Physics section

The following course structure is taken directly from the MOE (SEAB) website for O Level syllabus for Science(Physics/Biology) (5077).

CONTENT STRUCTURE

SECTION		Topics
I.	MEASUREMENT	1. Physical Quantities, Units and Measurement
II.	NEWTONIAN MECHANICS	2. Kinematics 3. Dynamics 4. Mass, Weight and Density 5. Turning Effect of Forces 6. Pressure 7. Energy, Work and Power
III.	THERMAL PHYSICS	8. Kinetic Model of Matter 9. Transfer of Thermal Energy 10. Thermal Properties of Matter
IV.	WAVES	11. General Wave Properties 12. Light 13. Electromagnetic Spectrum 14. Sound
V.	ELECTRICITY AND MAGNETISM	15. Static Electricity 16. Current of Electricity 17. D.C. Circuits 18. Practical Electricity 19. Magnetism and Electromagnetism

SUBJECT CONTENT

SECTION I: MEASUREMENT

Overview

In order to gain a better understanding of the physical world, scientists use a process of investigation that follows a general cycle of observation, hypothesis, deduction, test and revision, sometimes referred to as the scientific method. Galileo Galilei, one of the earliest architects of this method, believed that the study of science had a strong logical basis that involved precise definitions of terms and physical quantities, and a mathematical structure to express relationships between these physical quantities.

In this section, we examine how a set of base physical quantities and units is used to describe all other physical quantities. These precisely defined quantities and units, with accompanying order-of-ten prefixes (e.g. milli, centi and kilo) can then be used to describe the interactions between objects in systems that range from celestial objects in space to sub-atomic particles.

1. Physical Quantities, Units and Measurement

Content

- Physical quantities
- SI units
- Prefixes
- Scalars and vectors
- Measurement of length and time

Learning Outcomes:

Candidates should be able to:

(a) show understanding that all physical quantities consist of a numerical magnitude and a unit

(b) recall the following base quantities and their units: mass (kg), length (m), time (s), current (A), temperature (K)

(c) use the following prefixes and their symbols to indicate decimal sub-multiples and multiples of the SI units: nano (n), micro (μ), milli (m), centi (c), deci (d), kilo (k), mega (M), giga (G)

(d) show an understanding of the orders of magnitude of the sizes of common objects ranging from a typical atom to the Earth

(e) state what is meant by *scalar* and *vector* quantities and give common examples of each

(f) add two vectors to determine a resultant by a graphical method

(g) describe how to measure a variety of lengths with appropriate accuracy by means of tapes, rules, micrometers and calipers, using a vernier scale as necessary

(h) describe how to measure a short interval of time including the period of a simple pendulum with appropriate accuracy using stopwatches or appropriate instruments

SECTION II: NEWTONIAN MECHANICS

Overview

Mechanics is the branch of physics that deals with the study of motion and its causes. Through a careful process of observation and experimentation, Galileo Galilei used experiments to overturn Aristotle's ideas of the motion of objects, for example the flawed idea that heavy objects fall faster than lighter ones, which dominated physics for about 2000 years.

The greatest contribution to the development of mechanics is by one of the greatest physicists of all time, Isaac Newton. By extending Galileo's methods and understanding of motion and gravitation, Newton developed the three laws of motion and his law of universal gravitation, and successfully applied them to both terrestrial and celestial systems to predict and explain phenomena. He showed that nature is governed by a few special rules or laws that can be expressed in mathematical formulae. Newton's combination of logical experimentation and mathematical analysis shaped the way science has been done ever since.

In this section, we begin by examining kinematics, which is a study of motion without regard for the cause. After which, we study the conditions required for an object to be accelerated and introduce the concept of forces through Newton's Laws. Subsequently, concepts of moments and pressure are introduced as consequences of a force. Finally, this section rounds up by leading the discussion from force to work and energy, and the use of the principle of conservation of energy to explain interactions between bodies.

2. Kinematics

Content

- Speed, velocity and acceleration
- Graphical analysis of motion
- Free fall

Learning Outcomes:

Candidates should be able to:

(a) state what is meant by speed and velocity

(b) calculate average speed using *distance travelled* / *time taken*

(c) state what is meant by uniform acceleration and calculate the value of an acceleration using *change in velocity* / *time taken*

(d) interpret given examples of non-uniform acceleration

(e) plot and interpret a distance-time graph and a speed-time graph

(f) deduce from the shape of a distance-time graph when a body is:
  (i) at rest
  (ii) moving with uniform speed
  (iii) moving with non-uniform speed

(g) deduce from the shape of a speed-time graph when a body is:
  (i) at rest
  (ii) moving with uniform speed
  (iii) moving with uniform acceleration
  (iv) moving with non-uniform acceleration

(h) calculate the area under a speed-time graph to determine the distance travelled for motion with uniform speed or uniform acceleration

(i) state that the acceleration of free fall for a body near to the Earth is constant and is approximately 10 m / s^2

3. Dynamics

Content

- Balanced and unbalanced forces
- Free-body diagram
- Friction

Learning Outcomes:

Candidates should be able to:

(a) apply Newton's Laws to:
  (i) describe the effect of balanced and unbalanced forces on a body
  (ii) describe the ways in which a force may change the motion of a body (stating of Newton's laws is not required)

(b) identify forces acting on an object and draw free-body diagram(s) representing the forces acting on the object (for cases involving forces acting in at most 2 dimensions)

(c) recall and apply the relationship *resultant force = mass ´ acceleration* to new situations or to solve related problems

(d) explain the effects of friction on the motion of a body

4. Mass, Weight and Density

Content

- Mass and weight
- Gravitational field and field strength
- Density

Learning Outcomes:

Candidates should be able to:

(a) state that mass is a measure of the amount of substance in a body

(b) state that mass of a body resists a change in the state of rest or motion of the body (inertia)

(c) state that a gravitational field is a region in which a mass experiences a force due to gravitational attraction

(d) define gravitational field strength, *g*, as *gravitational force per unit mass*

(e) recall and apply the relationship *weight = mass ´ gravitational field strength* to new situations or to solve related problems

(f) distinguish between mass and weight

(g) recall and apply the relationship *density* = *mass* / *volume* to new situations or to solve related problems

5. Turning Effect of Forces

Content

- Moments
- Centre of gravity
- Stability

Learning Outcomes:

Candidates should be able to:

(a) describe the moment of a force in terms of its turning effect and relate this to everyday examples

(b) recall and apply the relationship *moment of a force* (or *torque*) = *force ´ perpendicular distance from the pivot* to new situations or to solve related problems

(c) state the principle of moments for a body in equilibrium

(d) apply the principle of moments to new situations or to solve related problems

(e) show understanding that the weight of a body may be taken as acting at a single point known as its centre of gravity

(f) describe qualitatively the effect of the position of the centre of gravity on the stability of objects

6. Pressure

Content

- Pressure

Learning Outcomes:

Candidates should be able to:

(a) define the term pressure in terms of force and area

(b) recall and apply the relationship *pressure* = *force* / *area* to new situations or to solve related problems

7. Energy, Work and Power

Content

- Energy conversion and conservation
- Work
- Power

Learning Outcomes:

Candidates should be able to:

(a) show understanding that kinetic energy, potential energy (chemical, gravitational, elastic), light energy, thermal energy, electrical energy and nuclear energy are examples of different forms of energy

(b) state the principle of the conservation of energy and apply the principle to new situations or to solve related problems

(c) state that kinetic energy $E_k = ½ mv^2$ and gravitational potential energy $E_p = mgh$ (for potential energy changes near the Earth's surface)

(d) apply the relationships for kinetic energy and potential energy to new situations or to solve related problems

(e) recall and apply the relationship *work done = force ´ distance moved in the direction of the force* to new situations or to solve related problems

(f) recall and apply the relationship *power = work done / time taken* to new situations or to solve related problems

SECTION III: THERMAL PHYSICS

Overview

Among the early scientists, heat was thought of as some kind of invisible, massless fluid called ‘caloric’. Certain objects that released heat upon combustion were thought to be able to ‘store’ the fluid. However, this explanation failed to explain why friction was able to produce heat. In the 1840s, James Prescott Joule used a falling weight to drive an electrical generator that heated a wire immersed in water. This experiment demonstrated that work done by a falling object could be converted to heat.

In the previous section, we studied energy and its conversion. Many energy conversion processes which involve friction will have heat as a product. This section begins with the introduction of the kinetic model of matter. This model is then used to explain and predict the physical properties and changes of matter at the molecular level in relation to heat or thermal energy transfer.

8. Kinetic Model of Matter

Content

- States of matter
- Kinetic model

Learning Outcomes:

Candidates should be able to:

(a) compare the properties of solids, liquids and gases

(b) describe qualitatively the molecular structure of solids, liquids and gases, relating their properties to the forces and distances between molecules and to the motion of the molecules

(c) describe the relationship between the motion of molecules and temperature

9. Transfer of Thermal Energy

Content

- Conduction
- Convection
- Radiation

Learning Outcomes:

Candidates should be able to:

(a) show understanding that thermal energy is transferred from a region of higher temperature to a region of lower temperature

(b) describe, in molecular terms, how energy transfer occurs in solids

(c) describe, in terms of density changes, convection in fluids

(d) explain that energy transfer of a body by radiation does not require a material medium and the rate of energy transfer is affected by:
  (i) colour and texture of the surface
  (ii) surface temperature
  (iii) surface area

(e) apply the concept of thermal energy transfer to everyday applications

10. Thermal Properties of Matter

Content

- Internal energy
- Melting, boiling and evaporation

Learning Outcomes:

Candidates should be able to:

(a) describe a rise in temperature of a body in terms of an increase in its internal energy (random thermal energy)

(b) describe melting / solidification and boiling / condensation as processes of energy transfer without a change in temperature

(c) explain the difference between boiling and evaporation

SECTION IV: WAVES

Overview

Waves are inherent in our everyday lives. Much of our understanding of wave phenomena has been accumulated over the centuries through the study of light (optics) and sound (acoustics). The nature of oscillations in light was only understood when James Clerk Maxwell, in his unification of electricity, magnetism and electromagnetic waves, stated that all electromagnetic fields spread in the form of waves. Using a mathematical model (Maxwell's equations), he calculated the speed of electromagnetic waves and found it to be close to the speed of light, leading him to make a bold but correct inference that light consists of propagating electromagnetic disturbances. This gave the very nature of electromagnetic waves, and hence its name.

In this section, we examine the nature of waves in terms of the coordinated movement of particles. The discussion moves on to wave propagation and its uses by studying the properties of light, electromagnetic waves and sound, as well as their applications in wireless communication, home appliances, medicine and industry.

11. General Wave Properties

Content

- Describing wave motion
- Wave terms
- Longitudinal and transverse waves

Learning Outcomes:

Candidates should be able to:

(a) describe what is meant by wave motion as illustrated by vibrations in ropes and springs and by waves in a ripple tank

(b) show understanding that waves transfer energy without transferring matter

(c) define *speed*, *frequency*, *wavelength*, *period* and *amplitude*

(d) state what is meant by the term *wavefront*

(e) recall and apply the relationship *velocity* = *frequency* ´ *wavelength* to new situations or to solve related problems

(f) compare transverse and longitudinal waves and give suitable examples of each

12. Light

Content

- Reflection of light
- Refraction of light
- Thin converging lenses

Learning Outcomes:

Candidates should be able to:

(a) recall and use the terms for reflection, including *normal*, *angle of incidence* and *angle of reflection*

(b) state that, for reflection, the angle of incidence is equal to the angle of reflection and use this principle in constructions, measurements and calculations

(c) recall and use the terms for refraction, including *normal*, *angle of incidence* and *angle of refraction*

(d) recall and apply the relationship $\sin i / \sin r = constant$ to new situations or to solve related problems

(e) define *refractive index* of a medium in terms of the ratio of speed of light in vacuum and in the medium

(f) explain the terms *critical angle* and *total internal reflection*

(g) describe the action of a thin converging lens on a beam of light

(h) define the term *focal length* for a converging lens

(i) draw ray diagrams to illustrate the formation of real and virtual images of an object by a thin converging lens

13. Electromagnetic Spectrum

Content

- Properties of electromagnetic waves
- Applications of electromagnetic waves

Learning Outcomes:

Candidates should be able to:

(a) state that all electromagnetic waves are transverse waves that travel with the same speed in vacuum and state the magnitude of this speed

(b) describe the main components of the electromagnetic spectrum

(c) state examples of the use of the following components:
  (i) radiowaves (e.g. radio and television communication)
  (ii) microwaves (e.g. microwave oven and satellite television)
  (iii) infra-red (e.g. infra-red remote controllers and intruder alarms)
  (iv) light (e.g. optical fibres for medical uses and telecommunications)
  (v) ultra-violet (e.g. sunbeds and sterilisation)
  (vi) X-rays (e.g. radiological and engineering applications)
  (vii) gamma rays (e.g. medical treatment)

14. Sound

Content

- Sound waves
- Speed of sound
- Echo

Learning Outcomes:

Candidates should be able to:

(a) describe the production of sound by vibrating sources

(b) describe the longitudinal nature of sound waves in terms of the processes of compression and rarefaction

(c) explain that a medium is required in order to transmit sound waves and the speed of sound differs in air, liquids and solids

(d) relate loudness of a sound wave to its amplitude and pitch to its frequency

(e) describe how the reflection of sound may produce an echo, and how this may be used for measuring distances

SECTION V: ELECTRICITY AND MAGNETISM

Overview

For a long time, electricity and magnetism were seen as independent phenomena. Hans Christian Oersted, in 1802, discovered that a current carrying conductor deflected a compass needle. This discovery was overlooked by the scientific community until 18 years later. It may be a chance discovery, but it takes an observant scientist to notice. The exact relationship between an electric current and the magnetic field it produced was deduced mainly through the work of Andre Marie Ampere. However, the major discoveries in electromagnetism were made by two of the greatest names in physics, Michael Faraday and James Clerk Maxwell.

The section begins with a discussion of electric charges that are static, i.e. not moving. Next, we study the phenomena associated with moving charges and the concepts of current, voltage and resistance. We also study how these concepts are applied to simple circuits and household electricity. Thereafter, we study the interaction of magnetic fields to pave the way for the study of the interrelationship between electricity and magnetism. The phenomenon in which a current interacts with a magnetic field is studied in electromagnetism.

15. Static Electricity

Content

- Principles of electrostatics
- Electric field

Learning Outcomes:

Candidates should be able to:

(a) state that there are positive and negative charges and that charge is measured in coulombs

(b) state that unlike charges attract and like charges repel

(c) describe an electric field as a region in which an electric charge experiences a force

(d) draw the electric field of an isolated point charge and recall that the direction of the field lines gives the direction of the force acting on a positive test charge

(e) draw the electric field pattern between two isolated point charges

16. Current of Electricity

Content

- Conventional current and electron flow
- Electromotive force
- Potential difference
- Resistance

Learning Outcomes:

Candidates should be able to:

(a) state that current is a rate of flow of charge and that it is measured in amperes

(b) distinguish between conventional current and electron flow

(c) recall and apply the relationship *charge* = *current* ´ *time* to new situations or to solve related problems

(d) define electromotive force (e.m.f.) as the work done by a source in driving a unit charge around a complete circuit

(e) state that the e.m.f. of a source and the potential difference (p.d.) across a circuit component is measured in volts

(f) define the p.d. across a component in a circuit as the work done to drive a unit charge through the component

(g) state the definition that *resistance* = *p.d.* / *current*

(h) apply the relationship $R = V / I$ to new situations or to solve related problems

(i) describe an experiment to determine the resistance of a metallic conductor using a voltmeter and an ammeter, and make the necessary calculations

(j) recall and apply the formulae for the effective resistance of a number of resistors in series and in parallel to new situations or to solve related problems

(k) recall and apply the relationship of the proportionality between resistance and the length and cross-sectional area of a wire to new situations or to solve related problems

17. D.C. Circuits

Content

- Current and potential difference in circuits
- Series and parallel circuits

Learning Outcomes:

Candidates should be able to:

(a) draw circuit diagrams with power sources (cell or battery), switches, lamps, resistors (fixed and variable), fuses, ammeters and voltmeters

(b) state that the current at every point in a series circuit is the same and apply the principle to new situations or to solve related problems

(c) state that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and apply the principle to new situations or to solve related problems

(d) state that the current from the source is the sum of the currents in the separate branches of a parallel circuit and apply the principle to new situations or to solve related problems

(e) state that the potential difference across the separate branches of a parallel circuit is the same and apply the principle to new situations or to solve related problems

(f) recall and apply the relevant relationships, including $R = V / I$ and those for current, potential differences and resistors in series and in parallel circuits, in calculations involving a whole circuit

18. Practical Electricity

Content

- Electric power and energy
- Dangers of electricity
- Safe use of electricity in the home

Learning Outcomes:

Candidates should be able to:

(a) describe the use of the heating effect of electricity in appliances such as electric kettles, ovens and heaters

(b) recall and apply the relationships $P = VI$ and $E = VIt$ to new situations or to solve related problems

(c) calculate the cost of using electrical appliances where the energy unit is the kW h

(d) state the hazards of using electricity in the following situations
  (i) damaged insulation
  (ii) overheating of cables
  (iii) damp conditions

(e) explain the use of fuses and circuit breakers in electrical circuits and of fuse ratings

(f) explain the need for earthing metal cases and for double insulation

(g) state the meaning of the terms *live*, *neutral* and *earth*

(h) describe the wiring in a mains plug

(i) explain why switches, fuses, and circuit breakers are wired into the live conductor

19. Magnetism and Electromagnetism

Content

- Laws of magnetism
- Magnetic properties of matter
- Magnetic field
- Magnetic effect of a current
- Application of the magnetic effect of a current
- Force on a current-carrying conductor

Learning Outcomes:

Candidates should be able to:

(a) state the properties of magnets

(b) describe induced magnetism

(c) describe electrical methods of magnetisation and demagnetisation

(d) distinguish between the properties and uses of temporary magnets (e.g. iron) and permanent magnets (e.g. steel)

(e) draw the magnetic field pattern around a bar magnet and between the poles of two bar magnets

(f) describe the plotting of magnetic field lines with a compass

(g) draw the pattern of the magnetic field due to currents in straight wires and in solenoids and state the effect on the magnetic field of changing the magnitude and / or direction of the current

(h) describe the application of the magnetic effect of a current in a circuit breaker

(i) describe experiments to show the force on a current-carrying conductor in a magnetic field, including the effect of reversing
  (i) the current
  (ii) the direction of the field

(j) deduce the relative directions of force, field and current when any two of these quantities are at right angles to each other using Fleming's left-hand rule

(k) explain how a current-carrying coil in a magnetic field experiences a turning effect (recall of structure of an electric motor is not required)

SUMMARY OF KEY QUANTITIES, SYMBOLS AND UNITS

Students should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured. Students should be able to define those items indicated by an asterisk (*).

Quantity	***Symbol***	***Unit***
length	*l, h …*	km, m, cm, mm
area	*A*	m^2, cm^2
volume	*V*	m^3, cm^3
weight*	*W*	N*
mass	*m, M*	kg, g, mg
time	*t*	h, min, s, ms
period*	*T*	s
density*	ρ	g / cm^3, kg / m^3
speed*	*u, v*	km / h, m / s, cm / s
acceleration*	*a*	m / s^2
acceleration of free fall	*g*	m / s^2, N / kg
force*	*F, f*	N
moment of force*		N m
work done*	*W, E*	J*
energy	*E*	J, kW h*
power*	*P*	W*
pressure*	*p, P*	Pa*, N / m^2
temperature	θ, *T*	°C, K
frequency*	*f*	Hz
wavelength*	λ	m, cm
focal length	*f*	m, cm
angle of incidence	*i*	degree (°)
angles of reflection, refraction	*r*	degree (°)
critical angle	*c*	degree (°)
potential difference* / voltage	*V*	V*, mV
current*	*I*	A, mA
charge	*q, Q*	C, A s
e.m.f.*	*E*	V
resistance	*R*	Ω

Biology section

The following course structure is taken directly from the MOE (SEAB) website for O Level syllabus for Science(Physics/Biology) (5077).

CONTENT STRUCTURE

SECTION	Topics
I. PRINCIPLES OF BIOLOGY	1. Cell Structure and Organisation 2. Movement of Substances 3. Biological Molecules
II. MAINTENANCE AND REGULATION OF LIFE PROCESSES	4. Nutrition in Humans 5. Nutrition in Plants 6. Transport in Flowering Plants 7. Transport in Humans 8. Respiration in Humans 9. Co-ordination and Response in Humans
III. CONTINUITY OF LIFE	10. Reproduction 11. Molecular Genetics 12. Inheritance
IV. MAN AND HIS ENVIRONMENT	13. Organisms and their Environment

SUBJECT CONTENT

SECTION I: PRINCIPLES OF BIOLOGY

Overview

A basic characteristic of life is the hierarchy of structural order within the organism. Robert Hooke (1635–1703), one of the first scientists to use a microscope to examine pond water, cork and other things,was the first to refer to the cavities he saw in cork as “cells”, Latin for chambers. Subsequent scientists developed Hooke’s discovery of the cell into the Cell Theory upon which modern biology is built. The Cell Theory states that all organisms are composed of one or more cells, and that those cells have arisen from pre-existing cells.

In this section, we study two key principles of biology. The first principle is the correlation of structure to function. This is illustrated by how each part of the cell is suited for its intended function.

The second principle is that specialisation results in the division of labour which enables the cell to effectively carry out a number of vital life processes. A strong foundation in the principles of biology will pave the way for students to master the content in the subsequent topics.

1. Cell Structure and Organisation

Content

- Plant and animal cells
- Specialised cells, tissues and organs

Learning Outcomes:

Candidates should be able to:

(a) identify cell structures (including organelles) of typical plant and animal cells from diagrams, photomicrographs and as seen under the light microscope using prepared slides and fresh material treated with an appropriate temporary staining technique:
  (i) chloroplasts
  (ii) cell membrane
  (iii) cell wall
  (iv) cytoplasm
  (v) cell vacuoles (large, sap-filled in plant cells, small, temporary in animal cells)
  (vi) nucleus

(b) identify the following organelles from diagrams and electronmicrographs:
  (i) mitochondria
  (ii) ribosomes

(c) state the functions of the organelles identified above

(d) compare the structure of typical animal and plant cells

(e) state, in simple terms, the relationship between cell function and cell structure for the following:
  (i) absorption – root hair cells
  (ii) conduction and support – xylem vessels
  (iii) transport of oxygen – red blood cells

(f) differentiate cell, tissue, organ and organ system

Use the knowledge gained in this section in new situations or to solve related problems.

2. Movement of Substances

Content

- Diffusion
- Osmosis

Learning Outcomes:

Candidates should be able to:

(a) define *diffusion* and describe its role in nutrient uptake and gaseous exchange in plants and humans

(b) define *osmosis* and describe the effects of osmosis on plant and animal tissues

Use the knowledge gained in this section in new situations or to solve related problems.

3. Biological Molecules

Content

- Water and living organisms
- Carbohydrates, fats and proteins
- Enzymes

Learning Outcomes:

Candidates should be able to:

(a) state the roles of water in living organisms

(b) describe and carry out tests for
  (i) starch (iodine in potassium iodide solution)
  (ii) reducing sugars (Benedict's solution)
  (iii) protein (biuret test)
  (iv) fats (ethanol emulsion)

(c) state that large molecules are synthesised from smaller basic units
  (i) glycogen from glucose
  (ii) polypeptides and proteins from amino acids
  (iii) lipids such as fats from glycerol and fatty acids

(d) explain enzyme action in terms of the 'lock and key' hypothesis (explain the mode of action of enzymes in terms of an active site, enzyme-substrate complex and enzyme specificity)

(e) investigate and explain the effects of temperature and pH on the rate of enzyme-catalysed reactions

Use the knowledge gained in this section in new situations or to solve related problems.

SECTION II: MAINTENANCE AND REGULATION OF LIFE PROCESSES

Overview

Life is sustained through the integrated organisation of the whole organism. In humans, the maintenance and regulation of life processes include nutrition, transport, respiration, excretion, homeostasis and co-ordination and response. The key overarching theme in the study of the organ systems is the correlation between form and function.

4. Nutrition in Humans

Content

- Human alimentary canal
- Chemical digestion
- Absorption and assimilation

Learning Outcomes:

Candidates should be able to:

(a) describe the functions of main regions of the alimentary canal and the associated organs: mouth, salivary glands, oesophagus, stomach, duodenum, pancreas, gall bladder, liver, ileum, colon, rectum, anus, in relation to ingestion, digestion, absorption, assimilation and egestion of food, as appropriate

(b) describe the functions of enzymes (e.g. amylase, maltase, protease, lipase) in digestion, listing the substrate and end-products

(c) state the function of the hepatic portal vein as the transport of blood rich in absorbed nutrients from the small intestine to the liver

(d) state the role of the liver in:
  (i) the metabolism of glucose
  (ii) the metabolism of amino acids and the formation of urea
  (iii) the breakdown of alcohol

Use the knowledge gained in this section in new situations or to solve related problems.

5. Nutrition in Plants

Content

- Leaf structure
- Photosynthesis

Learning Outcomes:

Candidates should be able to:

(a) identify the cellular and tissue structure of a dicotyledonous leaf, as seen in cross-section under the microscope and state their functions:
  (i) distribution of chloroplasts – photosynthesis
  (ii) stomata and mesophyll cells – gaseous exchange
  (iii) vascular bundles – transport

(b) state the equation, in words only, for photosynthesis

(c) describe the intake of carbon dioxide and water by plants

(d) state that chlorophyll traps light energy and converts it into chemical energy for the formation of carbohydrates and their subsequent storage

(e) investigate and state the effect of varying light intensity, carbon dioxide concentration and temperature on the rate of photosynthesis (e.g. in submerged aquatic plants)

(f) briefly explain why most forms of life are completely dependent on photosynthesis

Use the knowledge gained in this section in new situations or to solve related problems.

6. Transport in Flowering Plants

Content

- Water and ion uptake
- Transpiration and translocation

Learning Outcomes:

Candidates should be able to:

(a) identify the positions of xylem vessels and phloem in sections of a typical dicotyledonous stem and leaf, under the light microscope, and state their functions

(b) relate the structure and functions of root hairs to their surface area, and to water and ion uptake

(c) state that transpiration is the loss of water vapour from the stomata

(d) briefly explain the movement of water through the stem in terms of transpiration pull

(e) describe
  (i) the effects of variation of air movement, temperature, humidity and light intensity on transpiration rate
  (ii) how wilting occurs

(f) define the term *translocation* as the transport of food in the phloem tissue

Use the knowledge gained in this section in new situations or to solve related problems.

7. Transport in Humans

Content

- Circulatory system

Learning Outcomes:

Candidates should be able to:

(a) name the main blood vessels to and from the heart, lungs, liver and kidney

(b) state the functions of blood
  (i) red blood cells – haemoglobin and oxygen transport
  (ii) plasma – transport of blood cells, ions, soluble food substances, hormones, carbon dioxide, urea, vitamins, plasma proteins
  (iii) white blood cells – phagocytosis, antibody formation and tissue rejection
  (iv) platelets – fibrinogen to fibrin, causing clotting

(c) relate the structure of arteries, veins and capillaries to their functions

(d) describe the structure and function of the heart in terms of muscular contraction and the working of valves (histology of the heart muscle, names of nerves and transmitter substances are **not** required)

(e) describe coronary heart disease in terms of the occlusion of coronary arteries and list the possible causes, such as diet, stress, smoking, and the possible preventative measures

Use the knowledge gained in this section in new situations or to solve related problems.

8. Respiration in Humans

Content

- Human gas exchange
- Aerobic respiration
- Anaerobic respiration

Learning Outcomes:

Candidates should be able to:

(a) identify on diagrams and name the larynx, trachea, bronchi, bronchioles, alveoli and associated capillaries and state their functions in human gas exchange

(b) state the characteristics of, and describe the role of, the exchange surface of the alveoli in gas exchange

(c) describe the effect of tobacco smoke and its major toxic components – nicotine, tar and carbon monoxide, on health

(d) define and state the equation, in words only, for aerobic respiration in humans

(e) define and state the equation, in words only, for anaerobic respiration in humans

(f) describe the effect of lactic acid in muscles during exercise

Use the knowledge gained in this section in new situations or to solve related problems.

9. Co-ordination and Response in Humans

Content

- Receptors – eye
- Nervous system – neurones
- Effectors – endocrine glands

Learning Outcomes:

Candidates should be able to:

(a) state the relationship between receptors, the central nervous system and the effectors

(b) state the principal functions of component parts of the eye in producing a focused image of near and distant objects on the retina

(c) describe the pupil reflex in response to bright and dim light

(d) outline the functions of sensory neurones, relay neurones and motor neurones

(e) define a *hormone* as a chemical substance, produced by a gland, carried by the blood, which alters the activity of one or more specific target organs and is then destroyed by the liver

(f) state what is meant by an endocrine gland, with reference to the islets of Langerhans in the pancreas

(g) outline how the blood glucose concentration is regulated by insulin and glucagon

Use the knowledge gained in this section in new situations or to solve related problems.

SECTION III: CONTINUITY OF LIFE

Overview

The many aspects of form and function that we have examined in this syllabus can be viewed in the widest context as various adaptations aimed at ensuring reproductive success. Reproduction is vital for the survival of species across generations. In 1953, James Watson and Francis Crick developed the model for deoxyribonucleic acid (DNA), a chemical that had then recently been deduced to be the physical carrier of inheritance. In this section, we examine how genes interact to produce hereditary characteristics in the offspring. This section focuses on understanding the processes involved in the continuity of life and how genetic information is passed from one generation to the next.

10. Reproduction

Content

- Asexual reproduction
- Sexual reproduction in plants
- Sexual reproduction in humans
- Sexually transmitted diseases

Learning Outcomes:

Candidates should be able to:

(a) define *asexual reproduction* as the process resulting in the production of genetically identical offspring from one parent

(b) define *sexual reproduction* as the process involving the fusion of nuclei to form a zygote and the production of genetically dissimilar offspring

(c) state the functions of the sepals, petals, anthers and carpels

(d) outline the process of pollination

(e) describe the growth of the pollen tube and its entry into the ovule followed by fertilisation (production of endosperm and details of development are **not** required)

(f) identify on diagrams of the male reproductive system and give the functions of: testes, scrotum, sperm ducts, prostate gland, urethra and penis

(g) identify on diagrams of the female reproductive system and give the functions of: ovaries, oviducts, uterus, cervix and vagina

(h) briefly describe the menstrual cycle with reference to the alternation of menstruation and ovulation, the natural variation in its length, and the fertile and infertile phases of the cycle, with reference to the roles of oestrogen and progesterone only

(i) briefly describe fertilisation and early development of the zygote simply in terms of the formation of a ball of cells which becomes implanted in the wall of the uterus

(j) discuss the spread of human immunodeficiency virus (HIV) and methods by which it may be controlled

Use the knowledge gained in this section in new situations or to solve related problems.

11. Molecular Genetics

Content

- The structure of DNA
- The role of DNA in protein synthesis

Learning Outcomes:

Candidates should be able to:

(a) outline the relationship between genes, chromosomes, and DNA

(b) state the structure of DNA in terms of the bases, sugar and phosphate groups found in each of the nucleotides

(c) state the rule of complementary base pairing

(d) state that DNA is used to carry the genetic code (details of translation and transcription are **not** required)

(e) state that each gene
  (i) is a sequence of nucleotides, as part of a DNA molecule
  (ii) controls the production of one polypeptide

Use the knowledge gained in this section in new situations or to solve related problems.

12. Inheritance

Content

- The passage of information from parent to offspring
- The nature of genes and alleles, and their role in determining the phenotype
- Monohybrid crosses
- Variation

Learning Outcomes:

Candidates should be able to:

(a) define a *gene* as a unit of inheritance and distinguish clearly between the terms *gene* and *allele*

(b) describe the difference between continuous and discontinuous variation and give examples of each

(c) explain the terms *dominant*, *recessive*, *homozygous*, *heterozygous*, *phenotype* and *genotype*

(d) predict the results of simple crosses with expected ratios of 3:1 and 1:1, using the terms *homozygous*, *heterozygous*, F_1 *generation* and F_2 *generation*

(e) state why observed ratios often differ from expected ratios, especially when there are small numbers of progeny

(f) describe the determination of sex in humans – XX and XY chromosomes

(g) describe mutation as a change in the structure of a gene such as in sickle cell anaemia, or in the chromosome number such as the 47 chromosomes in a condition known as Down's Syndrome

(h) name radiation and chemicals as factors which may increase the rate of mutation

Use the knowledge gained in this section in new situations or to solve related problems.

SECTION IV: MAN AND HIS ENVIRONMENT

Overview

All living organisms are part of a complex network of interactions called the web of life. This section focuses on the interrelationships between living things and the environment. These include two major processes. The first is the cycling of nutrients, as illustrated by the carbon cycle. The second major process is the flow of energy from sunlight to organisms further down the food chain.

Human activities can upset natural ecosystems, causing permanent damage not just to local environments but also the global environment. As a part of this environment, humans must show a sense of responsibility for its maintenance.

13. Organisms and their Environment

Content

- Energy flow
- Food chains and food webs
- Carbon cycle
- Effects of man on the ecosystem
- Environmental biotechnology
- Conservation

Learning Outcomes:

Candidates should be able to:

(a) briefly describe the non-cyclical nature of energy flow

(b) establish the relationship of the following in food webs: producer, consumer, herbivore, carnivore, decomposer, food chain, trophic level

(c) describe energy losses between trophic levels and infer the advantages of short food chains

(d) interpret pyramids of numbers and biomass

(e) explain the importance of the carbon cycle and outline the role of forests and oceans as carbon sinks

(f) evaluate the effects of
  (i) water pollution by sewage
  (ii) pollution due to insecticides including bioaccumulation up food chains and impact on top carnivores

(g) outline the roles of microorganisms in sewage treatment as an example of environmental biotechnology

(h) discuss reasons for conservation of species with reference to the maintenance of biodiversity and how this is done, e.g. management of fisheries and management of timber production

Use the knowledge gained in this section in new situations or to solve related problems.

SUMMARY OF KEY QUANTITIES, SYMBOLS AND UNITS

The list below is intended as a guide to the more important quantities which might be encountered in teaching and learning. This list is not exhaustive.

Quantity	***Symbol***	***Unit***
length	l	mm, cm, m
area	A	cm^2, m^2
volume	V	cm^3, dm^3, m^3
mass	m	mg, g, kg
concentration	c	g / dm^3
time	t	ms, s, min
pH	pH	–
temperature	T	$^\circ$ C
energy	E	J

GLOSSARY OF TERMS USED IN SCIENCE PAPERS

It is hoped that the glossary (which is relevant only to science papers) will prove helpful to candidates as a guide, i.e. it is neither exhaustive nor definitive. The glossary has been deliberately kept brief not only with respect to the number of terms included but also to the descriptions of their meanings. Candidates should appreciate that the meaning of a term must depend in part on its context.

1. *Calculate* is used when a numerical answer is required. In general, working should be shown, especially where two or more steps are involved.

2. *Classify* requires candidates to group things based on common characteristics.

3. *Comment* is intended as an open-ended instruction, inviting candidates to recall or infer points of interest relevant to the context of the question, taking account of the number of marks available.

4. *Compare* requires candidates to provide both similarities and differences between things or concepts.

5. *Construct* is often used in relation to chemical equations where a candidate is expected to write a balanced equation, not by factual recall but by analogy or by using information in the question.

6. *Define (the term(s)…)* is intended literally, only a formal statement or equivalent paraphrase being required.

7. *Describe* requires candidates to state in words (using diagrams where appropriate) the main points of the topic. It is often used with reference either to particular phenomena or to particular experiments. In the former instance, the term usually implies that the answer should include reference to (visual) observations associated with the phenomena. In the latter instance the answer may often follow a standard pattern, e.g. Apparatus, Method, Measurement, Results and Precautions.

   In other contexts, *describe and give an account of* should be interpreted more generally, i.e. the candidate has greater discretion about the nature and the organisation of the material to be included in the answer. *Describe and explain* may be coupled in a similar way to *state and explain.*

8. *Determine* often implies that the quantity concerned cannot be measured directly but is obtained by calculation, substituting measured or known values of other quantities into a standard formula.

9. *Discuss* requires candidates to give a critical account of the points involved in the topic.

10. *Estimate* implies a reasoned order of magnitude statement or calculation of the quantity concerned, making such simplifying assumptions as may be necessary about the points of principle and about values of quantities not otherwise included in the question.

11. *Explain* may imply reasoning or some reference to theory, depending on the context.

12. *Find* is a general term that may be variously interpreted as calculate, measure, determine, etc.

13. *List* requires a number of points, generally each of one word, with no elaboration. Where a given number of points is specified, this should not be exceeded.

14. *Measure* implies that the quantity concerned can be directly obtained from a suitable measuring instrument, e.g. length, using a rule, or angle, using a protractor.

15. *Outline* implies brevity, i.e. restricting the answer to giving essentials.

16. *Predict* or *deduce* implies that the candidate is not expected to produce the required answer by recall but by making a logical connection between other pieces of information. Such information may be wholly given in the question or may depend on answers extracted from an earlier part of the question. *Predict* also implies a concise answer with no supporting statement required.

17. *Sketch*, when applied to graph work, implies that the shape and / or position of the curve need only be qualitatively correct, but candidates should be aware that, depending on the context, some quantitative aspects may be looked for, e.g. passing through the origin, having the intercept, asymptote or discontinuity at a particular value.

    In diagrams, *sketch* implies that a simple, freehand drawing is acceptable; nevertheless, care should be taken over proportions and the clear exposition of important details.

18. *State* implies a concise answer with little or no supporting argument, e.g. a numerical answer that can be obtained 'by inspection'.

19. *Suggest* is used in two main contexts, i.e. either to imply that there is no unique answer, or to imply that candidates are expected to apply their general knowledge to a 'novel' situation, one that may be formally 'not in the syllabus'.

20. *What do you understand by/What is meant by (the term(s)...)* normally implies that a definition should be given, together with some relevant comment on the significance or context of the term(s) concerned, especially where two or more terms are included in the question. The amount of supplementary comment intended should be interpreted in light of the indicated mark value.

SPECIAL NOTE

Nomenclature

Students will be expected to be familiar with the nomenclature used in the syllabus. The proposals in '*Signs, Symbols and Systematics*' (The Association for Science Education Companion to 16–19 Science, 2000) and the recommendations on terms, units and symbols in 'Biological Nomenclature 4th Edition (2009)' published by the Institute of Biology, in conjunction with the ASE, will generally be adopted although the traditional names sulfate, sulfite, nitrate, nitrite, sulfurous and nitrous acids will be used in question papers. Sulfur (and all compounds of sulfur) will be spelt with f (not with ph) in question papers, however students can use either spelling in their answers.

It is intended that, in order to avoid difficulties arising out of the use of l as the symbol for litre, use of dm^3 in place of l or litre will be made.

In chemistry, full *structural formulae (displayed formulae)* in answers should show in detail both the relative placing of atoms and the number of bonds between atoms. Hence, $–CONH_2$ and $–CO_2H$ are not satisfactory as full structural formulae, although either of the usual symbols for the benzene ring is acceptable.

Units, significant figures

Candidates should be aware that misuse of units and / or significant figures, i.e. failure to quote units where necessary, the inclusion of units in quantities defined as ratios or quoting answers to an inappropriate number of significant figures, is liable to be penalised.

Calculators

An approved calculator may be used.

Geometrical Instruments

Candidates should have geometrical instruments with them.