Republic of Namibia

MINISTRY OF EDUCATION, ARTS AND CULTURE

NAMIBIA SENIOR SECONDARY CERTIFICATE (NSSC)

PHYSICS SYLLABUS

ORDINARY LEVEL

SYLLABUS CODE: 6118

GRADE 10 - 11

FOR IMPLEMENTATION IN 2019
FOR FIRST EXAMINATION IN 2020

Ministry of Education, Arts and Culture
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Physics Syllabus Ordinary Level Grades 10 - 11

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1. INTRODUCTION

The Namibia Senior Secondary Certificate Ordinary (NSSCO) level syllabus is designed as a two-year course leading to examination after completion of the Junior Secondary phase. The syllabus is designed to meet the requirements of the *National Curriculum for Basic Education (NCBE)* and has been approved by the National Examination, Assessment and Certification Board (NEACB).

The National Curriculum for Basic Education, applicable at the stage of senior secondary education (Grades 10 and 11) and at equivalent stages of non-formal education, as a part of life-long learning, recognises the uniqueness of the learner and adheres to the philosophy of learner-centred education.

The Namibia National Curriculum Guidelines:

- recognise that learning involves developing values and attitudes as well as knowledge and skills
- promote self-awareness and an understanding of the attitudes, values and beliefs of others in a multilingual and multicultural society
- encourage respect for human rights and freedom of speech
- provide insight and understanding of crucial "global" issues in a rapidly changing world which affects quality of life, the AIDS pandemic, global warming, environmental degradation, distribution of wealth, expanding and increasing conflicts, the technological explosion and increased connectivity
- recognise that as information in its various forms becomes more accessible, learners need to develop higher cognitive skills of analysis, interpretation and evaluation to use information effectively
- seek to challenge and to motivate learners to reach their full potential and to contribute positively to the environment, economy and society

Thus the Namibia National Curriculum Guidelines should provide opportunities for developing essential skills across the various fields of study. Such skills cannot be developed in isolation and they may differ from context to context according to a field of study. The skills marked with an * are relevant to this syllabus.

The skills are:
- communication skills*
- numeracy skills*
- information skills*
- problem-solving skills*
- self-management and competitive skills*
- social and cooperative skills
- physical skills
- work and study skills*
- critical and creative thinking*

2. RATIONALE

This syllabus describes the intended learning and assessment for Physics in the NSSC phase. As a subject, Physics is within the natural science area/areas of learning in the curriculum, but has thematic links to other subjects across the curriculum.

The subject Physics places strong emphasis on the learners' understanding of the physical and environmental world around them at the local, regional and international levels. It thus includes how societies use natural resources to satisfy their needs, and how the environment may be changed in ecologically sustainable ways. At this phase and subject area, the application of scientific knowledge and attitudes to health is of special relevance for the individual, the family, and society as a whole as well as the environment around us including the sustainability of our natural resources. Critical thinking, investigating phenomena, interpreting data, and applying knowledge to practical (experimental and investigative) skills and abilities are essential to understanding the value and limitations of natural scientific knowledge and methods, and their application to daily life. This requires advanced technology through the efficient and effective usage of equipment, materials and processes. Modern technology is required in order to assist our learners and society to solve problems through planning, design, realisation, and evaluation of activities and goals.

3. AIMS

The aims of the syllabus are the same for all learners. These are set out below and describe the educational purposes of a course in Physics for the NSSCO examination. They are not listed in order of priority.

Physics promotes the following aims in the curriculum:

1. To provide, through well designed studies of experimental and practical science, a worthwhile educational experience for all learners, whether or not they go on to study science beyond this level and, in particular, to enable them to acquire sufficient understanding and knowledge to:
   - become confident citizens in a technological world, to take or develop an informed interest in matters of scientific importance
   - recognise the usefulness and limitations of scientific method and to appreciate its applicability in other disciplines and in everyday life
   - be suitably prepared for studies beyond the NSSCO level in pure sciences, in applied sciences or in science-dependent vocational courses

2. To develop abilities and skills that:
   - are relevant to the study and practice of Physics
   - are useful in everyday life
   - encourage efficient and safe practice
   - encourage effective communication

3. To develop attitudes relevant to Physics such as: concern for accuracy and precision, objectivity, integrity, enquiry, initiative and inventiveness.

4. To stimulate interest in, and care for, the environment.

5. To promote an awareness that:
   - scientific theories and methods have developed, and continue to do so, as a result of the co-operative activities of groups and individuals
   - the study and practice of science is subject to social, economic, technological, ethical and cultural influences and limitations
   - the applications of science may be both beneficial and detrimental to the individual, the community and the environment
   - science transcends national boundaries and that the language of science, correctly and rigorously applied, is universal

4. ADDITIONAL INFORMATION

4.1 Guided learning hours

The NSSCO level syllabuses are designed on the assumption that learners have about 130 guided learning hours per subject over the duration of two years, but this is for guidance only. The number of hours required to gain the qualification may vary according to local conditions and the learners' prior experience of the subject. The National Curriculum for Basic Education (NCBE) indicates that this subject will be taught for 8 periods of 40 minutes each per 7-day cycle, or 6 periods of 40 minutes each per 5-day cycle, over two years.

4.2 Prior learning

It is recommended that learners who are beginning this course should have previously studied Physical Science at Junior Secondary (JS) level.

4.3 Progression

NSSCO levels are general qualifications that enable learners to progress either directly to employment, or to proceed to further qualifications. Learners who are awarded grades C to A* in NSSCO are well prepared to follow courses leading to Namibia Senior Secondary Certificate Advanced Subsidiary (NSCCAS) level Physics.

4.4 Grading and reporting

NSSCO results are shown by one of the grades A, B, C, D, E, F or G indicating the standard achieved, grade A being the highest and grade G the lowest. 'Ungraded' indicates that the candidate has failed to reach the minimum standard required for a pass at NSSCO level.

4.5 Support materials and approved textbooks

NSSCO syllabuses, question papers and examiners reports are sent to all schools. Assessment manuals in subjects, where applicable are sent to schools. Approved learning support materials are available on the Senior Secondary Textbook Catalogue for Schools. The Senior Secondary Textbook Catalogue is available on the institution's (NIED) website (http://www.nied.edu.na).

5. LEARNING CONTENT

The content is divided into Topics and sub-topics as follow:

Topic 1: Scientific processes
1.1 Mathematical requirement
1.2 Scientific skills
1.2.1 Planning and conducting investigations
1.2.2 Recording data
1.2.3 Drawing graphs and tables
1.2.4 Basic units and derived units
1.2.5 Error, accuracy and uncertainty

Topic 2: General Physics
2.1 Length, time and volume
2.2 Scalars and vectors
2.3 Speed, velocity and acceleration
2.3.1 Position, displacement and distance
2.3.2 Speed, average speed, average velocity and instantaneous velocity
2.3.3 Acceleration
2.4 Effects of forces
2.5 Mass and weight
2.6 Density
2.7 Turning effect
2.8 Centre of mass
2.9 Friction
2.10 Energy, work and power
2.10.1 Major sources of energy
2.10.2 Renewable energy sources
2.10.3 Energy conversion
2.10.4 Work
2.10.5 Power
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Topic 3: Thermal Physics
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3.2 Thermal properties
3.2.1 Measurement of temperature
3.2.2 Thermal capacity
3.2.3 Melting, boiling and evaporation
3.3 Transfer of thermal energy
3.3.1 Conduction
3.3.2 Convection
3.3.3 Radiation
3.3.4 Consequences of energy transfer

Topic 4: Properties of waves

4.1 General wave properties
4.2 Light
4.2.1 The basic concepts of light
4.3 Properties of light
4.3.1 Transmission and absorption
4.3.2 Reflection by mirrors
4.3.3 Refraction of light
4.3.4 Electromagnetic spectrum
4.4 Sound

Topic 5: Electricity and magnetism

5.1 Electrostatics and electric charge
5.2 Current electricity
5.2.1 Current
5.2.2 Potential difference (p.d) and electro-motive force
5.2.3 Resistance
5.2.4 Relationship between current and voltage in an electric conductor (Ohm's Law)
5.3 Electric circuits (series and parallel)
5.4 Electrical power
5.5 Electricity in the home
5.6 Simple phenomena of magnetism
5.7 Electromagnetic effects
5.7.1 Electromagnetism
5.7.1.1 Force on a current-carrying conductor
5.7.1.2 Direct current (d.c) motor
5.7.2 Electromagnetic induction
5.7.2.1 Principles of electromagnetic induction
5.7.2.2 Alternating current (a.c) generator
5.7.2.3 Transformer

Topic 6: Nuclear Physics

6.1 The nuclear atom
6.1.1 The nucleus
6.1.2 Isotopes
6.2 Radioactivity
6.2.1 Safety precautions
6.2.2 Detection of radioactivity
6.2.3 Characteristics of the three kinds of emission
6.2.4 Radioactive decay
6.2.5 Half-life

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
1. Scientific processes		
1.1 Mathematical requirement	• know mathematical procedures which are required throughout the syllabus	• add, subtract, multiply and divide rounding the answer correctly • use averages, decimals, fractions, percentages, ratios and reciprocals • use direct and inverse proportion • use positive and negative, whole number indices and exponents in calculations • make approximate evaluations of numerical expressions • use usual mathematical instruments (ruler, compasses, protractor, set square) • explain the meaning of angle, curve, circle, radius, diameter, square, parallelogram, rectangle, diagonal • recall and use formulae for the area of a square, rectangle, triangle and circle • recall and use formulae for the volume of a cuboid and a cylinder • use the refractive index $n = \sin i / \sin r$ • solve equations of the form $x = y + z$ and $x = yz$ for any one term when the other two are known • recall and use Pythagoras' theorem for a right angled triangle • recognise and use points of the compass (N, S, E, W), bearings taken and the rules for bearing taking
1.2 Scientific skills		
1.2.1 Planning and conducting investigations	• know the scientific way of planning and conducting an investigation	• make observations accurately; use appropriate techniques; handle apparatus/ material competently and have due regard to safety • distinguish between dependent, independent, and control variables • predict the hypothesis or aim of the investigation in relation to dependent, independent and control variables

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
1.2.2 Recording data	• know the scientific way of presenting data	• locate, select and organise information from a variety of sources • record results of experimental investigations in a logical manner (tables or graphs) and explain the importance of units and recording results of experimental investigations • present each column of a table by heading it with the physical quantity and the appropriate unit, e.g. time/s (units should be in the heading of the column and not in the measurements in the column) • use column headings of the table to be directly transferred to the axes of a constructed graph
1.2.3 Drawing graphs and tables	• understand and recognise the correct way to draw graphs and tables	• record entries in tables with constancy in terms of decimal places for initial readings and significant figures for calculations • select suitable scales and axes for graphs • plot the independent variable on the *x*-axis (horizontal axis) and plot the dependent variable on the *y*-axis (vertical axis) • label each graph with the appropriate heading (by convention always the dependent versus independent variable) • label each axis with the physical quantity and the appropriate unit, e.g. time/s • draw the graph as the whole diagrammatic presentation. It may have one or several curves plotted on it, which should be labelled • draw appropriate lines through relevant points being a straight line or smooth curve • present points on the curve as crosses (x) or encircled dots (⊙). If a further curve is included, vertical crosses (+) may be used to mark the points • calculate the gradient (slope) of a straight-line graph as $m = \frac{\Delta y}{\Delta x}$

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
1.2.4 Basic units and derived units (**Note**: The solidus (/) will be used for a quotient and to indicate units in labels of tables and graphs e.g. distance/cm)	• understand scientific notation, prefixes and significant figures	• explain and use the relationship between length, surface area and volume and their units on metric scales • identify the correct SI unit and derived units (see annexe C) • explain and use multiple prefixes (mega, kilo) and sub-multiple prefixes (centi, milli, micro, nano) of units • use standard notation • round a value correctly to an appropriate number of significant figures when required • use acceptable methods of stating units, e.g. metres per second or m per s can be written as m/s or m s^{-1}
1.2.5 Error, accuracy and uncertainty	• understand errors, sources of error, their rectification, accuracy, precision and uncertainty	• explain that precise measurements are all close to one another and that accurate measurements have an average close to the true value • explain that any measurement may involve error, which is the difference between the measurement and the true value • explain uncertainty as the interval on either side of a measured value within which the true value is expected to lie • handle and process experimental observations and data, including dealing with anomalous or inconsistent results • evaluate presented results or experimental data by applying scientific knowledge and interpret and draw appropriate conclusions from practical observations and data in relation to the hypotheses • discuss trends in results and suggest sources of error (random and systematic errors) • suggest possible improvements to reduce errors

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2. General Physics		
2.1 Length, time and volume	• know how to use equipment to measure time, length and volume	• use and describe the use of a metre rule, a ruler and measuring tape to determine length, and measuring cylinders to determine volume • use and describe the use of mechanical methods for the measurement of a small distance (ruler, caliper (vernier or dial) and micrometer screw gauge) • use and describe the use of clocks and devices for measuring an interval of time (wrist watch and stop watch) • evaluate the advantages and disadvantages of the above devices • measure and describe how to measure a short interval of time including the period of a pendulum • describe a simple experiment to establish that the only variable that affects the period of a pendulum is the length
2.2 Scalars and vectors	• know the difference between scalars and vectors, add vectors and represent the resultant vector graphically	• define a scalar as a quantity which has a magnitude, but no direction (e.g. mass) • define a vector as a quantity which has both magnitude and direction (e.g. velocity) • explain the difference between scalars and vectors and give common examples • add two vectors at right angles by calculation to determine a resultant in magnitude and direction • add two vectors that are not at right angles by a graphical method to determine a resultant in magnitude and direction
2.3 Speed, velocity and acceleration		
2.3.1 Position, displacement and distance	• understand position, displacement and distance	• recognise and state that the concepts *'position'* and *'reference point'* (can be represented as x, y or z) are fundamental in the study of speed, velocity and acceleration • recognise that position, relative to a reference point, can be either *positive* or *negative* • define *distance* as a measure of how far an object travels along a particular path (without considering direction) • define *displacement* as a vector which has a magnitude equal to the shortest distance between the initial and final points and a direction from the initial to the final point

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.3.2 Speed, average speed, average velocity and instantaneous velocity	• understand speed, average speed, average velocity and instantaneous velocity	• define *speed* as a rate of change of distance • define *instantaneous velocity* as a 'rate of change of displacement' or speed in a given direction • define *average velocity* as the velocity an object would have if it covered a certain displacement in a certain interval and travelled at the same speed the whole time ($\frac{displacement\ for\ the\ whole\ motion}{time\ taken\ for\ the\ whole\ motion}$) • explain what positive and negative values of velocity mean • use and recall the equations: *average speed* = $\frac{total\ distance}{total\ time}$; *speed* = $\frac{distance}{time}$ • plot readings for and interpret a distance-time graph • plot readings for and interpret a speed-time graph • identify from the shape of a distance-time or speed-time graph when a body is – at rest – moving with constant speed – moving with changing speed • distinguish between speed and velocity by means of similarities and differences
2.3.3 Acceleration	• understand acceleration as well as recognise different types of motion on graphs	• define *acceleration* as the rate of change of velocity • explain what positive and negative values of acceleration mean • identify linear motion for which the acceleration is constant and calculate the acceleration • identify motion for which the acceleration is not constant • calculate the area under a speed-time graph to determine the distance travelled for motion with constant acceleration • state that the acceleration of free fall for a body near the Earth's surface is constant and has a value of approximately 10 m/s^2 • recall and use motion equations in calculations involving constant acceleration: $a = \frac{v-u}{t}$; $v = u + at$; $s = ut + \frac{1}{2}at^2$; $v^2 = u^2 + 2as$; $s = \frac{v+u}{2}t$

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.4 Effects of forces	• know the concept and effect of force • recall from earlier work the existence of forces in nature and everyday life • appreciate Newton's first and second laws of motion • understand Hooke's law • understand momentum and conservation of momentum	• state that a force, measured in newtons, may produce a change in size, shape or velocity of a body and relate these ideas to Newton's first and second laws of motion • describe the ways in which a force may change the motion of a body • identify in everyday life: – different forces (e.g. contact, electrical, magnetic, gravitational, weight, tension, friction and air resistance) – the agent applying the force – the object the force is applied to • find the resultant of two or more forces acting along the same line • plot and interpret extension-load graphs, describe the associated experimental procedure and use proportionality in simple calculations • state Hooke's law and recall and use the expression $F = kx$ where F is the force applied, k is the spring constant and x is the extension of the spring • identify the 'limit of proportionality' for an extension-load graph • describe the relation between force, mass and acceleration, including direction, and recall and use the formula $F = ma$ (Newton's second law of motion) • recall and use the formula momentum = mass × velocity • recall and use the change in momentum = force × time of action • define the principle of conservation of momentum as when two or more objects interact, their total momentum remains constant, provided that no external resultant force is acting on them • apply the conservation of momentum in simple applications, including elastic and inelastic collisions between two bodies in one dimension (definitions of an elastic and inelastic collision are not required)

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.5 Mass and weight	• understand the terminology mass and weight of a body • determine the mass and weight of a body	• define the mass of a body as a measure of the matter in it and that mass depends on the number of particles the body contains and the mass of those atoms • define inertia as the property of mass which 'resists' change in motion (Newton's first law of motion) • define gravitational field strength (g) as the gravitational force or weight per unit mass • state that gravitational field strength (g) is equal to the gravitational acceleration (a) • describe qualitatively the motion of bodies falling in a uniform gravitational field with and without air resistance, including reference to terminal velocity • recall and use the equation weight = mass × gravitational field strength and know that near the Earth's surface *g* is approximately 10 N/kg • determine the mass of an object from its weight (using a balance or a spring)
2.6 Density	• know the meaning of density and use the term to calculate the density of an object	• relate the term density to the mass and volume of an object and recall and use the equation density = $\frac{mass}{volume}$ • describe an experiment to determine the density of a liquid and of a regularly shaped solid • describe the determination of the density of an irregularly shaped solid by the method of displacement • describe floating and sinking in terms of different densities • state that the density of water around 4°C is a maximum and explain how this is an advantage to aquatic life

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.7 Turning effect	• know the turning effect and the conditions for equilibrium	• describe the moment of a force as a measure of its turning effect and give everyday examples (such as crowbar, wheelbarrow, pliers, scissors, tweezers or tongs) • describe the difference between moment and work (moment is a vector, work is a scalar; and that the distance involved in moment is perpendicular to the force whilst the distance involved in work is in the same direction as the applied force) • identify load, effort and fulcrum in everyday examples of common machines (e.g. spanner, wheelbarrow) • recall and use the formula moment = force × perpendicular distance • state that, when there is no resultant force and no resultant turning effect, a system is in equilibrium • describe an experiment (involving vertical forces) to verify that there is no net moment on a body in equilibrium • use the conditions of equilibrium in simple calculations
2.8 Centre of mass	• understand the centre of mass	• describe an experiment to determine the position of the centre of mass of a plane lamina • describe qualitatively the effect of the position of the centre of mass on the stability of simple objects
2.9 Friction	• understand the effect of friction on objects and how friction depends on the surfaces	• describe the effect of friction on objects and how friction depends on the surfaces • describe how to reduce friction and discuss the advantages and disadvantages of friction in everyday life

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.10 Energy, work and power		
2.10.1 Major sources of energy	• show understanding of major sources of energy and alternative sources of energy • know renewable and non-renewable sources of energy and their advantages and disadvantages	• outline sources of energy including reference to: − chemical/fuel energy (a regrouping of atoms) − potential energy from water (hydroelectric energy, waves, tides) − geothermal energy − nuclear energy (nuclear fission of heavy nuclei) − solar energy (producing thermal and photovoltaic energy from the fusion of nuclei in the Sun) − wind energy • compare advantages and disadvantages of the use of different sources of energy, including environmental considerations and the distinction between finite (non-renewable sources such as oil, coal and nuclear) and renewable sources (such as solar, hydroelectricity, geothermal and wind energy) • discuss radioactive isotopes as the source of nuclear energy, its conversion to electrical energy and the problems associated with this process (no nuclide formulas are required)
2.10.2 Renewable energy sources	• show how renewable energy sources are used in Namibia	• explain the use of renewable energy sources for electricity generation, heating, water pumping, greenhouses, refrigeration, and air-conditioning (**NB**: also, appreciate Namibia's solar energy potential – second highest irradiance in the World (after Chile)) • describe a basic solar photovoltaic (PV) system, a basic solar water heater and basic wind energy systems stating the energy changes involved

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
2.10.3 Energy conversions	• understand all aspects of energy	• give examples of energy in different forms, its conversion and conservation and apply the principle of energy conservation to simple examples (e.g. the kinetic energy changing to potential energy in a pendulum and the sum of the two is constant if air resistance is negligible) • describe energy transfer in terms of work done and make calculations involving $F \times d$ • describe kinetic energy as energy of motion and potential energy as energy of position (e.g. gravitational potential energy and strain potential energy) • recall and use the formulae for kinetic energy and gravitational potential energy $E_p = mgh$ and $E_k = ½ mv^2$
2.10.4 Work	• understand work	• define work done as the product of the magnitude of a force and distance moved in the direction of the force • recall and use the equation $\Delta W = F \times d$ • explain that energy is the ability to do work and that the joule [J] is the unit of both work and energy • state the unit of work as 1 J = 1 N m • identify examples of levers, gears and pulleys and explain how they are used for making the effort easier (NOTE: the work stays the same but the force required becomes less) • define efficiency as the percentage of useful energy output from the total energy input • recall and use the equation: efficiency = $\frac{useful\ energy\ output}{total\ energy\ input} \times \frac{100\%}{1}$

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
2.10.5 Power	• understand the principle of power	• define power as the rate of doing work or the rate of energy conversion (1 J s^{-1}= 1 W) • relate power as the amount of work done per unit time (power is measured in watt) and recall and use the formula $P = \frac{E}{t} = \frac{W}{t}$ to calculate the power output in everyday applications or in simple systems
2.11 Pressure	• relate pressure to force and area using appropriate examples	• define pressure as the perpendicular force acting on a unit area • recall and use the equation $P = \frac{F}{A}$ (unit of pressure: pascal [Pa] = 1 N/m^2 - due to the smallness of the unit pascal, the unit kilopascal [kPa] will be used) • interpret the relationship between pressure, force and area: explain, for example, what happens to the pressure when either the force or the area is changed • describe and explain the transmission of pressure in hydraulic systems with particular reference to hydraulic brakes on vehicles and hydraulic jacks • state that the pressure beneath a liquid surface is related to depth and to density using appropriate examples • derive, from the definitions of pressure and density, the equation $\Delta p = \rho g \Delta h$ • recall and use the equation $\Delta p = \rho g \Delta h$ • describe the atmospheric pressure changes with changes of altitude • use and describe the use of a manometer and perform calculations on the manometer • perform calculations involving interconversion of units of pressure (mm Hg, Pa) • state that a wind is caused by high and low pressure systems

The practical activities, approaches or demonstrations required for Topic 2 General Physics are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement and should be an integral part of the teaching and learning.

- *determine the period of a simple pendulum*
- *construct a simple pendulum and investigate which of the variable(s) determines the period of the pendulum*
- *determine the period of a ticker timer or the periodic time for a drop of water from a tap*
- *determine the time for a very short distance moved*
- *measure an interval of time for an object falling a very short distance using a stopwatch*
- *take measurements and draw a distance-time graph for a person walking slowly and at different speeds*
- *investigate motion to determine approximate constant walking speed*
- *investigate motion of a ball rolling down an inclined plane to draw a distance-time graph and a speed-time graph to determine the acceleration of the ball (e.g, by measuring the time t to roll from rest through a distance s of 10 cm, 20 cm, 30 cm etc, calculating the speed v at each distance, using the average speed from rest = s/t = (u+v)/2 = v/2)*
- *describe an experiment to determine the density of a liquid, a regular solid and make necessary calculations*
- *design and carry out experiments to find the density of:*
  - *a liquid*
  - *regular and*
  - *irregular shaped solids*
- *plot extension-load graphs*
- *take readings from and interpret extension-load graphs*
- *use a spring (or office elastic band) and an appropriate set of masses to investigate the elasticity of the spring (or elastic band)*
- *describe an experiment to verify that there is no net moment on a body in equilibrium*
- *use a balanced ruler and sets of masses to show that there is no net moment in an equilibrium*
- *describe an experiment to determine the position of the centre of mass of a plane lamina*
- *use a mounted nail, a plumb line and irregular lamina to find the centre of mass of the plane lamina*
- *investigate the power of your leg muscles when jumping (climbing) up a stair case (chair) or lifting a weight*
- *measure the pressure exerted by a learner standing on the ground*
- *investigate the transmission of pressure in hydraulic systems e.g. using different sized syringes*
- *investigate the relationship between pressure in liquids and depth*

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
3. Thermal Physics		
3.1 The particle nature of matter	• understand the significance of the kinetic particle model of matter, including phase changes and pressure changes	• explain the kinetic particle model of matter as: – the particles and the space the particles occupy – the forces between particles – the constant state of motion of the particles – elastic collisions between particles – an increase in kinetic energy of the particles as temperature rises • explain and analyse by means of the kinetic particle model of matter the processes of expansion and compressibility in solids, liquids and gases and diffusion in liquids and gases • identify and explain some of the everyday applications and consequences of thermal expansion • compare the differences between phases of matter in terms of differences in the behaviour and arrangement of particles • interpret the change from one phase of matter to another which involves an energy change (heat energy is either given out or taken in) and explain that the temperature of matter is constant during a phase change • describe the phases of matter and explain their inter-conversion in terms of the kinetic particle model in everyday life • interpret the temperature of a gas in terms of the motion of its molecules • describe qualitatively the pressure of a gas in terms of the motion of its molecules • describe qualitatively the effect of a change of temperature on the pressure of a gas at constant volume (Pressure Law) • describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure (Charles's Law) • describe qualitatively the effect of a change of volume on the pressure of a gas at constant temperature (Boyle's Law) • describe the random motion of particles in a suspension as evidence for the kinetic particle model of matter • describe this random motion (sometimes known as Brownian motion) in terms of random molecular bombardment

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
3.2 Thermal properties		
3.2.1 Measurement of temperature	• appreciate how a physical property which varies with temperature may be used for the measurement of temperature	• state the concept of absolute zero and the Kelvin scale of temperature • recall and use the information that absolute temperature is given by T/K = T/°C + 273 (example 20ºC is 20ºC + 273 = 293 K) • state and apply examples, including calculations, of how a physical property which varies with temperature may be used for the measurement of temperature, e.g. volume of a liquid and resistance of a metal • explain what is meant by the sensitivity, range and linearity of thermometers • state the need for and identify fixed points • describe the structure and action of liquid-in-glass thermometers and how the structure affects the range and sensitivity • describe the advantages and disadvantages of different liquids in liquid-in-glass thermometers • describe the structure and action of a thermocouple and explain its use for measuring high temperatures and those which vary rapidly

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
3.2.2 Thermal capacity	• know thermal capacity of matter	• relate a rise in the temperature of a body to an increase in internal energy • explain the term thermal capacity • define heat capacity of an object [*C*] as the heat required [*Q*] to raise its temperature [ΔT] by one kelvin • recall and use the equation $C = \frac{Q}{\Delta T}$ • define specific heat capacity [*c*] as the heat required [*Q*] to raise the temperature of a 1 kg mass [m] of a substance by one kelvin • recall and use the equation $c = \frac{Q}{m \Delta T}$ • describe an experiment to measure the specific heat capacity [*c*] of a substance • describe an investigation to establish that the temperature increase is proportional to the time of heating (for a constant mass) and inversely proportional to mass (for a constant time of heating) • define latent heat [*L*] as the quantity of heat energy [*Q*] absorbed or released when a substance changes state without changing its temperature ($L = Q$) • define specific latent heat [*l*]as the quantity of heat energy [*Q*] absorbed or released when a 1 kg mass [m] of a substance changes state without changing its temperature • use the term, and give a molecular interpretation of latent heat [*L*] • recall and use in calculations, the equation ($l = \frac{Q}{m}$)
3.2.3 Melting, boiling and evaporation	• understand the process of melting, boiling and evaporation	• describe melting and boiling in terms of energy input without a change in temperature • define melting point and boiling point as the temperature at which a change of state occurs • distinguish between boiling and evaporation • plot and interpret heating and cooling curves of water

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
3.3 Transfer of thermal energy		
3.3.1 Conduction	• understand conduction as one form of energy transfer	• define conduction of heat as the flow of heat through a material without any flow of the material • describe experiments to demonstrate the properties of good and bad conductors of heat • give a simple molecular account of the heat transfer in insulators and the migration of electrons in metals
3.3.2 Convection	• understand convection as one form of energy transfer	• define convection as the flow of liquid or gas caused by a change in density, in which the whole medium moves and carries heat energy with it • explain the difference between conduction and convection in terms of the physical movement of the medium • describe convection in fluids as due to density change • describe experiments to illustrate convection
3.3.3 Radiation	• understand radiation as one form of energy transfer	• define radiation as the transfer of heat by electromagnetic waves which do not require a medium • identify infra-red radiation as the part of the electromagnetic spectrum • describe experiments to show the properties of good and bad emitters and good and bad absorbers of infra-red radiation
3.3.4 Consequences of energy transfer	• identify and explain some everyday applications and consequences of conduction, convection and radiation	• identify and explain some of the everyday applications and consequences of conduction, convection and radiation

The practical activities, approaches or demonstrations required for Topic 3 Thermal Physics are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement and should be an integral part of the teaching and learning.
• *experiments to compare expansion and contraction in solids, liquids and gases* • *establish and interpret heating (cooling) curves for water* • *measure the power output of a heating device, e.g. a kettle by heating water, given the specific heat capacity of water 4200 J/(kg ˚C)* • *measure the specific latent heat of water by boiling water in a kettle of known power* • *heat a sample of ice and record the temperature at constant intervals* • *describe an experiment to demonstrate good and bad conductors* • *perform an experiment to illustrate convection in fluids* • *perform an experiment to demonstrate the properties of good and bad emitters and absorbers* • *check the fixed points on a thermometer* • *compare the range, sensitivity and linearity of several different thermometers*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
4. Properties of waves		
4.1 General wave properties	• understand general wave properties	• define a pulse as a single disturbance • define oscillations or simple harmonic motion as any repeated to-and-fro motion of a fluid or elastic solid, e.g. a tuning-fork, pendulum or stretched string • describe what is meant by wave motion (propagation), an oscillation which transfers energy from one place to another without any net movement of the medium, as illustrated by vibration in ropes, springs and by experiments using water waves • state typical values of the speed of sound and light in air, water and glass and the speed of light in a vacuum • explain why sound travels faster in solids than in gases, using ideas about molecules • outline some of the practical consequences of the difference of the speed of sound and light in air, such as the observation that thunder always follows lightning • distinguish between transverse and longitudinal waves (in terms of the direction of vibration of the particles and the direction of travel of the wave) and give examples of each • give the meaning of speed *c*, frequency *f*, period *T*, wavelength λ and amplitude • recall and use the equations $c = \lambda f$ and $f = \frac{1}{T}$ • define the term wave front in wave motion, as the line containing adjacent points that are in the same phase • draw circular and plane wave fronts on the surface of water • use the term wave front to describe the observation of water waves in a ripple tank undergoing: – reflection at a plane surface (wave fronts reflect at the same angle to the surface) – refraction due to a change in depth, changing the speed, and the wavelength but not the frequency

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
4.2 Light		
4.2.1 The basic concepts of light	• know that light travels in straight lines and understand how this leads to the formation of shadows, the appearance of the image in a pin-hole camera and eclipses of the sun and moon	• outline the difference between luminous and illuminated objects • explain that light travels in straight lines and how this leads to the – formation of shadows – appearance of the image (pin-hole camera) – eclipses of the sun and moon, including the terms umbra and penumbra
4.3 Properties of light		
4.3.1 Transmission and absorption	• understand the properties of light when using different apparatus and when light falls on different objects that are translucent, transparent and opaque	• explain the use of apparatus such as a ray-box, mirror, glass window, Perspex strips, protractor and rectangular block to investigate what happens when light falls on different objects that are translucent, transparent and opaque
4.3.2 Reflection by mirrors	• know reflection in plane mirrors, and by using ray boxes or pins, determine the position, nature and size of the image • know how to build an application of plane mirrors such as a periscope or a kaleidoscope and explain how these work	• draw a ray diagram to show the formation of the image of a point on an object produced by a plane mirror • give the characteristics (position, nature, size and lateral inversion) of an optical image formed by a plane mirror • identify and measure the angles of incidence and of reflection (angle of incidence is equal to angle of reflection) and the normal at the point a ray strikes the surface • describe advantages and disadvantages of reflection, including everyday applications of reflection such as the uses of different kinds of mirrors and the reflecting surfaces behind lights • recall and use the law: angle of incidence = angle of reflection • perform simple constructions, measurements and calculations on a ray diagram

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
4.3.3 Refraction of light	• know refraction of light and applications and consequences of refraction • understand that an image is an optical appearance of an object produced by a mirror or a lens • understand that the dispersion of white light forms a spectrum, that white light is composed of the colours of the spectrum and understand the formation of rainbows	• relate that light travels in straight lines to explain divergent, convergent and parallel rays or beams of light • define refraction of light as the change in direction of light entering or leaving a medium with different optical density • draw and describe the refraction of a ray of light as it passes through a rectangular block and a triangular prism • measure the angle of refraction *r* as light enters and leaves a rectangular block • recall and use the equation refractive index $n = \frac{\sin i}{\sin r}$ • give the meaning of critical angle • describe internal and total internal reflection • recall and use the definition of refractive index in terms of speed or wavelength • describe the action of a thin converging lens on a parallel beam of light • define the principal focus (focal point) of a converging lens • describe how to measure the focal length of a converging lens using a distant object • draw ray diagrams for the formation of real image and a virtual image by a single lens • distinguish between a real and a virtual image • give the characteristics of an optical image formed by a converging lens • describe the use of a single lens in a camera and the human eye, drawing ray diagrams to show how each forms an image and compare the functioning of the human eye with the functioning of the camera • describe short sight and long sight and describe the correction of these eye defects (diverging lenses are only mentioned at this stage) • describe applications of the refraction of light in nature such as the rainbow, size and position of objects under water and mirages to explain: – the passage of light through a prism (dispersion) and identify the colours of the spectrum produced from white light – how rainbows can be formed by the internal reflection of light in water – how mirages are formed as an optical illusion that uses the phenomena of reflection and refraction

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
4.3.4 Electromagnetic spectrum	• understand the electromagnetic spectrum	• state the components of the electromagnetic spectrum and place them in the correct order of frequency and wavelength • describe the main features of the electromagnetic spectrum and state that all electromagnetic waves are transverse and travel with the same high speed in vacuum and that this speed is 3.0×10^8 m/s • describe the role of electromagnetic waves in: – radio and television communications (radio waves) – satellite television and telephones (microwaves) – electrical appliances, remote controllers for televisions and intruder alarms (infrared) – sterilisation (ultra violet) – medicine and security (X-rays) – optical fibres (visible light and infrared) – killing cancerous cells and detecting cracks in metals (gamma rays) • describe the main dangers of the electromagnetic spectrum • outline the safety issues regarding the use of a microwave oven and X-rays
4.4 Sound	• understand the production and transmission of sound and the effect of noise on human hearing	• describe the production of sound by vibrating sources, how sound moves through the air and how the ear receives sound waves • suggest the approximate range of audible frequencies for the healthy human ear (20 Hz to 20 000 Hz) • discuss the effect of noise levels on human hearing • discuss the frequency of vibration in relation to the pitch of the sound • discuss the amplitude of vibration in relation to the loudness of the sound • describe displayed waveforms on a cathode-ray or a PC oscilloscope • explain that a medium (solid, liquid and gas) is required in order to transmit sound waves • design and conduct an experiment to show how sound is reflected and how echoes are produced • discuss how humans and animals make use of echoes • describe a measurement of the speed of sound in air using an echo from a vertical flat surface

The practical activities, approaches or demonstrations required for Topic 4 Properties of Waves, including Light and Sound are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement and should be an integral part of the teaching and learning.

- *use a variety of materials to show which are translucent, opaque and transparent*
- *demonstrate shadows showing the penumbra (fuzzy region) near the edge of a shadow*
- *use pins and a plane vertical mirror to plot rays, measure the angle of incidence and reflection and demonstrate the law of reflection*
- *make a periscope or a kaleidoscope from two plane mirrors*
- *using four pins or a ray-box investigate refraction through a parallel sided block. Learners may position and mark the pins so that they all appear in line or mark the incident and emergent rays from the block with the ray from a ray box. They then draw the ray inside the block (having removed the block from the paper) and measure angles of incidence and refraction. A graph of sin i against sin r can be used to measure the refractive index. If a ray box is not available then light from the Sun can be formed into a narrow beam for a demonstration. Measurements can also be made from simulations, e.g. from https://phet.colorado.edu/en/simulations/category/physics or http://www.physics-chemistry-interactive-flash-animation.com/optics_interactive/refraction_Snell_Descartes_law.htm*
- *demonstrate the use of water waves to show:*
  - *reflection at a plane surface*
  - *refraction due to change of speed*

  with either a ripple tank or a simulation e.g. from https://phet.colorado.edu/en/simulations/category/physics or http://www.falstad.com/ripple/
- *perform an investigation to determine the speed of sound*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
5. Electricity and magnetism		
5.1 Electrostatics and electric charge	• understand electrostatics and simple experiments to show nature of charge and the detection of charge	• describe simple experiments to show the production of charges by friction and detection of electrostatic charges (using an electroscope) • state that there are positive and negative charges • state that charge is measured in coulomb • state that unlike charges attract and that like charges repel • state that electrostatics is used in. photocopying, electrostatic precipitator and ink-jet printing • explain lightning as discharge from a cloud • describe an electric field as a region in which an electric charge experiences a force due to its charge • distinguish between electrical conductors and insulators using the simple electron model and give typical examples • state the direction of the electric lines of force and describe simple electric field patterns, including the electric field around a point charge and between two parallel plates with opposite charges • describe and explain charging by induction
5.2 Current electricity		
5.2.1 Current	• know the basic concepts of charge and current	• state that a current is a flow of charge and that current is measured in amperes [A] using an ammeter • state and use the correct way to connect an ammeter • recall and use the equation current [I] = $\frac{charge[Q]}{time\ [t]}$ • distinguish between static electricity and current electricity • explain and distinguish between – alternating current (a.c) and direct current (d.c) – the direction of the electron flow and the direction of the conventional current

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
5.2.2 Potential difference (p.d.) and electro-motive force	• know the basic concepts of electric potential	• state that electromotive force (e.m.f) is measured by the energy dissipated (supplied) by a source in driving unit charge round a complete circuit • state that e.m.f. is $\frac{total\ energy}{charge}$, ($V = \frac{E}{Q}$) • state that the potential difference (p.d) [V] across a component in a circuit is given by $\frac{work\ done\ in\ the\ component}{charge\ passed\ through\ the\ component}$, ($V = \frac{W}{Q}$) • state that both e.m.f and p.d across a circuit component are measured in volts [*V*] • state the correct way to connect a voltmeter • state that the potential difference between the terminals of a cell enables current to flow around a circuit • state the difference between e.m.f. as the total energy per charge and p.d as the work per charge in a part of the circuit and that the e.m.f. and p.d. involve different energy changes
5.2.3 Resistance	• know and understand the concept of resistance.	• state that resistance [*R*] is the tendency of a conductor to oppose the flow of charges, measured in ohms [Ω], using an ohmmeter • state that: – resistance is directly proportional to the length of a wire – resistance is inversely proportional to the cross-sectional area of a wire – as the temperature of a wire increases, the resistance also increases
5.2.4 Relationship between current and voltage in an electric conductor (Ohm's Law)	• understand the meaning of the terms electrical current, potential difference, resistance and Ohm's Law and use them in simple experiments and calculations circuit	• sketch and interpret graphically and by calculation the relationship between current and voltage in an electrical conductor at a fixed temperature • state Ohm's Law and discuss the temperature limitation on Ohm's Law • define resistance as $\frac{potential\ difference}{current}$ • recall and use the equation resistance = $\frac{voltage}{current}$, [$R = \frac{V}{I}$] • describe an experiment to measure the resistance of a metallic conductor using a voltmeter and an ammeter and make the necessary calculations • distinguish between ohmic (e.g. fixed resistors) and non-ohmic (e.g. light bulbs and semi-conductors) conductors and sketch their V/I characteristic graphs

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
5.3 Electric circuits (series and parallel)	• become aware of the applications of electrical circuits	• draw circuit diagrams with power sources (cell, battery or a.c. mains), switches (closed and open), resistors (fixed and variable), bulbs/lamps, ammeters, voltmeters, fuses, and relays • state that the current at every point in a series circuit is the same and use this in calculations • state that the current from the source is the sum of the currents in the separate branches of a parallel circuit • state that sum of the potential difference (p.d.) across the components in a series circuit is equal to the potential difference (p.d) across the power supply and use this in calculations • state that, for a parallel circuit, the potential difference (p.d) is the same across each branch • state that the combined resistance of two or more resistors in parallel is less than that of each resistor by itself • recall and use the equations $R_T = R_1 + R_2 + \ldots$ for combining resistances in series and $\frac{1}{R_T} = \frac{1}{R_1} + \frac{1}{R_2} + \ldots$ for combining resistances in parallel • discuss the advantage of making a battery from several identical sources of e.m.f. arranged in parallel • explain that increasing the number of cells in series in a circuit increases the current flowing around the circuit and increases the potential difference across components in the circuit • state the use of variable resistors (rheostat), fuses and relays
5.4 Electrical power	• know power as the rate of doing work, the unit of power as the watt and interpret the power rating of bulbs/lamps and other electrical appliances	• define electric power as the rate at which electrical energy is transferred to other sources of energy by an electric circuit, and is measured in watt [W] • recall and use the equations power = voltage × current [P=VI], and energy = voltage × current × time [E=VIt] and energy = power x time [E=Pt] • interpret the power rating of bulb/lamps and other electrical appliances and the energy consumption in kilowatt hours • calculate the cost of using electrical appliances where the unit is the kWh

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
5.5 Electricity in the home	• understand the use of electricity in everyday life with due regard to safety considerations	• distinguish between mains electricity (a.c 220 V) and electricity from batteries (d.c low voltage) • describe the uses of electricity in heating, lighting (including bulb/lamps in parallel), motors, bell and relay • state the dangers of electricity caused by damaged insulation, overheating of electric cables, overloading of sockets (multiple plugs on one socket) and damp conditions • discuss the importance of safety devices, including earthing, circuit breakers, placing switches in the live wire, circuit breaker settings, double insulation, fuses and fuse ratings • describe how to wire a mains plug safely, state the meaning of the terms live, neutral and earth and be able to identify the wires by colour code • discuss how electrical energy in the home can be conserved
5.6 Simple phenomena of magnetism	• relate to the simple phenomena of magnetism, magnetic properties and uses of magnets	• state the properties of magnets • explain magnetism and induced magnetism in terms of alignment of magnetic dipoles (molecular magnets) • state that the Earth has bar-magnet like properties and that a magnet freely suspended will align itself with the Earth's magnetic field (convention: the north-seeking pole will be termed the "north pole" of the magnet) • distinguish between ferrous and non-ferrous materials • state that iron, nickel, cobalt and their alloys are ferromagnetic materials • describe an experiment to show the magnetic field around a bar magnet • draw and explain the pattern of field lines around a bar magnet and a horseshoe magnet • describe and explain the difference between the design and use of permanent magnets and electromagnets (as used in e.g. a bell and a d.c. motor)

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
5.7 Electromagnetic effects		
5.7.1 Electromagnetism		
5.7.1.1 Force on a current-carrying conductor	• know the magnetic effect of an electrical current in a straight conductor and a solenoid • know how to build electromagnets • know the relative directions of the force, current and magnetic field	• describe an experiment to demonstrate that a current carrying conductor (a straight conductor and a solenoid) has an induced magnetic field around it • sketch the magnetic field around a current carrying solenoid and around a current-carrying wire (both shape and direction of magnetic field lines are required, the direction can be found from the right-hand grip rule) • describe how to build an electromagnet and outline its uses • describe an experiment that shows the difference between the electromagnetic properties of iron and steel • describe and use the relative directions of the force, current and magnetic field for a wire carrying a current in the field using Fleming's left-hand rule • describe an experiment to show the corresponding force on beams of charged particles
5.7.1.2 Direct current (d.c) motor	• understand the structure and how a d.c motor works	• explain how a current-carrying coil in a magnetic field experiences a turning effect and that the turning effect is increased by increasing (1) the number of turns on the coil, (2) the current and (3) the strength of the magnetic field. • discuss how this turning effect is used to make a simple electric motor • suggest how to convert an electric motor into a generator • describe the action of a split-ring commutator in a two-pole, single-coil motor and the effect of winding the coil onto a soft-iron cylinder
5.7.2 Electromagnetic induction		
5.7.2.1 Principles of electromagnetic induction	• know the principles of electromagnetic induction	• describe an experiment which shows that a changing magnetic field in a circuit or a magnetic field moves across a wire can induce an e.m.f. • state the factors affecting the magnitude of the induced e.m.f • state that the direction of induced current is such as to oppose the change causing it (Lenz's Law)

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
5.7.2.2 Alternating current (a.c) generator	• show understanding of the structure and working of an a.c generator	• describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings where needed • sketch a graph of voltage output against time for a simple a.c. generator and the effect on the graph of increasing the frequency of rotation • discuss the generation of current using a simple generator
5.7.2.3 Transformer	• know how electrical energy is generated and transmitted in Namibia and understand why this process requires the use of transformers • understand the functioning of a transformer	• describe the structure and principle of operation of a simple iron-cored transformer • recall and use the equation ($\frac{Vp}{Vs} = \frac{Np}{Ns}$ • state the advantages of high voltage transmission • discuss the environmental and cost implications of underground power transmission compared to overhead lines • recall and use the equation $V_p I_p = V_s I_s$ (for 100% efficiency) • describe how electricity is generated and transmitted in Namibia and how this process requires the use of transformers **Note:** V_p, N_p and I_p are the voltage, number of turns and current in the primary coil and V_S, N_S and I_S are the voltage, number of turns and current in the secondary coil

The practical activities, approaches or demonstrations required for Topic 5 Electricity and magnetism are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement and should be an integral part of the teaching and learning.

- *use a plotting compass (or iron filings) to establish the magnetic field around a bar magnet*
- *investigate methods of induced magnetism*
- *using a permanent magnet investigate the magnetic properties of iron and steel*
- *use an electromagnet to show how the strength of the magnet varies with current by picking up paperclips*
- *charge plastic rods/ rulers by friction and show that there are two different types of charge by their attraction and repulsion*
- *use an electroscope to show that a rod is charged*
- *construct a circuit using correctly an ammeter, voltmeter, one or more resistors in series or parallel, bulbs/lamps, a power source (cells or power supply)*
- *perform an experiment to determine resistance using a voltmeter and an ammeter (or multimeter)*
- *show that the current is the same in a series circuit and adds up in a parallel circuit*
- *show that the voltage adds up in a series circuit and is the same in a parallel circuit*
- *take measurements to plot the V/I characteristic graph for metallic (Ohmic) conductors*
- *investigate Ohm's Law for a variety of resistors (conductors)*
- *measure electrical current, using an ammeter, at different positions in series and parallel*
- *investigate the total resistance of two or more resistors in a series connection with an ohmmeter or voltmeter/ammeter method*
- *investigate the total resistance of two or more resistors in a parallel connection with an ohmmeter or voltmeter/ammeter method*
- *investigate the relationship between current and potential difference across various conductors (nichrome, eureka wires and bulb/lamps)*
- *use an ohmmeter to show proportionality between resistance and the length of a conductor, inverse proportionality between resistance and the cross sectional area of conductors and increase in resistance with temperature*

- *describe experiments to show that a changing magnetic field can induce an e.m.f. in a circuit*
- *investigate how a changing magnetic field induces a p.d. and how this induced p.d. can be maximised*
- *measure the potential difference across an electrical component in a circuit using a voltmeter and investigate the potential difference across*
- *potential difference across the whole circuit (the sum of the difference in potential across individual components)*
  individual components in a circuit
- *demonstrate an a.c. generator and a d.c. motor (if apparatus is not available then a video clip from YouTube can be used)*

TOPIC	GENERAL OBJECTIVES *Learners will:*	SPECIFIC OBJECTIVES *Learners should be able to:*
6. Nuclear Physics		
6.1 The nuclear atom		
6.1.1 The nucleus	• know the composition of the atom	• describe the composition of the nucleus in terms of protons and neutrons • use the term proton number (atomic number), denoted by Z • use the term nucleon number (mass number), denoted by A • use the term nuclide and nuclide notation ${}^{A}_{Z}X$ • use the nuclide notation in equations to show alpha and beta decay
6.1.2 Isotopes	• know isotopes and examples of applications	• define isotopes as atoms with the same proton number but different nucleon number • give and explain examples of practical applications of isotopes for example in carbon-14 dating; nuclear medicine, radiology, biochemical tracers; radiotherapy, detection of leaks in pipes; determination of thickness of material; power generation; sterilisation
6.2 Radioactivity		
6.2.1 Safety precautions	• know radioactive material safety precautions	• describe how radioactive materials are handled, used and stored in a safe way
6.2.2 Detection of radioactivity	• show awareness of the existence of background radioactivity	• describe the existence and major causes of background radioactivity • describe the detection of alpha-particles (α), beta-particles (β) and gamma-rays (γ), (cloud chamber, Geiger Mǜller (G-M) counter and photographic film)
6.2.3 Characteristics of the three kinds of emission	• know the characteristics of the three kinds of emission	• state that radioactive emissions occur randomly over space and time • describe radioactive emission: – their nature (e.g. its composition, relative charge, mass) – their relative ionising effects – their relative penetrating abilities • describe their deflection in electric fields and magnetic fields • interpret their relative ionising effects
6.2.4 Radioactive decay	• know radioactive decay	• state the meaning of radioactive decay and give appropriate nuclide equations to represent changes in the composition of the nucleus when particles are emitted

TOPIC	**GENERAL OBJECTIVES** *Learners will:*	**SPECIFIC OBJECTIVES** *Learners should be able to:*
6.2.5 Half-life	• understand half-life	• define half-life as the time taken for half of the radioactive nuclei to decay • use the term half-life in simple calculations which might involve information in tables or decay curves

The practical activities, approaches or demonstrations required for Topic 6 Nuclear Physics are listed below. These are considered basic and all learners should be exposed to them as a minimum requirement and should be an integral part of the teaching and learning.
• *establish half-life of radioactive material (using dice or coins e.g. http://practicalphysics.org/simple-model-exponential-decay.html)*

6. ASSESSMENT OBJECTIVES

The assessment will include, wherever appropriate, personal, social, environmental, economic and technological applications of Physics in modern society. Learners are required to demonstrate the assessment objectives in the context of the content and skills prescribed. Within each of the Assessment Objectives the assessment must take account of the learners' ability to communicate clearly and logically and apply conventions where appropriate.

The three Assessment Objectives in Physics are:

A Knowledge with understanding
B Handling information, application and solving problems
C Practical (experimental and investigative) skills and abilities

The following is a description of each Assessment Objective:

A Knowledge with understanding

Learners should be able to demonstrate knowledge and understanding in relation to:

A1 scientific phenomena, facts, laws, definitions, concepts and theories;
A2 scientific vocabulary, terminology and conventions, (including symbols, quantities, units)
A3 scientific instruments and apparatus, including techniques of operation and aspects of safety
A4 scientific quantities and their determination
A5 scientific and technological applications with their social, economic and environmental implications

The Learning Content defines what learners may be required to recall and explain. Questions testing assessment objectives will often begin with one of the following words: *define, name, list, indicate, give examples, state, describe, calculate compare, explain, distinguish, outline and give reasons.*

B Handling information, application and solving problems

Learners should be able to, in word or using other written forms of presentation (i.e. symbolic, graphical and numerical) to:

B1 locate, select, organise and present information from a variety of sources;
B2 translate information from one form to another
B3 manipulate numerical and other data
B4 use information to identify patterns, report trends and draw inferences
B5 present reasoned explanations for phenomena, patterns and relationships
B6 make predictions and hypotheses
B7 solve quantitative and qualitative problems as they relate to everyday life

These skills cannot be precisely specified in the Learning Content, because questions testing such skills are often based on information that is unfamiliar to the learner. In answering such questions, learners are required to use principles and concepts that are within the syllabus and apply them in a logical, deductive manner to a novel situation. Questions testing these objectives will often begin with one of the following words: *discuss, deduce, compare and discuss, find, estimate, interpret, evaluate, sketch, predict, identify, relate, suggest and calculate* or *determine.*

C Practical (experimental and investigative) skills and abilities

Learners should be able to:

C1 demonstrate knowledge of how to safely use techniques, apparatus and materials (including following a sequence of instructions where appropriate)

C2 plan experiments and investigations

C3 make and record observations, measurements and estimates

C4 interpret and evaluate experimental observations and data, including dealing with anomalous or inconsistent results

C5 evaluate methods and suggest possible improvements

7. SCHEME OF ASSESSMENT

All learners should be entered for **Papers 1, 2 and 3** which are compulsory papers.

Paper	**Description of paper and types of questions**	**Duration of paper**	**Marks**
Paper 1: Theory: Multiple choice questions	This paper will consist of forty multiple-choice items of the four-choice type. The questions will be based on the content described in the specific objectives and will test abilities in assessment objectives A and B. Learners should attempt all questions	45 minutes	40
Paper 2: Theory: Structured questions	This paper will consist of compulsory short-answer, structured and free-response questions. The questions will test skills and abilities in Assessment Objectives A and B	1 hour 30 minutes	80
Paper 3: Alternative to practical: Assessment of practical skills and abilities	The purpose of this component is to test appropriate skills in Assessment Objective C. This paper is a written paper of compulsory questions designed to test familiarity with practical laboratory procedures and will test skills in assessment objective C. This implies that learners must be exposed to practical work and demonstrations	1 hour 15 minutes	40
		TOTAL	**160**

Weighting of papers

All learners will be entered for Papers 1, 2 and 3 as specified below.
Learners will be graded from (A* - G) depending on their abilities and achievements.

Weighting of papers in overall qualification	
Paper 1 Paper 2 Paper 3 (Alternative to Practical Paper)	30% 50% 20%

8. SPECIFICATION GRID

The approximate weightings allocated to each of the Assessment Objectives across the papers are summarised in the table below:

Assessment Objective		Weighting across all components	Paper 1	Paper 2	Paper 3
A	Knowledge with understanding	47% (not more than 24% recall)	25 marks	50 marks	0
B	Handling information, application and solving problems	28%	15 marks	30 marks	0
C	Practical (experimental and investigative) skills and abilities	25%	0 marks	0 marks	40 marks
			40 marks	**80 marks**	**40 marks**
			160 marks		

It should be noted that there is a greater weighting of 53% for skills (including handling information, solving problems, experimental skills and investigations) compared to 47% cent for knowledge and understanding. Teachers should make sure that their **schemes of work** and the **sequence of learning activities** reflect this balance so that the aims of the syllabus are met and the candidates are suitably prepared for the assessment.

9. GRADE DESCRIPTIONS

The scheme of assessment is intended to encourage positive achievement by all learners. Grade descriptions are therefore provided for judgmental Grades A, C and F to give a general indication of the standards of achievement likely to have been shown by learners awarded particular grades. The description must be interpreted in relation to the content specified by the Physics syllabus but is not designed to define that content. The grade awarded will depend in practice upon the extent to which the learner has met the assessment objective overall. Shortcomings in some aspects of the assessment may be balanced by better performance in others. Grade descriptions for Science Subjects will range from A, C and F.

*At **Grade A**, the learner is expected to:*

- recall a wide range of knowledge from all areas of the syllabus
- use detailed scientific knowledge and understanding in a range of applications relating to scientific systems or phenomena
- use a wide range of scientific and technical vocabulary throughout their work
- explain how theories can be changed by new evidence and identify some areas of uncertainty in science
- select and collate information from a number of sources and present it in a clear, logical form
- solve problems in situations that may involve a wide range of variables
- process data from a number of sources to identify patterns or trends
- generate a hypothesis to explain facts, or find facts to support a hypothesis

*At **Grade C**, the learner is expected to:*

- recall a range of scientific information from all areas of the syllabus
- use and apply scientific knowledge and understanding in some general contexts
- use appropriate scientific and technical vocabulary in a range of contexts
- explain how scientific theories can be modified by new scientific evidence
- select a range of information from a given source and present it in a clear, logical form
- identify patterns or trends in given information
- solve problems involving more than one step, but with a limited range of variables
- generate a hypothesis to explain a given set of facts or data

*At **Grade F**, the learner is expected to:*

- recall and communicate limited knowledge and understanding of scientific phenomena, facts, laws, definitions, concepts and theories
- apply a limited range of scientific facts and concepts to give basic explanations of familiar phenomena, to solve straightforward problems and make simple predictions
- communicate and present simple scientific ideas, observations and data using a limited range of scientific terminology and conventions
- select a single piece of information from a given source, and use it to support a given conclusion, and to make links between scientific information and its scientific, technological, social, economic or environmental implications
- solve problems involving more than one step if structured help is given
- analyse data to identify a pattern or trend
- select, describe and evaluate techniques for a limited range of scientific operations and laboratory procedures.

10. GLOSSARY OF TERMS

Analyse	Examine information in detail to discover patterns and relationships, or to study and determine relationship or accuracy
Apply/use	Emphasises the correct use of a equipment, procedures, rules or facts, e.g. a child may be able to use a Bunsen burner, but not do so correctly or have no regard to safety
Calculate	A numerical answer is required - working must be shown
Compare	To explain the resemblances, similarities or differences between two or more numbers, objects, or figures by considering their attributes/characteristics; or to determine if two or more items, entries or variables are the same and if not, identify differences and give a reason for your answer
Distinguish / Identify	Tell apart, show or indicate the difference between, find out what is unique about a material or situation Example: Distinguish between a heat and solar energy
Draw / Record	Make an accurate drawing, graphs, tables, charts or representation by using mathematical instruments and/or rules. In case of diagrams, make detailed drawing with heading and all relevant labels. In graph work or charts, an accurate to scale curves or lines should be given with a heading and relevant labels and units. In tables the heading and labels should be given. In tables the units should be given in the heading of the columns or with each entry but not both
Convert	Change from one unit of measure to another
Deduce	Use the information provided to come to a conclusion, e.g. reference to a law or principles, or the necessary reasoning is to be included in the answer
Define	A literal statement is required
Describe / observe	Write down what you do, or what you would see, hear, feel, smell and taste, in as much detail as possible with due regards to safety
Design	Make a plan or drawing to show the appearance of something before it is made
Determine	Use the information given to work out the answer
Discuss	Give a critical account of the points involved in the topic
Estimate	Implies a reasoned statement or calculation about something. Produce an approximate answer using rational, logical procedures (e.g., rounding for numbers and benchmarks for measures)
Evaluate	Use the information provided to make a judgement about something
Explain	Give a reason for your answer
Find	A general term which means calculate, determine or measure
Give / state / write down	Write down your answer
Interpret	Reasoning or some reference to theory, depending on the content; explain the meaning of something
Investigate	Examine a problem in a systematic way
List	Give a number of points, generally each of one word
Name	Identify by mentioning the name of something
Outline	Give a brief answer writing down the main points
Predict	To determine the next step or value (to make an educated guess), based on evidence or a pattern; make a logical deduction either from your own knowledge or from the

	information given in the question or both
Relate	Find the relationship between one or more variables
Recall and use	Remember a particular formula and apply it in calculations
Select	Choose from a number of alternatives
Sketch	Make a rough drawing that shows the salient or distinguishing features of an object; in diagrams, make a simple, freehand drawing and in graph work, the shape and/or position of the curve should be given
Study	Use the information or data provided to investigate a problem in a systematic way
Suggest	Use your knowledge of the context of the problem and mathematical procedures to give what you think is the best strategy to use or answer to the question use your knowledge of science and the information in the question to give what you think is the best answer

ANNEXE A: Practical assessment and Paper 3, Alternative to Practical Paper

Scientific subjects are, by their nature, experimental. It is, accordingly, important that an assessment of a learner's knowledge and understanding of Physics should contain a component relating to practical work and experimental skills (as identified by assessment objective C).

1. Experimental contexts

Candidates may be asked questions on the following experimental contexts:

(a) measurement of physical quantities (e.g. length, mass, volume, force)
(b) cooling and heating
(c) springs and balances
(d) timing motion or oscillations
(e) electric circuits
(f) optics equipment such as mirrors, prisms and lenses
(g) procedures using simple apparatus, in situations where the method may not be familiar to the candidate.

2. Experimental skills and investigations requirements

Candidates may be required to do the following:

(a) describe the use of common techniques, apparatus and materials, for example ray-tracing equipment or the connection of electric circuits
(b) select the most appropriate apparatus or method for a task and justify the choice made
(c) draw, complete or label diagrams of apparatus
(d) explain the manipulation of the apparatus to obtain observations or measurements, for example:
   (i) when determining a derived quantity, such as the extension per unit load for a spring
   (ii) when testing/identifying the relationship between two variables, such as between the p.d. across a wire and its length
   (iii) when comparing physical quantities, such as two masses using a balancing method
(e) make estimates or describe outcomes which demonstrate their familiarity with an experiment, procedure or technique
(f) take readings from an image of the device (for example thermometer, ruler, protractor, measuring cylinder, ammeter, stopwatch), including:
   (i) reading analogue and digital scales with accuracy and appropriate precision
   (ii) interpolating between scale divisions when appropriate
   (iii) correcting for zero errors, where appropriate
(g) plan to take a sufficient number and range of measurements, repeating where appropriate to obtain an average value
(h) describe or explain precautions taken in carrying out a procedure to ensure safety or the accuracy of observations and data, including the control of variables
(i) identify key variables and describe how, or explain why, certain variables should be controlled
(j) record observations systematically, for example in a table, using appropriate units and to a consistent and appropriate degree of precision
(k) process data, using a calculator where necessary
(l) present and analyse data graphically, including the use of best-fit lines where appropriate, interpolation and extrapolation, and the determination of a gradient, intercept or intersection
(m) draw an appropriate conclusion, justifying it by reference to the data and using an appropriate explanation
(n) comment critically on a procedure or point of practical detail and suggest an appropriate improvement
(o) evaluate the quality of data, identifying and dealing appropriately with any anomalous results
(p) identify possible causes of uncertainty, in data or in a conclusion
(q) plan an experiment or investigation including making reasoned predictions of expected results and suggesting suitable apparatus and techniques.

3. Teaching experimental skills

We expect you to look for suitable opportunities to embed practical techniques and investigative work throughout the teaching. The best way to prepare candidates for these papers is to integrate practical work fully into the course so that it becomes a normal part of your teaching. Practical work helps candidates to:

- develop a deeper understanding of the syllabus topics
- learn to appreciate the way in which scientific theories are developed and tested
- develop experimental skills and positive scientific attitudes such as objectivity, integrity, cooperation, enquiry and inventiveness.

4. Apparatus list

This list contains the items you will need for teaching the experimental skills needed. It is not exhaustive. As far as possible, teachers should improvise and use easily accessible and familiar materials from the local environment.

- an ammeter full scale deflection (FSD) 1 A or 1.5 A (*a multimeter is recommended)
- voltmeter full scale deflection (FSD) 1 V, 5 V (*a multimeter is recommended)
- cells and holders to enable several cells to be joined
- connecting leads and crocodile clips
- d.c. power supply, variable to 12 V
- low voltage filament lamps in holders
- various resistors and resistance wire
- switch
- metre ruler
- good supply of masses and holder
- springs
- stop-watch
- newton meter
- plastic or polystyrene cup
- Plasticine or modelling clay
- thermometer, –10 °C to +110 °C at 1 °C graduations
- wooden board
- converging lens with f = 15 cm
- glass or Perspex block, rectangular and semicircular
- optics pins
- ray box
- measuring cylinder, 25 cm^3, 100 cm^3.

ANNEXE B: Data sheet: the Periodic Table of the elements

Group																	
I	II											III	IV	V	VI	VII	0
							1 H Hydrogen 1										4 He Helium 2
7 Li Lithium 3	9 Be Beryllium 4											11 B Boron 5	12 C Carbon 6	14 N Nitrogen 7	16 O Oxygen 8	19 F Fluorine 9	20 Ne Neon 10
23 Na Sodium 11	24 Mg Magnesium 12											27 Al Aluminium 13	28 Si Silicon 14	31 P Phosphorus 15	32 S Sulphur 16	35.5 Cl Chlorine 17	40 Ar Argon 18
39 K Potassium 19	40 Ca Calcium 20	45 Sc Scandium 21	48 Ti Titanium 22	51 V Vanadium 23	52 Cr Chromium 24	55 Mn Manganese 25	56 Fe Iron 26	59 Co Cobalt 27	59 Ni Nickel 28	64 Cu Copper 29	65 Zn Zinc 30	70 Ga Gallium 31	73 Ge Germanium 32	75 As Arsenic 33	79 Se Selenium 34	80 Br Bromine 35	84 Kr Krypton 36
85 Rb Rubidium 37	88 Sr Strontium 38	89 Y Yttrium 39	91 Zr Zirconium 40	93 Nb Niobium 41	96 Mo Molybdenum 42	- Tc Technetium 43	101 Ru Ruthenium 44	103 Rh Rhodium 45	106 Pd Palladium 46	108 Ag Silver 47	112 Cd Cadmium 48	115 In Indium 49	119 Sn Tin 50	122 Sb Antimony 51	128 Te Tellurium 52	127 I Iodine 53	131 Xe Xenon 54
133 Cs Caesium 55	137 Ba Barium 56	139 La Lanthanum 57 *	178 Hf Hafnium 72	181 Ta Tantalum 73	184 W Tungsten 74	186 Re Rhenium 75	190 Os Osmium 76	192 Ir Iridium 77	195 Pt Platinum 78	197 Au Gold 79	201 Hg Mercury 80	204 Tl Thallium 81	207 Pb Lead 82	209 Bi Bismuth 83	- Po Polonium 84	- At Astatine 85	- Rn Radon 86
- Fr Francium 87	226 Ra Radium 88	227 Ac actinium 89 †															

*58-71 Lanthanoid series

†90-103 Actinoid series

140 Ce Cerium 58	141 Pr Praseodymium 59	144 Nd Neodymium 60	- Pm Promethium 61	150 Sm Samarium 62	152 Eu Europium 63	157 Gd Gadolinium 64	159 Tb Terbium 65	163 Dy Dysprosium 66	165 Ho Holmium 67	167 Er Erbium 68	169 Tm Thulium 69	173 Yb Ytterbium 70	175 Lu Lutetium 71
232 Th Thorium 90	- Pa Protactinium 91	- U Uranium 92	- Np Neptunium 93	- Pu Plutonium 94	- Am Americium 95	- Cm Curium 96	- Bk Berkelium 97	- Cf Californium 98	- Es Einsteinium 99	- Fm Fermium 100	- Md Mendelevium 101	- No Nobelium 102	- Lr Lawrencium 103

Key: A_r
X
Z

A_r = relative atomic mass
X = atomic symbol
Z = proton (atomic) number

The volume of one mole of any gas is 24 dm^3 at room temperature and pressure (r.t.p.)

ANNEXE C: Units of the common physical quantities

1. Numbers

The decimal point will be placed on the line, e.g. 52.35.
Numbers from 1000 to 9999 will be printed without commas or spaces.
Numbers greater than or equal to 10 000 will be printed without commas. A space will be left between each group of three whole numbers, e.g. 4 256 789.

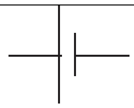
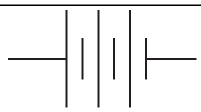
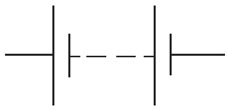
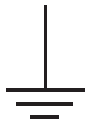
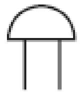
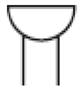
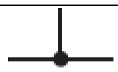
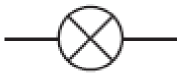
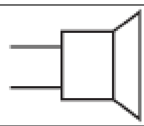
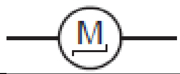
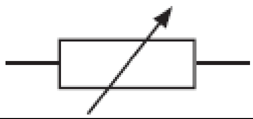
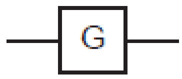
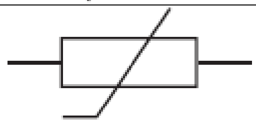
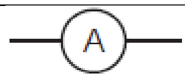
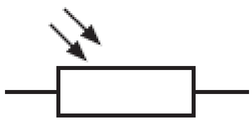
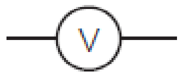
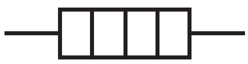
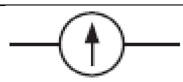
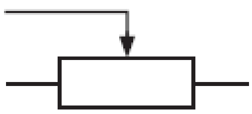
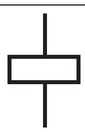
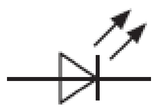
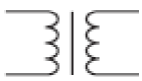
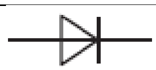
2. Units

Learners should be able to state the symbols for the following physical quantities and where indicated, state the units in which they are measured.
The acceptable method of stating units will be in the form such as m/s or m s^{-1} for metres per second. The solidus (/) will be used for a quotient and indicate units in labels of tables and graphs e.g. distance/cm).

Note: The units of Physical quantities written in words should be in **lower case**.

Quantity	Usual symbol	Usual unit
length	*l, s, h, d*	km, m, cm, mm
mass	*m*	kg, g, mg
weight	*w*	N
time, period	*t, T*	h, min, s, ms
area	*A*	m^2, cm^2, mm^2
volume	*V*	m^3, cm^3
density	*ρ*	kg/m^3, g/cm^3
speed	*u, v*	km/h, m/s, cm/s
acceleration	*a*	m/s^2
acceleration of free fall	*g*	N/kg or m/s^2
gravitational field strength	*g*	N/kg or m/s^2
force	*F*	N
work done	*W, E*	J
energy	*E*	J
power	*P*	W
pressure	*P*	Pa, N/m^2
moment	τ	N m
momentum	*p*	kg m/s
temperature	*T, θ*	°C, K
heat capacity, latent heat	*C, L*	J
specific heat capacity	*c*	J/(kg °C)
specific latent heat	*l*	J/kg
focal length	*f*	cm, mm
angle of incidence	*i*	degree, °
angle of reflection, refraction	*r*	degree, °
critical angle	*c*	degree, °
potential difference/voltage	*V*	V, mV
current	*I*	A, mA
electromotive force (e.m.f).	*ε*	V
resistance	*R*	Ω
charge	*Q*	C
wavelength	λ	m, cm
refractive index	*n*	(no unit)
frequency	*f*	Hz

ANNEXE D: Electrical symbols

cell		switch	
batter of cells	 or 	earth or ground	
power supply		electric bell	
a.c power supply		buzzer	
junction of conductors		microphone	
lamp		loudspeaker	
fixed resistor		motor	
variable resistor		generator	
thermistor		ammeter	
light dependent resistor		voltmeter	
heater		galvanometer	
potential divider		oscilloscope	
relay coil		light-emitting diode	
transformer		fuse	
diode			

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