STANDARDS FOR SECONDARY EDUCATION

PHYSICS

Quality Assurance and Development Services
Ministry of Education, Youth and Sports 2004

PHYSICS

CONTENT STANDARD NO. 1
Express physical quantities using the International System of Units (S.I. system).

Learning Outcomes
Third Form

1.1 Recall the most common fundamental quantities and the corresponding base units of the International System of Units (S.I. system) and their related symbols.
1.2 Express standard units using prefixes and their symbols.
1.3 Express and calculate numbers in standard form (scientific notation).
1.4 Know that multiplying and dividing fundamental quantities and corresponding units produce 'derived quantities' and the corresponding units.
1.5 Express derived units using the index notation.

CONTENT STANDARD NO. 2
Know that every measurement of a quantity is an attempt to determine its true value and that failure to obtain this arises from limitations on the part of the experimenter and the apparatus used.

Learning Outcomes
Third Form

2.1 Differentiate between linear and non-linear scales, and between analogue and digital scales.
2.2 Express the result of a measurement or calculation to an appropriate number of significant figures or decimal places.
2.3 Identify possible sources of error in any measurement, including those made with digital instruments.
2.4 Identify ways of reducing errors when taking measurements.
2.5 Use common laboratory instruments to measure different physical quantities such as length, mass, time, temperature, volume, and force.
2.6 Assess the suitability of instruments on the basis of sensitivity, accuracy and range.
2.7 Investigate the factors, which might affect the period (***T***) of a simple pendulum.
2.8 Measure the area of both regular and irregular shapes.
2.9 Measure the volume of both regular and irregular solids, which float and sink in water.
2.10 Determine density using $Density, \rho = \frac{mass, m}{volume, V}$, and calculate the relative density for different materials.

CONTENT STANDARD NO. 3
Recognize the importance of graphical presentation and analysis of data in Physics by practicing suitable graph construction techniques, and by drawing valid conclusions through analysis.

Learning Outcomes
Third Form

3.1 Plot and draw a line of 'best fit' of experimental data.
3.2 Interpret and use graphs of experimental data by determining the gradient (slope), the intercept, and standard deviation (error calculation) from a theoretical value for straight-line graphs.

CONTENT STANDARD NO. 4
Know the various effects of balanced forces and the ways in which these effects may be transmitted.

Learning Outcomes
Third Form

4.1 Recall that a force can cause a change in the size, shape or motion of a body.
4.2 Identify situations in which electric, magnetic, nuclear or gravitational forces act.

4.3 Determine the weight of objects using the relationship: *weight = mass* $\times$ *gravitational field strength*, that is, $W = mg$.

4.4 Identify everyday situations in which a turning effect on a body will result from the application of a force.

4.5 State and use the Principle of Moments to solve problems.

4.6 Explain the action of common tools and devices such as levers.

4.7 Determine the location of the centre of gravity of regular and irregular shaped solids, including lamina.

4.8 Relate the stability of an object to the position of its centre of gravity and its weight in relation to the ground.

4.9 Investigate the relationship between extension and force, for springs and elastic bands, and use this relationship to solve problems.

CONTENT STANDARD NO. 5

Describe certain physical quantities using the magnitude as well as the direction.

Learning Outcomes

Third Form

5.1 Distinguish between scalars and vectors and give examples of each.

5.2 Find the resultant of two vectors.

5.3 Describe common situations by determining the horizontal and vertical components of a single resultant vector.

CONTENT STANDARD NO. 6

Analyze quantities for objects in motion.

Learning Outcomes

Third Form

6.1 Describe how the methodology employed by Galileo contributed to the development of physical principles of motion.

6.2 Recall the meaning of the terms: distance, displacement, speed, velocity, and acceleration.

6.3 Draw and interpret displacement-time and velocity-time graphs.

6.4 Use the equations of motion in the solution of problems for constant acceleration.

CONTENT STANDARD NO. 7

Apply the laws of dynamics and the conservation of momentum.

Learning Outcomes

Third Form

7.1 Recall Aristotle's arguments in support of his "law of motion, $v \propto F$", and recall why this law was eventually discredited.

7.2 State and use Newton's three laws of motion to explain dynamical systems.

7.3 Describe everyday situations that demonstrate the law of conservation of linear momentum, and use the law to solve problems.

7.4 Identify the presence of an unbalanced force in uniform circular motion.

CONTENT STANDARD NO. 8

Participate in the efficient use of energy as individuals, appreciate the need to conserve energy resources as a region, and apply to the solution of everyday problems the law of conservation of energy.

Learning Outcomes

Third Form

8.1 Identify the various forms of energy, and recall the unit of measurement, the joule.

8.2 Describe and illustrate energy transformation(s).

8.3 Discuss the use of energy from alternative sources, and its importance to the Caribbean and Central American regions.

8.4 Suggest ways in which energy may be used more efficiently and economically in Belize.

8.5 Apply the law of conservation of energy to the solution of problems.

8.6 Define potential energy as the energy stored by an object by virtue of its position or state, and calculate the change in gravitational potential energy using the expression $\Delta E_P = mg\Delta h$.

8.7 Define kinetic energy as the energy possessed by a body by virtue of its motion, and calculate kinetic energy using the expression: $E_K = \frac{1}{2}mv^2$.

8.8 Recall power as energy converted per unit time, $P = \frac{E}{t}$, and use this relationship to solve problems.

8.9 Identify a given machine as a force or distance multiplier, and assess its suitability for performing a given task.

8.10 Explain the term efficiency, and recall the factors that affect its value.

8.11 Perform activities to measure and calculate input and output quantities, and find the efficiency of the given system.

CONTENT STANDARD NO. 9
Discuss the application of the principles of hydrostatics to everyday life.

Learning Outcomes
Third Form

9.1 Define pressure and use it to solve problems.

9.2 Relate the pressure at a point in a fluid to its depth and the density using everyday examples as evidence.

9.3 Show how a manometer is used to measure excess gas pressure.

9.4 Recall that pressure is uniformly transmitted through a fluid and cite examples of the application of this principle.

9.5 Apply Archimedes' principle to predict whether a body would float or sink in a given fluid.

CONTENT STANDARD NO. 10
Know that the supply of thermal energy to a body may produce changes in temperature, pressure and physical properties, and relate those changes to the nature of the material from which the body is made.

Learning Outcomes
Third Form

10.1 Relate temperature to the direction of net energy transfer, and to the average kinetic energy of molecules of a body.

10.2 Identify some physical properties which vary with temperature and which therefore may be used as the basis for measuring temperature.

10.3 Relate the use of a thermometer to its design.

10.4 Explain advantages and disadvantages of everyday effects of thermal expansion, and identify ways to compensate for its negative effects.

10.5 Show the relationships among pressure (*p*), volume (*V*), and temperature (*T*) for a fixed mass of gas.

10.6 Relate graphs of pressure or volume against temperature to the establishment of the Kelvin scale.

10.7 Use the approximate relationship between Kelvin and Celsius scale: $T / K = \theta / ^\circ C + 273$

10.8 Apply Boyle's, Charles', Pressure and General gas laws, and describe the behavior of gases in terms of the motion of its molecules.

10.9 Describe Brownian motion.

CONTENT STANDARD NO. 11
Discuss the development of the theories of heat.

Learning Outcomes
Third Form

11.1 Differentiate between the caloric and kinetic theories of heat as they existed in the eighteenth century.

11.2 Discuss Rumford's cannon-boring experiments as evidence against the caloric theory.

11.3 Recall the role of Joule's experiments in establishing the principle of conservation of energy.

CONTENT STANDARD NO. 12

***Apply the relationship between thermal quantities, and relate them to the Kinetic Theory of Matter*.**

Learning Outcomes

Third Form

12.1 Define heat capacity ***C*** and specific heat capacity ***c***, and recall that specific heat capacity, ***c*** and heat capacity, ***C*** are related by the formula $C = mc$, where ***m*** is mass.

12.2 Recall $E_H = mc\Delta\theta$ and use it to solve problems.

12.3 Determine the specific heat capacity of metals and liquids.

12.4 Discuss the formation of land and sea breezes in terms of the specific heat capacities of the earth and the sea.

12.5 Distinguish amongst solids, liquids and gases using the Kinetic theory to explain the different macroscopic properties.

12.6 Show that temperature remains constant during a phase change.

12.7 Define the specific latent heat and use the relationship $E_H = ml$ to solve problems.

12.8 Determine specific latent heat of fusion of ice, l_f and the specific latent heat of vaporization of water, l_v.

12.9 Use the Kinetic theory to explain boiling and evaporation, and describe applications of the cooling effect of evaporation.

CONTENT STANDARD NO. 13

***Analyze the various modes of thermal energy transfer*.**

Learning Outcomes

Third Form

13.1 Describe the transfer of thermal energy by conduction.

13.2 Relate the fact that air is a very poor conductor to the insulation properties of certain materials like expanded polystyrene and hollow blocks.

13.3 Describe the transfer of thermal energy by convection

13.4 Show convection in fluids, and relate convection to common phenomena like land and sea breezes.

13.5 Describe the transfer of thermal energy by radiation and show that radiant energy requires no medium for transmission.

13.6 Investigate the factors on which absorption and emission of radiation depend.

13.7 Relate the principles of thermal energy transfer (conduction, convection, radiation) to the design of devices such as vacuum flasks and solar water heaters.

13.8 Describe the glass (green) house effect including the role of atmospheric CO_2, and discuss its possible effect on global warming.

CONTENT STANDARD NO. 14

Know that wave motion is a means of transferring energy.

Learning Outcomes

Fourth Form

14.1 Differentiate between types of waves.

14.2 Identify and illustrate that wave motion is a means of transferring energy.

14.3 Recall the meaning of the wave parameters: wave speed, frequency, wavelength, period, amplitude, phase, and solve problems involving these parameters.

14.4 Draw and interpret displacement-time and displacement-position graphs for transverse and longitudinal waves.

CONTENT STANDARD NO. 15

Know that there are certain features common to the character and behavior of all waves.

Learning Outcomes

Fourth Form

15.1 Recall that all waves undergo reflection, refraction and diffraction.

15.2 Demonstrate reflection of plane and circular wave fronts at plane surfaces.

15.3 Demonstrate refraction of plane wave fronts at plane boundaries.
15.4 Relate refraction at a plane boundary to change in speed across the boundary, and recall that the frequency remains unchanged after refraction and use the relationship $\frac{\sin\theta_1}{\sin\theta_2}=\frac{v_1}{v_2}=\frac{\lambda_1}{\lambda_2}$ to solve problems on refraction.
15.5 Demonstrate diffraction of plane wave fronts at edges and at single slits of different widths.
15.6 Demonstrate the superposition or interference of waves.

CONTENT STANDARD NO. 16

Describe how sound waves are produced and propagated, and apply this knowledge to practical situations.

Learning Outcomes
Fourth Form

16.1 Describe how sound is propagated in a medium.
16.2 Use the terms 'pitch' and 'loudness', and equate them to the wave parameters of 'frequency' and 'amplitude', and relate 'quality' to the nature of the vibrating body and harmonics.
16.3 Recall the order of magnitude of the speed of sound and apply the knowledge to practical situations.
16.4 Recall the range of frequencies detectable by the normal human ear.

CONTENT STANDARD NO. 17

Analyze electromagnetic (e.m.) waves.

Learning Outcomes
Fourth Form

17.1 Recall the properties of e.m. waves and differentiate between types of e.m. waves in terms of their wavelengths.
17.2 Identify a source and use of each type of e.m. waves.

CONTENT STANDARD NO. 18

Discuss the historical development of the theory of light.

Learning Outcomes
Fourth Form

18.1 Compare the rival theories of light held by scientists such as Huygens, Newton, Young, and Einstein.
18.2 Demonstrate that light travels in straight lines.

CONTENT STANDARD NO. 19

***Illustrate the knowledge of the reflection and refraction of light in simple situations*.**

Learning Outcomes
Fourth Form

Show that the angles of incidence and reflection are equal.

19.1 Investigate the formation of images in a plane mirror.
19.2 Cite evidence for the refraction of light.
19.3 Demonstrate the refraction of light rays through rectangular blocks, and triangular prisms.
19.4 State the laws of refraction and use Snell's Law to solve numerical problems.
19.5 Define refractive index, ***n***, and explain with the aid of diagrams what is meant by 'critical angle' and 'total internal reflection'.
19.6 Calculate critical angle and use it to make predictions about total internal reflection.
19.7 Illustrate applications of total internal reflection in devices such as periscopes, fibre optic cables, and endoscopes.
19.8 Show how a prism may be used to produce a spectrum from a source of white light.
19.9 Discuss the significance of Newton's prisms experiments for the scientific methodology.

CONTENT STANDARD NO. 20

Recall the ways in which physicists have utilized the knowledge of reflection and refraction to design simple optical instruments.

Learning Outcomes

Fourth Form

20.1 Recall the meaning of the terms: principal axis, principal focus, focal length, focal plane, and magnification.

20.2 Illustrate the effect of converging and diverging lens on a beam of parallel rays.

20.3 Differentiate between real and virtual images.

20.4 Determine the magnification of an image.

20.5 Measure the focal length, ***f*** of converging lens.

20.6 Show how a single lens is used as a magnifying glass, in a simple lens camera, and in a projector.

20.7 Describe how the eye forms an image.

CONTENT STANDARD NO. 21

Show a qualitative understanding of electrostatic phenomena.

Learning Outcomes

Fourth Form

21.1 Explain the charging of objects in terms of properties of negatively charged electrons, which are relatively free to move.

21.2 Show how an object may become charged by friction.

21.3 Show how a charged object can attract objects that have zero net charge.

21.4 Define an electric field as a region in which an electric charge experiences a force of electrical origin.

21.5 Show the electric fields around point charges and between charged parallel plates.

21.6 Describe hazards and useful applications of static charge such as lightning strikes, dust extraction and xerography.

CONTENT STANDARD NO. 22

Recall ways in which electricity is conducted and analyze different types of current flow.

Learning Outcomes

Fourth Form

22.1 Distinguish between electrical conductors and insulators.

22.2 Recall that an electric current in a metal consists of a flow of negative electrons and that an electric current in fluids consists of the movement of both negative and positive charge carriers.

22.3 Differentiate between electron flow and conventional current.

22.4 Recall the relationship $Q = It$, and apply it to solve simple problems.

22.5 Differentiate between direct and alternating currents.

22.6 Draw current-time or voltage-time graphs to represent direct and alternating currents.

22.7 Use current-time or voltage-time graphs to deduce the period, frequency, peak and root-mean-square (r.m.s.) values of alternating currents and voltages.

CONTENT STANDARD NO. 23

Apply the relationship between electrical quantities to the solution of problems and discuss mechanisms to reduce the wastage of electrical energy.

Learning Outcomes

Fourth Form

23.1 Cite examples of the conversion of electrical energy to other forms and vice versa.

23.2 Define the potential difference between the ends of a conductor and use the relationship $V = \frac{E}{Q}$ to solve problems involving energy transformations.

23.3 Recall the relationship $P = VI$ and use it to solve problems.

23.4 Perform calculations on the cost of electrical energy expressed in kilowatthours (kWh).
23.5 Discuss the need for reducing wastage of electrical energy and the means of doing so.

CONTENT STANDARD NO. 24
Relate electrical components and circuits to everyday life.

Learning Outcomes
Fourth Form

24.1 Use circuit symbols for cells, switches, wires, fuses, fixed and variable resistors, filament lamps, voltmeters, ammeters, and semiconductor diodes.
24.2 Draw simple circuit diagrams to represent a given arrangement of electrical components, and set up a simple circuit given a circuit diagram paying due regard to the polarity and suitability of components.
24.3 Draw a diagram of a zinc-carbon cell and explain the functions of its various parts.
24.4 State the difference between primary and secondary cells and their relative advantages and disadvantages.
24.5 Draw a circuit diagram to show how a secondary cell can be recharged.
24.6 Use an ammeter and a voltmeter to investigate the relationship between current and potential difference for metallic conductors at constant temperature, filament lamps, semiconductor diodes, and solutions of copper sulphate in water using copper electrodes.
24.7 Draw and analyze ***I-V*** graphs.
24.8 Use the relationship $R = \frac{V}{I}$ to solve problems.
24.9 Explain why it is necessary for an ammeter to have a very low resistance, and why it is necessary for a voltmeter to have a very high resistance.
24.10 Differentiate between series and parallel circuits.
24.11 Recall that the current in a series circuit is the same everywhere in the circuit and apply this concept to solve problems; and recall that the sum of the currents in the branches of a parallel circuit is equal to the current entering or leaving the parallel section and apply this concept to solve problems.
24.12 Recall that the sum of the potential differences across any number of components in series is equal to the potential difference across all those components and apply this concept to solve problems; and recall that the potential difference across any number of components in parallel is the same and apply this concept to solve problems.
24.13 Recall and use the formulae: $R_S = R_1 + R_2 + R_3 + ...$ for resistors in series; and
$\frac{1}{R_P} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + ...$ for resistors in parallel.
24.14 Discuss the reasons for using parallel connections in domestic appliances.
24.15 Explain the purpose of a fuse, circuit breaker, surge protector, and UPS; and select a fuse or circuit breaker of suitable current rating for a given appliance.
24.16 Explain the function of the earth wire.
24.17 Recall the international insulation code.
24.18 State the adverse effect of connecting electrical appliances to incorrect or fluctuating voltage supplies.

CONTENT STANDARD NO. 25
Describe some applications of electronics in everyday life.

Learning Outcomes
Fourth Form

25.1 Describe how a semiconductor diode can be used in half wave rectification.
25.2 Differentiate between direct current from batteries and rectified alternating current by a consideration of the V-t graphs for both cases.
25.3 Determine if a semiconductor diode is defective.
25.4 Recall the symbols for AND, OR, NOT, NAND, NOR logic gates and state the function of each gate with the aid of truth tables.

25.5 Analyze circuits involving the combinations of not more than three logic gates as in a simple alarm circuit and doorbells.

CONTENT STANDARD NO. 26
Demonstrate a qualitative understanding of simple phenomena associated with magnets.

Learning Outcomes
Fourth Form

26.1 Identify the poles of a magnetic dipole.
26.2 Show that a repulsive force exists between like poles and an attractive force between unlike poles.
26.3 Differentiate between magnetic and non-magnetic materials; explain how a magnet can attract an unmagnetized object; and distinguish between materials used to make 'permanent' and 'temporary' magnets.
26.4 Define a magnetic field as the region in which a magnetic force may be exerted and map the magnetic fields around a single strong magnet, and around and between two strong magnets.
26.5 Recall that a magnetic field line indicates the direction of the magnetic force acting on an N-pole.
26.6 Show how permanent magnets can be used to create a uniform magnetic field over a small region.

CONTENT STANDARD NO. 27
Demonstrate a working knowledge of electromagnetic phenomena.

Learning Outcomes
Fourth Form

27.1 Investigate the magnetic field pattern around current-carrying conductors such as straight conductors, flat coils and solenoids.
27.2 Apply suitable rules, which relate the direction of current flow to the direction of the magnetic field.
27.3 Describe commercial applications of electro-magnets.
27.4 Explain the action of a simple magnetic relay (starter motor relay) in the construction of protection systems, AC and diesel generators.
27.5 Show that there is an existence of a force on a current-carrying conductor placed in a magnetic field.
27.6 Sketch the resultant magnetic flux pattern where a current carrying wire is placed perpendicular to a uniform magnetic field.
27.7 Apply Fleming's left hand (Motor) Rule to predict what will happen when current flows perpendicular to a uniform magnetic field.
27.8 Recall that the force on a current-carrying conductor in a magnetic field depends on the strength of the fields and on the magnitude of the current.
27.9 Explain the action of a d.c. motor.
27.10 Explain the principles underlying the operation of a simple moving coil loudspeaker.
27.11 Show that an induced e.m.f. caused by changing magnetic flux.
27.12 Show how the magnitude of the e.m.f. induced in a conductor depends on the rate of change of magnetic flux experienced by the conductor.
27.13 Explain the action of a simple a.c. generator.
27.14 Give a simple explanation of the principle of operation of a transformer.
27.15 Describe features of a transformer, which make for efficiency.
27.16 Recall the advantages of using a.c. for transferring electrical energy.
27.17 Perform activities to show that for an ideal transformer $P_{OUT} = P_{IN}$ and $\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$.
27.18 Use the transformer formulae $\frac{V_S}{V_P} = \frac{N_S}{N_P} = \frac{I_P}{I_S}$ to solve numerical problems.

CONTENT STANDARD NO. 28
Describe the development of atomic theory and the concept of the nucleus.

Learning Outcomes
Third Form

28.1 Describe the work done in establishing the modern view of the atom by scientists such as Thomson, Rutherford, Bohr and Chadwick.

28.2 Describe the Geiger-Marsden experiment, which established the nuclear structure of the atom.

CONTENT STANDARD NO. 29
Apply the knowledge of how the elements differ in atomic structure.

Learning Outcomes
Third Form

29.1 Represent diagrammatically the structure of simple atoms, including the charge distribution.

29.2 Compare the mass and charge of the electron with the mass and charge of the proton and explain why an atom is normally neutral and stable.

29.3 Recall and use the relationship $A = Z + N$ such that A - nucleon (mass) number, Z – proton (atomic) number, N – neutron number, and use the standard notation ${}^{A}_{Z}X$ to represent a nuclide.

29.4 Explain what is meant by the term 'isotope'.

29.5 Relate the shell model of the atom to the Periodic Table.

CONTENT STANDARD NO. 30
Describe the phenomena of radioactivity.

Learning Outcomes
Fourth Form

30.1 Describe Marie Curie's work in the field of radioactivity.

30.2 Recall the nature of the three types of emissions from radioactive substances, and describe experiments used to compare the ranges of alpha (α), beta (β) and gamma (γ) emission in various media.

30.3 Describe the appearance of the tracks of radioactive emissions in a cloud chamber, and predict the effects of magnetic and electric fields on the motion of α and β particles and γ rays.

30.4 Represent and interpret nuclear reactions in the standard form:

$${}^{226}_{88}\mathrm{Ra} \rightarrow {}^{222}_{86}\mathrm{Rn} + {}^{4}_{2}\mathrm{He} \quad \text{and} \quad {}^{14}_{6}\mathrm{C} \rightarrow {}^{14}_{7}\mathrm{N} + {}^{0}_{-1}\mathrm{e}$$

30.5 Demonstrate the random nature of radioactive decay and obtain a radioactive decay curve.

30.6 Recall that the decay process is independent of the conditions external to the nucleus.

30.7 Define the term 'half-life', $t_{½}$ and use graphs of random decay to show that such processes have constant half-lives and solve simple problems involving half-life.

30.8 Discuss the useful applications of radioisotopes such as tracers, and recall precautions to be taken while handling radioisotopes.

CONTENT STANDARD NO. 31
Identify that a change in the nuclear mass is associated with the release of energy.

Learning Outcomes
Fourth Form

31.1 Relate the release of energy in a nuclear reaction to a change in mass, and solve problems using Einstein's equation $\Delta E = \Delta m c^2$, including fission and fusion reactions.

31.2 Cite arguments for and against the utilization of nuclear energy.