5. Syllabus content

It is expected that any course in physics will be based on experimental work. Teachers are encouraged to develop appropriate practical work for candidates to facilitate a greater understanding of the subject. Candidates should be aware of the appropriate safety precautions to follow when carrying out practical work.

Certain learning outcomes of the syllabus have been marked with an asterisk (*) to indicate the possibility of the application of IT.

Section I: General Physics

1. Physical Quantities, Units and Measurement

Content

1.1 Scalars and vectors

1.2 Measurement techniques

1.3 Units and symbols

Learning outcomes

Candidates should be able to:

(a) define the terms *scalar* and *vector*.

(b) determine the resultant of two vectors by a graphical method.

(c) list the vectors and scalars from distance, displacement, length, speed, velocity, time, acceleration, mass and force.

(d) describe how to measure a variety of lengths with appropriate accuracy using tapes, rules, micrometers and calipers. (The use of a vernier scale is **not** required.)

(e) describe how to measure a variety of time intervals using clocks and stopwatches.

(f) recognise and use the conventions and symbols contained in ‘Signs, Symbols and Systematics’, Association for Science Education, 2000.

Section II: Newtonian Mechanics

2. Kinematics

Content

2.1 Speed, velocity and acceleration

2.2 Graphical analysis of motion

2.3 Free-fall

Learning outcomes

Candidates should be able to:

(a) state what is meant by *speed* and *velocity*.

(b) recall and use *average speed = distance travelled/time taken*.

(c) state what is meant by *uniform acceleration* and recall and use *acceleration = change in velocity/time taken*.

(d) discuss non-uniform acceleration.

(e) recall that deceleration is a negative acceleration.

(f) *plot and *interpret speed–time and distance–time graphs.

(g) *recognise from the shape of a speed–time graph when a body is

(1) at rest,

(2) moving with uniform speed,

(3) moving with uniform acceleration,

(4) 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 $10\ \text{m}/\text{s}^2$.

(j) describe qualitatively the motion of bodies with constant weight falling with and without air resistance (including reference to terminal velocity).

3. Dynamics

Content

3.1 Balanced and unbalanced forces

3.2 Friction

3.3 Circular motion

Learning outcomes

Candidates should be able to:

(a) state Newton's third law.

(b) describe the effect of balanced and unbalanced forces on a body.

(c) describe the ways in which a force may change the motion of a body.

(d) recall and use the equation *force* = *mass* × *acceleration*.

(e) explain that friction is a force that impedes motion and produces heating.

(f) discuss the effect of friction on the motion of a vehicle in the context of tyre surface, road conditions (including skidding), braking force, braking distance, thinking distance and stopping distance.

(g) describe qualitatively motion in a circular path due to a constant perpendicular force, including electrostatic forces on an electron in an atom and gravitational forces on a satellite. ($F = mv^2/r$ is **not** required.)

(h) discuss how ideas of circular motion are related to the motion of planets in the solar system.

4. Mass, Weight and Density

Content

4.1 Mass and weight

4.2 Gravitational fields

4.3 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 the mass of a body resists change from its state of rest or motion.

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

(d) recall and use the equation *weight* = *mass* × *gravitational field strength*.

(e) explain that weights, and therefore masses, may be compared using a balance.

(f) describe how to measure mass and weight by using appropriate balances.

(g) describe how to use a measuring cylinder to measure the volume of a liquid or solid.

(h) describe how to determine the density of a liquid, of a regularly shaped solid and of an irregularly shaped solid which sinks in water (volume by displacement).

(i) define density and recall and use the formula *density* = *mass/volume*.

5. Turning Effect of Forces

Content

5.1 Moments

5.2 Centre of mass

5.3 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) state the principle of moments for a body in equilibrium.

(c) define *moment of a force* and recall and use the formula *moment* = *force* × *perpendicular distance from the pivot* and the principle of moments.

(d) describe how to verify the principle of moments.

(e) describe how to determine the position of the centre of mass of a plane lamina.

(f) describe qualitatively the effect of the position of the centre of mass on the stability of simple objects.

6. Deformation

Content

6.1 Elastic deformation

Learning outcomes

Candidates should be able to:

(a) state that a force may produce a change in size and shape of a body.

(b) *plot, draw and interpret extension–load graphs for an elastic solid and describe the associated experimental procedure.

(c) *recognise the significance of the term "limit of proportionality" for an elastic solid (an understanding of the elastic limit is **not** required).

(d) calculate extensions for an elastic solid using proportionality.

7. Pressure

Content

7.1 Pressure

7.2 Pressure changes

Learning outcomes

Candidates should be able to:

(a) define the term *pressure* in terms of force and area, and do calculations using the equation *pressure* = *force*/*area*.

(b) explain how pressure varies with force and area in the context of everyday examples.

(c) describe how the height of a liquid column may be used to measure the atmospheric pressure.

(d) explain quantitatively how the pressure beneath a liquid surface changes with depth and density of the liquid in appropriate examples.

(e) recall and use the equation for hydrostatic pressure $p = \rho g h$.

(f) describe the use of a manometer in the measurement of pressure difference.

(g) describe and explain the transmission of pressure in hydraulic systems with particular reference to the hydraulic press and hydraulic brakes on vehicles.

(h) describe how a change in volume of a fixed mass of gas at constant temperature is caused by a change in pressure applied to the gas.

(i) recall and use $p_1V_1 = p_2V_2$.

Section III: Energy and Thermal Physics

8. Energy Sources and Transfer of Energy

Content

8.1 Energy forms

8.2 Major sources of energy

8.3 Work

8.4 Efficiency

8.5 Power

Learning outcomes

Candidates should be able to:

(a) list the different forms of energy with examples in which each form occurs.

(b) state the principle of the conservation of energy and apply this principle to the conversion of energy from one form to another.

(c) state that kinetic energy is given by $E_k = \frac{1}{2}mv^2$ and that gravitational potential energy is given by $E_P = mgh$, and use these equations in calculations.

(d) list renewable and non-renewable energy sources.

(e) describe the processes by which energy is converted from one form to another, including reference to

(1) chemical/fuel energy (a re-grouping of atoms),

(2) hydroelectric generation (emphasising the mechanical energies involved),

(3) solar energy (nuclei of atoms in the Sun),

(4) nuclear energy,

(5) geothermal energy,

(6) wind energy.

(f) explain nuclear fusion and fission in terms of energy-releasing processes.

(g) describe the process of electricity generation and draw a block diagram of the process from fuel input to electricity output.

(h) discuss the environmental issues associated with power generation.

(i) define work done and use the formula *work* = *force* × *distance moved in the line of action of the force*.

(j) recall and use the formula *efficiency* = *energy converted to the required form*/*total energy input* for an energy conversion.

(k) discuss the efficiency of energy conversions in common use, particularly those giving electrical output.

(l) discuss the usefulness of energy output from a number of energy conversions.

(m) define power and recall and use the formula *power* = *work done*/*time taken.*

9. Transfer of Thermal Energy

Content

9.1 Conduction

9.2 Convection

9.3 Radiation

Learning outcomes

Candidates should be able to:

(a) describe how to distinguish between good and bad conductors of heat.

(b) describe, in terms of the movement of molecules or free electrons, how heat transfer occurs in solids.

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

(d) describe the process of heat transfer by radiation.

(e) describe the effect of surface colour (black or white) and texture (dull or shiny) on the emission, absorption and reflection of radiation.

(f) describe how to distinguish between good and bad emitters and good and bad absorbers of infrared radiation.

(g) describe how heat is transferred to or from buildings and to or from a room.

(h) state and explain the use of the important practical methods of thermal insulation for buildings.

10. Temperature

Content

10.1 Principles of thermometry

10.2 Practical thermometers

Learning outcomes

Candidates should be able to:

(a) explain how a physical property which varies with temperature may be used for the measurement of temperature and state examples of such properties.

(b) explain the need for fixed points and state what is meant by the *ice point* and *steam point*.

(c) discuss sensitivity, range and linearity of thermometers.

(d) describe the structure and action of liquid-in-glass thermometers (including clinical) and of a thermocouple thermometer, showing an appreciation of its use for measuring high temperatures and those which vary rapidly.

(e) describe and explain how the structure of a liquid-in-glass thermometer affects its sensitivity, range and linearity.

11. Thermal Properties of Matter

Content

11.1 Specific heat capacity

11.2 Melting and boiling

11.3 Thermal expansion of solids, liquids and gases

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) define the terms *heat capacity* and *specific heat capacity*.

(c) recall and use the formula *thermal energy* = *mass* × *specific heat capacity* × *change in temperature*.

(d) describe melting/solidification and boiling/condensation in terms of energy transfer without a change in temperature.

(e) state the meaning of *melting point* and *boiling point*.

(f) explain the difference between boiling and evaporation.

(g) define the terms *latent heat* and *specific latent heat*.

(h) explain latent heat in terms of molecular behaviour.

(i) calculate heat transferred in a change of state using the formula *thermal energy* = *mass* × *specific latent heat*.

(j) describe qualitatively the thermal expansion of solids, liquids and gases.

(k) describe the relative order of magnitude of the expansion of solids, liquids and gases.

(l) list and explain some of the everyday applications and consequences of thermal expansion.

(m) describe qualitatively the effect of a change of temperature on the volume of a gas at constant pressure.

12. Kinetic Model of Matter

Content

12.1 States of matter

12.2 Molecular model

12.3 Evaporation

Learning outcomes

Candidates should be able to:

(a) state the distinguishing 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.

(d) explain the pressure of a gas in terms of the motion of its molecules.

(e) describe evaporation in terms of the escape of more energetic molecules from the surface of a liquid.

(f) describe how temperature, surface area and draught over a surface influence evaporation.

(g) explain that evaporation causes cooling.

Section IV: Waves

13. General Wave Properties

Content

13.1 Describing wave motion

13.2 Wave terms

13.3 Wave behaviour

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 experiments using a ripple tank.

(b) state what is meant by the term *wavefront*.

(c) define the terms *speed*, *frequency*, *wavelength* and *amplitude* and recall and use the formula *velocity* = *frequency* × *wavelength*.

(d) describe transverse and longitudinal waves in such a way as to illustrate the differences between them.

(e) describe the use of a ripple tank to show

(1) reflection at a plane surface,

(2) refraction due to a change of speed at constant frequency.

(f) describe simple experiments to show the reflection of sound waves.

14. Light

Content

14.1 Reflection of light

14.2 Refraction of light

14.3 Thin converging and diverging lenses

Learning outcomes

Candidates should be able to:

(a) define the terms used in reflection including *normal*, *angle of incidence* and *angle of reflection*.

(b) describe an experiment to illustrate the law of reflection.

(c) describe an experiment to find the position and characteristics of an optical image formed by a plane mirror.

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

(e) define the terms used in refraction including *angle of incidence*, *angle of refraction* and *refractive index*.

(f) describe experiments to show refraction of light through glass blocks.

(g) recall and use the equation $\sin i / \sin r = n$.

(h) define the terms *critical angle* and *total internal reflection* and recall and use the formula $\sin c = 1/n$.

(i) describe experiments to show total internal reflection.

(j) describe the use of optical fibres in telecommunications and state the advantages of their use.

(k) describe the action of thin lenses (both converging and diverging) on a beam of light.

(l) define the term *focal length*.

(m) *draw ray diagrams to illustrate the formation of real and virtual images of an object by a converging lens, and the formation of a virtual image by a diverging lens.

(n) define the term *linear magnification* and *draw scale diagrams to determine the focal length needed for particular values of magnification (converging lens only).

(o) describe the use of a single lens as a magnifying glass and in a camera, projector and photographic enlarger and draw ray diagrams to show how each forms an image.

(p) draw ray diagrams to show the formation of images in the normal eye, a short-sighted eye and a long-sighted eye.

(q) describe the correction of short-sight and long-sight.

15. Electromagnetic Spectrum

Content

15.1 Dispersion of light

15.2 Properties of electromagnetic waves

15.3 Applications of electromagnetic waves

Learning outcomes

Candidates should be able to:

(a) describe the dispersion of light as illustrated by the action on light of a glass prism.

(b) state the colours of the spectrum and explain how the colours are related to frequency/wavelength.

(c) state that all electromagnetic waves travel with the same high speed in air and state the magnitude of that speed.

(d) describe the main components of the electromagnetic spectrum.

(e) discuss the role of the following components in the stated applications:

(1) radio waves – radio and television communications,

(2) microwaves – satellite television and telephone,

(3) infrared – household electrical appliances, television controllers and intruder alarms,

(4) light – optical fibres in medical uses and telephone,

(5) ultraviolet – sunbeds, fluorescent tubes and sterilisation,

(6) X-rays – hospital use in medical imaging and killing cancerous cells, and engineering applications such as detecting cracks in metal,

(7) gamma rays – medical treatment in killing cancerous cells, and engineering applications such as detecting cracks in metal.

16. Sound

Content

16.1 Sound waves

16.2 Speed of sound

16.3 Ultrasound

Learning outcomes

Candidates should be able to:

(a) describe the production of sound by vibrating sources.

(b) describe the longitudinal nature of sound waves and describe compression and rarefaction.

(c) state the approximate range of audible frequencies for the healthy human ear as 20 Hz to 20 000 Hz.

(d) explain why a medium is required in order to transmit sound waves and describe an experiment to demonstrate this.

(e) describe a direct method for the determination of the speed of sound in air and make the necessary calculation.

(f) state the order of magnitude of the speeds of sound in air, liquids and solids.

(g) explain how the loudness and pitch of sound waves relate to amplitude and frequency.

(h) describe how the reflection of sound may produce an echo.

(i) describe how the shape of a sound wave as demonstrated by an oscilloscope is affected by the quality (timbre) of the sound wave.

(j) define *ultrasound*.

(k) describe the uses of ultrasound in cleaning, quality control and pre-natal scanning.

19. Current Electricity

Content

19.1 Current

19.2 Electromotive force

19.3 Potential difference

19.4 Resistance

Learning outcomes

Candidates should be able to:

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

(b) recall and use the equation *charge* = *current* × *time*.

(c) describe the use of an ammeter with different ranges.

(d) explain that electromotive force (e.m.f.) is measured by the energy dissipated by a source in driving a unit charge around a complete circuit.

(e) state that e.m.f. is work done/charge.

(f) state that the volt is given by J / C.

(g) calculate the total e.m.f. where several sources are arranged in series and discuss how this is used in the design of batteries.

(h) discuss the advantage of making a battery from several equal voltage sources of e.m.f. arranged in parallel.

(i) state that the potential difference (p.d.) across a circuit component is measured in volts.

(j) state that the p.d. across a component in a circuit is given by the work done in the component/charge passed through the component.

(k) describe the use of a voltmeter with different ranges.

(l) state that *resistance* = *p.d./current* and use the equation *resistance* = *voltage/current* in calculations.

(m) describe an experiment to measure the resistance of a metallic conductor using a voltmeter and an ammeter and make the necessary calculations.

(n) state Ohm's Law and discuss the temperature limitation on Ohm's Law.

(o) *use quantitatively the proportionality between resistance and the length and the cross-sectional area of a wire.

(p) calculate the net effect of a number of resistors in series and in parallel.

(q) describe the effect of temperature increase on the resistance of a resistor and a filament lamp and draw the respective sketch graphs of current/voltage.

(r) describe the operation of a light-dependent resistor.

20. D.C. Circuits

Content

20.1 Current and potential difference in circuits

20.2 Series and parallel circuits

Learning outcomes

Candidates should be able to:

(a) *draw circuit diagrams with power sources (cell, battery or a.c. mains), switches (closed and open), resistors (fixed and variable), light-dependent resistors, thermistors, lamps, ammeters, voltmeters, magnetising coils, bells, fuses, relays, diodes and light-emitting diodes.

(b) state that the current at every point in a series circuit is the same, and use this in calculations.

(c) state that the sum of the potential differences in a series circuit is equal to the potential difference across the whole circuit and use this in calculations.

(d) state that the current from the source is the sum of the currents in the separate branches of a parallel circuit.

(e) do calculations on the whole circuit, recalling and using formulae including $R = V/I$ and those for potential differences in series, resistors in series and resistors in parallel.

21. Practical Electricity

Content

21.1 Uses of electricity

21.2 Dangers of electricity

21.3 Safe use of electricity in the home

Learning outcomes

Candidates should be able to:

(a) describe the use of electricity in heating, lighting and motors.

(b) recall and use the equations *power* = *voltage* × *current*, and *energy* = *voltage* × *current* × *time*.

(c) define the kilowatt-hour (kWh) and calculate the cost of using electrical appliances where the energy unit is the kWh.

(d) state the hazards of damaged insulation, overheating of cables and damp conditions.

(e) explain the use of fuses and circuit breakers, and fuse ratings and circuit breaker settings.

(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 how to wire a mains plug safely. (Candidates will **not** be expected to show knowledge of the colours of the wires used in a mains supply.)

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

22. Electromagnetism

Content

22.1 Force on a current-carrying conductor

22.2 The d.c. motor

Learning outcomes

Candidates should be able to:

(a) describe experiments to show the force on a current-carrying conductor, and on a beam of charged particles, in a magnetic field, including the effect of reversing (1) the current, (2) the direction of the field.

(b) state the relative directions of force, field and current.

(c) describe the field patterns between currents in parallel conductors and relate these to the forces which exist between the conductors (excluding the Earth's field).

(d) explain how a current-carrying coil in a magnetic field experiences a turning effect and that the effect is increased by increasing (1) the number of turns on the coil, (2) the current.

(e) discuss how this turning effect is used in the action of an electric motor.

(f) 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.

23. Electromagnetic Induction

Content

23.1 Principles of electromagnetic induction

23.2 The a.c. generator

23.3 The transformer

Learning outcomes

Candidates should be able to:

(a) describe an experiment which shows that a changing magnetic field can induce an e.m.f. in a circuit.

(b) state the factors affecting the magnitude of the induced e.m.f.

(c) state that the direction of a current produced by an induced e.m.f. opposes the change producing it (Lenz's Law) and describe how this law may be demonstrated.

(d) describe a simple form of a.c. generator (rotating coil or rotating magnet) and the use of slip rings where needed.

(e) *sketch a graph of voltage output against time for a simple a.c. generator.

(f) describe the structure and principle of operation of a simple iron-cored transformer.

(g) recall and use the equation $(V_p / V_s) = (N_p / N_s)$

(h) state the advantages of high voltage transmission.

(i) discuss the environmental and cost implications of underground power transmission compared to overhead lines.

24. Introductory Electronics

Content

24.1 Thermionic emission and cathode-rays

24.2 Uses of an oscilloscope

24.3 Action and use of circuit components

Learning outcomes

Candidates should be able to:

(a) state that electrons are emitted by a hot metal filament.

(b) explain that to cause a continuous flow of emitted electrons requires (1) high positive potential and (2) very low gas pressure.

(c) describe the deflection of an electron beam by electric fields and magnetic fields.

(d) state that the flow of electrons (electron current) is from negative to positive and is in the opposite direction to conventional current.

(e) describe the use of an oscilloscope to display waveforms and to measure p.d.s and short intervals of time (the structure of the oscilloscope is **not** required).

(f) explain how the values of resistors are chosen according to a colour code and why widely different values are needed in different types of circuit.

(g) discuss the need to choose components with suitable power ratings.

(h) describe the action of thermistors and light-dependent resistors and explain their use as input sensors (thermistors will be assumed to be of the negative temperature coefficient type).

(i) describe the action of a variable potential divider (potentiometer).

(j) describe the action of a diode in passing current in one direction only.

(k) describe the action of a light-emitting diode in passing current in one direction only and emitting light.

(l) describe and explain the action of relays in switching circuits.

(m) describe and explain circuits operating as light-sensitive switches and temperature-operated alarms (using a relay or other circuits).

25. Electronic Systems

Note: There is no compulsory question set on Section 25 of the syllabus. Questions set on topics within Section 25 are always set as an alternative within a question.

Content

25.1 Switching and logic circuits

25.2 Bistable and astable circuits

Learning outcomes

Candidates should be able to:

(a) describe the action of a bipolar npn transistor as an electrically operated switch and explain its use in switching circuits.

(b) state in words and in truth table form, the action of the following logic gates, AND, OR, NAND, NOR and NOT (inverter).

(c) state the symbols for the logic gates listed above (American ANSI Y 32.14 symbols will be used).

(d) describe the use of a bistable circuit.

(e) discuss the fact that bistable circuits exhibit the property of memory.

Section VI: Atomic Physics

26. Radioactivity

Content

26.1 Detection of radioactivity

26.2 Characteristics of the three types of emission

26.3 Nuclear reactions

26.4 Half-life

26.5 Uses of radioactive isotopes including safety precautions

Learning outcomes

Candidates should be able to:

(a) describe the detection of alpha-particles, beta-particles and gamma rays by appropriate methods.

(b) state and explain the random emission of radioactivity in direction and time.

(c) state, for radioactive emissions, their nature, relative ionising effects and relative penetrating powers.

(d) describe the deflection of radioactive emissions in electric fields and magnetic fields.

(e) explain what is meant by *radioactive decay*.

(f) explain the processes of fusion and fission.

(g) describe, with the aid of a block diagram, one type of fission reactor for use in a power station.

(h) discuss theories of star formation and their energy production by fusion.

(i) explain what is meant by the term *half-life*.

(j) make calculations based on half-life which might involve information in tables or shown by decay curves.

(k) describe how radioactive materials are moved, used and stored in a safe way.

(l) discuss the way in which the type of radiation emitted and the half-life determine the use for the material.

(m) discuss the origins and effect of background radiation.

(n) discuss the dating of objects by the use of ^{14}C.

27. The Nuclear Atom

Content

27.1 Atomic model

27.2 Nucleus

Learning outcomes

Candidates should be able to:

(a) describe the structure of the atom in terms of nucleus and electrons.

(b) describe how the Geiger-Marsden alpha-particle scattering experiment provides evidence for the nuclear atom.

(c) describe the composition of the nucleus in terms of protons and neutrons.

(d) define the terms *proton number* (atomic number), Z and *nucleon number* (mass number), A.

(e) explain the term *nuclide* and use the nuclide notation $^{A}_{Z}X$ to construct equations where radioactive decay leads to changes in the composition of the nucleus.

(f) define the term *isotope*.

(g) explain, using nuclide notation, how one element may have a number of isotopes.

7. Appendix

7.1 Summary of key quantities, symbols and units

Candidates should be able to state the symbols for the following physical quantities and, where indicated, state the units in which they are measured.

Candidates should be familiar with the following multipliers: M mega, k kilo, c centi, m milli.

Quantity	Usual symbol	Usual 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
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
force	F	N
gravitational field strength	g	N/kg
moment of a 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, T	°C
heat capacity	C	J/°C
specific heat capacity	c	J/(kg °C), J/(g °C)
latent heat	L	J
specific latent heat	l	J/kg, J/g
frequency	f	Hz
wavelength	λ	m, cm

Quantity	Usual symbol	Usual unit
focal length	f	m, cm
angle of incidence	i	degree (°)
angles of reflection, refraction	r	degree (°)
critical angle	c	degree (°)
refractive index	n	
potential difference/voltage	V	V, mV
current	I	A, mA
charge	Q	C
e.m.f.	E	V
resistance	R	Ω

‘O’ Level Physics Formula Sheet

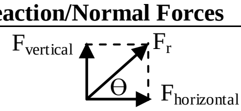
Measurements

Base SI Units	
Kg	SI Unit for mass: Kilogram
m	SI Unit for length: metre
s	SI Unit for time: second
A	SI Unit for current: Ampere
K	SI Unit for Temperature: Kelvin
mol	SI Unit for Amount of substance: molar
Number Prefix	
n (10^{-9})	nano
μ (10^{-6})	micro
m (10^{-3})	milli
c (10^{-2})	centi
d (10^{-1})	deci
K (10^{3})	Kilo
M (10^{6})	Mega

Kinematics

Average Speed **s** = $\Delta d / \Delta t$ **Average Velocity** **v** = $\Delta x/\Delta t$ **Acceleration** **a = Δv/Δt**	Δd = total distance travelled (area under speed-time graph) Δx = total displacement Δt = total time taken Δ**v** = change in velocity **Velocity** (slope of displacement-time graph) **Acceleration** (slope of velocity-time graph)
v = u + at **x** = ut + ½ at^2 $\mathbf{v^2}$ = u^2 + 2ax $v_{\text{free fall}} = \sqrt{2gh}$	u = initial velocity v = final velocity t = time a = acceleration x = displacement h = height g = gravitational constant = 9.81 m/s^2

Dynamics

Newton’s First Law $\sum \vec{F} = 0$ at equilibrium	A body continues to stay in its state of rest or uniform motion in a straight line as long as there is no net force/moment acting on the body.
Newton’s Second Law F= ma	The acceleration of an object is directly proportional to the net force acting on it and inversely proportional to its mass.
Newton’s Third Law	For every force object A acts on object B, object B will exert an equal and opposite force on object A giving rise to **Reaction/Normal Forces**
Resolving forces $F_{horizontal} = F_r \cos \Theta$ $F_{vertical} = F_r \sin \Theta$	

Mass, Weight, Density

Weight **w** = mg	w = Weight m = mass g = gravitational field strength
Density $\rho = \frac{m}{V}$	ρ = density m = mass V = volume

Turning effect of Force

Moment of Force M = F d	M = Moment F = force d = ⊥ distance from force to pivot
Principle of Moment Σ Anticlockwise Moment = Σ Clockwise Moment	For a body in rotational equilibrium, Sum of ACW Moment = sum of CW Moment

Pressure

Pressure **P** = $\frac{F}{A}$	P = Pressure F = Force over area, A A = Area
Pressure of liquid column **P** = hρg	P = Pressure ρ = density, h = height of liquid column g = gravitational field strength.

Energy, Work and Power

Work Done **W** = Fd	W = work done F= force d= distance in direction of force
Power **P** = W/t = Fv	Work done per unit time, t
Kinetic Energy $\mathbf{E_k} = \frac{1}{2} mv^2$	E_k = Kinetic Energy m = mass v = velocity
Gravitational Potential Energy $\mathbf{E_p}$ = mgh	g = gravity =9.81 m/s h = height m = mass
Conservation of Energy $E_1 = E_2$	E_1 = Total Energy Before E_2 = Total Energy After Energy cannot be created or destroyed. It can only be transformed or converted into other forms.

Kinetic Model of Matter

Ideal Gas Law PV ∞ T $P_1V_1 = P_2V_2$	P = pressure of fixed mass of gas V = volume occupies by fixed mass of gas T = Temperature of gas Subscript 1 = initial state Subscript 2 = final state

Thermal Properties of Matter

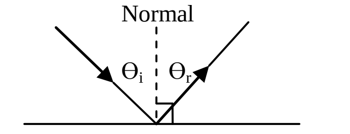
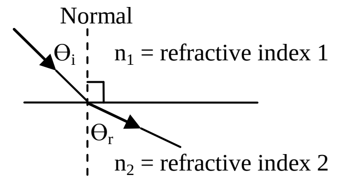
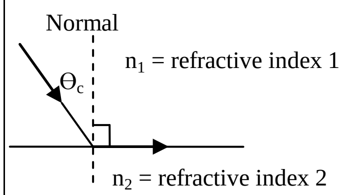
Specific Heat Capacity **E =** m c ΔT	c = Specific heat capacity (Energy required to raise the temperature of 1kg of the object by 1 °C) m = mass ΔT = change in temperature.
Latent Heat For melting, **E** = m L_{fusion} For boiling, **E** = m $L_{vaporization}$	L_{fusion} = latent heat of fusion (Energy required to change 1kg of solid to liquid at the constant temp) $L_{vaporization}$ = latent heat of vaporization (Energy required to change 1kg of liquid to gas at the constant temp) m = mass

General Wave Properties

Wave Velocity **v** = f λ	v = velocity of a wave f = frequency λ = wavelength
Wave frequency **f** = $\frac{1}{T}$	T = Period f = frequency

'O' Level Physics Formula Sheet

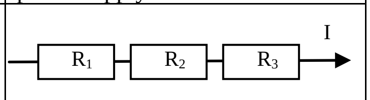
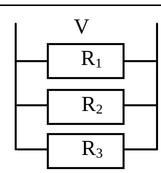
Light

Law of Reflection $\Theta_i = \Theta_r$ Θ_i = angle of incidence Θ_r = angle of reflection	
Snell's Law (refraction) $n_1 \text{Sin } \Theta_i = n2 \text{Sin } \Theta_r$ Θ_i = angle of incidence Θ_r = angle of refraction	
Critical angle $\sin \boldsymbol{\Theta_c} = \frac{n_2}{n_1}$ (special case of Snell's law where $\Theta_r = 90°$)	
Refractive Index $\mathbf{n} = \frac{c}{v}$ (n of air ≈ 1)	c = speed of light in vacuum. v = speed of light in medium Higher reflective index of a medium means light travel slower in the medium
Magnification $\mathbf{M} = \frac{h_i}{h_o} = \frac{d_i}{d_o}$	M = magnification h = height d = distance from lens Subscript i = image Subscript o = object

Current of Electricity

Current **I** = Q / Δt	Current = rate of flow of charges Q = Charge t=time
Ohm's Law **Resistance** **R** = V / I	V = voltage, R = resistance I = current
Resistance of a wire **R** = ρL/A	ρ = resistivity L = length of wire A = cross sectional area

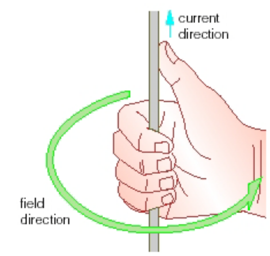
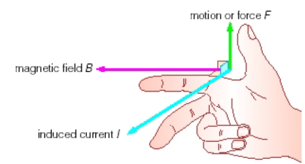
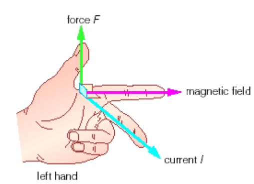
D.C. Circuits

Kirchoff's 1st Law $\sum I_{in} = \sum I_{out}$	Conservation of charges. $\sum I_{in}$ = Sum of current going into a junction $\sum I_{out}$ = Sum of current going out of a junction
Kirchoff's 2nd Law $\sum V = \text{E.M.F}$	∑V = Sum of potential difference V across all components in a circuit E.M.F = Voltage supplied by the power supply.
Resistance in Series $R_{total} = R_1 + R_2 + R_3$	
Resistance in Parallel $\frac{1}{R_{total}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3}$	

Practical Electricity

Electric Power **P** = VI = V^2/R = I^2R	P = Power V = voltage R = resistance I = current
Electrical Energy **E** = Pt = (VI)t	E = energy output P = power t = time V = voltage I = current

Electromagnetism

Transformer $\frac{V_p}{V_s} = \frac{N_p}{N_s}$ **(ideal transformer)** $V_pI_p = V_sI_s$	V = voltage N = number of coils I = current Subscript p = primary coil Subscript s = secondary coil
Right hand grip	
Fleming's Right Hand Rule	
Fleming's Left Hand Rule	

GCE Compilation