (PCBs) or any other suitable materials	• An electronic system created accordingly
	4.1.4 Electronic Waste Management	4.1.4.1 Practise sustainable ways of electronic waste management	• Investigating effects of electronic waste in our environment • Analysing the current electronic waste management practices • Practising sustainable electronic waste (e-waste) management ways (*prevention/elimination, reuse, recycle, recovery, reduce, and disposal*)	• Sustainable ways of electronic waste management practised accordingly
4.2 COMMUNICATION SYSTEM	**4.2.1 Communication System**	4.2.1.1 Create a communication system	• Describing the principles of communication systems (*analogue and digital, optical, wireless…)* • Analysing stages in	• A communication system created accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			communication (*message (signal), encoding, channel selection, message transmission and noise mitigation, decoding, feedback to the sender*). • Investigating signal propagation techniques (*amplification, modulation and demodulation, error correction, diversity, repeater…*) • Demonstrating factors that affect signal propagation (*distance, frequency, medium, noise interference, attenuation*) • Investigating the use of communication systems in the real-world (*weather monitoring, medical imaging, earthquake monitoring, tsunami warning systems, data lodging, telecommunication transmission, media…*) • Creating a communication system using a transmitter, receiver and channel	
4.3 ATOMIC PHYSICS	**4.3.1 Nuclear Atom**	4.3.1.1 Demonstrate understanding of a nuclear atom	• Exploring the basic structure of an atom including a nucleus composed of protons and neutrons, surrounded by electrons in orbit • Recognising the concepts of atomic number, mass number, and how these relate to the identity of elements • Demonstrating the strong forces that hold protons and neutrons together in the nucleus	• Understanding of a nuclear atom demonstrated accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			• Exploring the role of electrostatic force and how it acts between protons in the nucleus, leading to potential instability in certain nuclei • Creating a model of nuclear atom	
	4.3.2 Radioactivity	4.3.2.1 Demonstrate understanding of the nature, characteristics, detection and application of radiations	• Simulating radioactive decay by using computer software • Simulating nuclear fusion and fission by using computer software • Exploring the nature of radioactivity • Discussing characteristics of the three types of radiation • Detecting radiations using instruments such as Geiger Muller Counter, Scintillation Counter and Ionisation Chamber • Explaining the origin and effects of background radiation. • Explaining radioactive decay (alpha, beta and gamma) • Solving numerical problems on radioactivity using the equations $\frac{N_t}{N_o} = \left(\frac{1}{2}\right)^{\left(\frac{t}{T}\right)}$ $\frac{N_t}{N_o} = e^{\lambda t}$ • Determining half-life of radioactive materials (numerically and graphically)	• Understanding of the nature, characteristics, detection and application of radiations demonstrated accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
		4.3.2.2 Explore the applications of radioactive substances	• Discussing the applications of radioactive substances • Researching on precautions to take when handling radioactive substances • Discussing the effects of radioactive substances on health and the environment • Investigating nuclear waste management practices which safeguard the environment from radioactive contamination such as Zambia Environmental Management Agency (ZEMA) regulations, Radiation Protection Authority (RPA) regulations, International Atomic Energy Agency (IAEA) regulations, testing the local environment regularly, conduction of environmental impact assessment…	• Applications of radioactive substances explored accordingly
		4.3.2.3 Analysing innovative solutions for effective nuclear waste management	• Designing innovative solutions for effective nuclear waste management such as (*Collaboration and knowledge sharing, waste to energy conversion technology, recycling nuclear waste…)*	• Innovative solutions for effective nuclear waste management analysed accordingly
4.4 RENEWABLE ENERGY SYSTEM	**4.2.1 Renewable Energy Systems**	4.2.1.1 Explore renewable energy systems	• Exploring renewable energy systems (*wind, solar, hydro power, biomass….)* • Applying knowledge of renewable energy systems to improve energy efficiency in buildings and industries • Exploring the contributions of	• Renewable energy systems explored accordingly

TOPIC	SUBTOPIC	SPECIFIC COMPETENCES	LEARNING ACTIVITIES	EXPECTED STANDARD
			renewable systems to sustainable development • Exploring the role of renewable energy in mitigating climate change • Researching on renewable energy system (*geothermal energy system…)*	

LIST OF SUGGESTED APPARATUS AND EQUIPMENT

1.0 Measurements and Mechanics

Venier callipers, micrometer screw gauges, measuring cylinders, metre rules, displacement cans, beakers, conical flasks, different masses such as 50g, 100g, 200g, 1kg, ticker tape timers, pipettes, burettes, spring balances, beam balances, capillary tubes and pulleys.

2.0 Thermal physics

Mercury barometers, clinical and laboratory thermometer, six's maximum and minimum thermometers, manometers, calorimeter, thermos flasks, thermocouple thermometers and hypsometer.

3.0 Light

Plane mirrors, converging and diverging lenses, rectangular and triangular prisms, optical pins, colour discs, colour filters, optical camera, light ray boxes, coloured bulbs, projectors such as slide projectors and film projectors.

4.0 Sound

Sonometers, turning forks, stop watches, stop clocks, sources of sound such as guitars and drums.

5.0 Magnetism

Bar magnets, horseshoe magnets, iron and steel bars, iron filings and plotting compasses.

6.0 Wave motion

Ripple tanks, springs and spiral springs, ropes and strings.

7.0 Electric current/static electricity

Ammeters, voltmeters, rheostats, capacitors, connecting wires, lead-acid accumulators, dry cells, resistors, tapping keys, switches, fuses, semi-conductors, semi-conductor diodes, electric bells, resistance wires, ebonite and polythene rods, three-pin-plugs, electric bulbs, switch boards and gold leaf electroscopes.

8.0 Basic electronics

Cathode ray tubes, maltese cross tube, resistors, light dependant rays (LDRs), thermistors, diodes, capacitors, transistors, TV sets, radios, electronics teaching kits and computers.

9.0 Nuclear physics

Geiger muller tube, time scales, rate metres, cloud chambers, bubble chamber alpha emitting radioactive sources and extra high tension (EHT) power supply unit.

KEY QUANTITIES, SYMBOLS AND UNITS.

Quantity	Symbols	Unit
Mass	m	kg
Length	l	m
Time	t	s
Electric current	I	A
Thermodynamic temperature	T	K
Amount of substance	n	mol
Distance	d	m
Displacement	s, x	m
Area	An	m^2
Volume	V	m^3
Density	ρ	kgm^{-3}
Speed	u, v	ms^{-1}
Velocity	u, v	ms^{-1}
Acceleration	and	ms^{-2}
Acceleration of free-fall	g	ms^{-2}
Force	F	N
Weight	W	N
Momentum	P	Ns
Work	W	J
Energy	E, U, W	J
potential energy	Ep	J
Kinetic energy	Ek	J

Heat energy	Q	J
Change of internal-energy	ΔU	J
Power	P	W
Pressure	P	Pa
Torque	T	Nm
Gravitational constant	G	$Nkg^{-2}ms^{2}$
Period	T	s
Frequency	f	Hz
Wave length	λ	m
Speed of electromagnetic-waves	c	ms^{-1}
Avogadro constant number	N_A	mol^{-1}
Celsius temperature	θ	^{o}C
Half - life	$t_{½}$	s
Decay constant	λ	s^{-1}
Specific heat capacity	c	$JK^{-1}KG^{-1}$
Electromotive force	E	V
Resistance	R	Ω
Resistivity	ρ	Ωm

DATA AND FORMULAE

Speed of light in free space	$C = 3.00 \times 10^{8}\ ms^{-1}$
Elementary charge	$e = 1.60 \times 10^{-19}$_coulomb
The Planck constant	$h = 6.63 \times 10^{-34}\ Js$
Molar gas constant	$R = 8.31\ JK^{-1}\ mol^{-1}$
The Avogadro constant	$N_A = 6.02 \times 10^{23}\ mol^{-1}$
Gravitational constant	$G = 6.67 \times 10^{-11}\ Nm^2kg^2$
Acceleration of free fall	$g = 9.81\ ms^{-2}$
The Boltzmann constant	$k = 1.38 \times 10^{-23}\ JK^{-1}$
Uniformly accelerated motion	$s = ut + ½\ at^2$ Or $v^2 = u^2 + 2as$
Work done on/by a gas	$W = P\Delta V$
gravitational potential	$E_p = mgh$
Energy in motion	$E=mc^2$
Refractive index	$n = \frac{\sin i}{\sin r}$
Resistors in series	$R = R_1 + R_2 + R_3 + \ ...$
Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ... +$
Electric potential	$V = Q/4\pi\varepsilon_0 r$
Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...$

Capacitors in parallel	$C = C_1 + C_2 + C_3 +$
pressure of an ideal gas	$P = \frac{1}{3} \frac{NMC^3}{V}$
alternating current/voltage	$X = x_o \sin wt$
hydrostatic pressure	$P = \rho gh$
energy of charged capacitor	$w = \frac{1}{2}QV$
radio-active decay	$x = x_o \exp(-\lambda t)$
Decay constant	$\lambda = \frac{0.693}{t_{1/2}}$

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