

LEAVING CERTIFICATE PHYSICS

ORDINARY LEVEL

SYLLABUS

Ordinary Level Syllabus Objectives

Ordinary level physics provides an introduction to, and an overview of, physics.

Students are expected to develop an appreciation of the fundamental laws and principles and their application to everyday life.

The objectives of the syllabus are:

1. Knowledge

Students should know

- basic physical principles, terminology, facts, and methods
- that physics is fundamental to many technological developments
- that physics contributes to the social, historical, environmental, technological and economic life of society.

2. Understanding

Students should understand

- basic physical principles
- how physical problems can be solved
- how the scientific method contributes to physics
- how physics relates to everyday life.

3. Skills

Students should be able to

- measure physical quantities in the appropriate SI units
- work safely in a laboratory
- follow instructions
- use scientific equipment appropriately
- use experimental data appropriately.

4. Competence

Students should be able to

- present information in tabular, graphical, written and diagrammatic form, as appropriate
- report concisely on experimental procedures and results
- use calculators
- solve numerical problems
- read popular science writing
- relate scientific concepts to issues in everyday life
- explain the science underlying familiar facts, observations, and phenomena.

5. Attitudes

Students should appreciate

- the contribution of physics to the social and economic development of society
- the relationship between physics and technology
- that a knowledge of physics has many vocational applications.

MECHANICS			
Content	Depth of Treatment	Activities	STS
MOTION			
1. Linear motion	<p>Units of mass, length and time — definition of units not required.</p> <p>Displacement, velocity, acceleration: definitions and units.</p> <p>Equations of motion.</p>	<p>Measurement of velocity and acceleration, using any suitable apparatus. Use of distance-time, velocity-time graphs.</p> <p>Measurement of g. Appropriate calculations.</p>	<p>Sports, e.g. athletics.</p>
2. Vectors and Scalars	<p>Distinction between vector and scalar quantities.</p>		<p>Vector nature of physical quantities: everyday examples.</p>
FORCES			
1. Newton's laws of motion	<p>Statement of the three laws.</p> <p>Force and momentum, definitions and units. Vector nature of forces to be stressed. $F = ma$ as a special case of Newton's second law. Friction: a force opposing motion.</p>	<p>Demonstration of the laws using air track <i>or</i> tickertape timer <i>or</i> powder track timer, etc.</p> <p>Appropriate calculations.</p>	<p>Applications</p> <ul style="list-style-type: none"> • seat belts • rocket travel. <p>Sports, all ball games.</p> <p>Importance of friction in everyday experience, e.g. walking, use of lubricants, etc.</p>
2. Conservation of momentum	<p>Principle of conservation of momentum.</p>	<p>Demonstration by any one suitable method. Appropriate calculations (problems involving change of mass need not be considered).</p>	<p>Collisions (ball games), acceleration of spacecraft, jet aircraft.</p>

MECHANICS (CONTINUED)			
Content	Depth of Treatment	Activities	STS
3. Gravity	Newton's law of universal gravitation. $F = \frac{Gm_1m_2}{d^2}$ Weight = mg	Compare gravitational forces between Earth and Sun and between Earth and Moon.	Solar system.
	Value of acceleration due to gravity on other bodies in space, e.g. Moon.	Calculation of weight on different planets.	Presence of atmosphere.
4. Density and pressure	Definitions and units. Pressure in liquids and gases. Boyle's law. Archimedes' principle. Law of flotation.	Demonstration of atmospheric pressure, e.g. collapsing-can experiment. Appropriate calculations. Demonstration only. Calculations not required.	Atmospheric pressure and weather. The "bends" in diving, etc. Hydrometers.
5. Moments	Definition. Levers. Couple.	Simple experiments with a number of weights. Appropriate calculations. (Only problems involving co-planar parallel forces need be considered.)	Torque, e.g. taps, doors. Handlebars on bicycles. Reference to moving-coil meters and simple motor.
6. Conditions for equilibrium	The sum of the forces in any direction equals the sum of the forces in the opposite direction. The sum of the moments about any point is zero.	Appropriate calculations.	Static and dynamic equilibrium.

MECHANICS (CONTINUED)			
Content	Depth of Treatment	Activities	STS
ENERGY			
1. Work	Definition and unit.	Simple experiments. Appropriate calculations involving force and displacement in the same direction only.	Lifts, escalators.
2. Energy	Energy as the ability to do work. Different forms of energy. $E_p = mgh$ $E_k = \frac{1}{2}mv^2$ Mass as a form of energy $E = mc^2$ Conversions from one form of energy to another. Principle of conservation of energy.	Demonstrations of different energy conversions. Appropriate calculations.	Sources of energy: renewable and non-renewable. Mass transformed to other forms of energy in the Sun. Efficient use of energy in the home.
3. Power	Power as the rate of doing work or rate of energy conversion. Unit. Percentage efficiency $= \frac{\text{Power output} \times 100}{\text{Power input}}$	Estimation of average power developed by <ul style="list-style-type: none"> • person running upstairs • person repeatedly lifting weights, etc. Appropriate calculations.	Power of devices, e.g. light bulbs, motors, etc.

MECHANICS: Experiments

1. Measurement of velocity and acceleration.
2. To show that $a \propto F$.
3. Verification of the principle of conservation of momentum.
4. Measurement of g .
5. Verification of Boyle's law.
6. Investigation of the laws of equilibrium for a set of co-planar forces.

TEMPERATURE			
Content	Depth of Treatment	Activities	STS
1. Concept of temperature	<p>Measure of hotness or coldness of a body.</p> <p>The SI unit of temperature is the kelvin (definition of unit in terms of the triple point of water not required).</p> <p>Celsius scale is the practical temperature scale</p> $t/^{\circ}\text{C} = T/\text{K} - 273.15$		
2. Thermometric properties	A physical property that changes measurably with temperature.	<p>Demonstration of some thermometric properties:</p> <ul style="list-style-type: none"> • length of liquid column, e.g. length of mercury column • emf of thermocouple • resistance • pressure of a gas at constant volume • volume of a gas at constant pressure • colour. 	
3. Thermometers	<p>Thermometers measure temperature.</p> <p>Two thermometers do not necessarily give the same reading at the same temperature.</p> <p>The need for standard thermometers – use any commercial laboratory thermometer as school standard.</p>	Graduate two thermometers at ice and steam points. Compare values obtained for an unknown temperature, using a straight-line graph between reference points.	<p>Practical thermometers, e.g.</p> <ul style="list-style-type: none"> • clinical thermometer, • oven thermometers, • boiler thermometers, • temperature gauge in a car.

HEAT			
Content	Depth of Treatment	Activities	STS
1. Concept of heat	Heat as a form of energy that causes a rise in temperature when added or a fall in temperature when withdrawn.		
QUANTITY OF HEAT			
1. Heat capacity, specific heat capacity	Definitions and units.	Appropriate calculations.	Storage heaters.
2. Latent heat, specific latent heat	Definitions and units.	Appropriate calculations.	Heat pump, e.g. refrigerator. Perspiration.
HEAT TRANSFER			
1. Conduction	Qualitative comparison of rates of conduction through solids.	Simple experiments.	<i>U</i> -values: use in domestic situations.
2. Convection		Simple experiments.	Domestic hot-water and heating systems.
3. Radiation	Radiation from the Sun. Solar constant (also called solar irradiance).	Simple experiments.	Everyday examples. Solar heating.

HEAT: Experiments

1. Calibration curve of a thermometer using the laboratory mercury thermometer as a standard.
2. Measurement of specific heat capacity, e.g. of water *or* a metal by a mechanical *or* electrical method.
3. Measurement of the specific latent heat of fusion of ice.
4. Measurement of the specific latent heat of vaporisation of water.

WAVES			
Content	Depth of Treatment	Activities	STS
1. Properties of waves	Longitudinal and transverse waves: frequency, amplitude, wavelength, velocity. Relationship $c = f \lambda$	Appropriate calculations.	
2. Wave phenomena	Reflection. Refraction. Diffraction. Interference. Polarisation. Stationary waves; relationship between inter-node distance and wavelength. Diffraction effects <ul style="list-style-type: none"> • at an obstacle • at a slit with reference to significance of the wavelength.	Simple demonstrations using slinky, ripple tank, microwaves, <i>or</i> other suitable method.	Everyday examples, e.g. <ul style="list-style-type: none"> • radio waves • waves at sea • seismic waves.
3. Doppler effect	Qualitative treatment.	Sound from a moving source.	Red shift of stars. Speed traps.

VIBRATIONS AND SOUND			
Content	Depth of Treatment	Activities	STS
1. Wave nature of sound	Reflection, refraction, diffraction, interference. Speed of sound in various media.	Demonstration of interference, e.g. two loudspeakers and a signal generator. Demonstration that sound requires a medium.	Acoustics. Reduction of noise using destructive interference. Noise pollution.
2. Characteristics of notes	Amplitude and loudness, frequency and pitch, quality and overtones. Frequency limits of audibility.		Dog whistle.
3. Resonance	Natural frequency. Fundamental frequency. Definition of resonance, and examples.	Demonstration using tuning forks <i>or</i> other suitable method.	Vocal cords (folds).
4. Vibrations in strings and pipes	Stationary waves in strings and pipes. Relationship between frequency and length.	Use string and wind instruments, e.g. guitar, tin whistle.	String section and woodwind section in orchestras.
5. Sound intensity level	Threshold of hearing and frequency response of the ear. Sound intensity level, measured in decibels. The dB(A) scale is used because it is adapted to the ear's frequency response.	Use of sound-level meter.	Examples of sound intensity level. Hearing impairment. Ear protection in industry, etc.

SOUND: Experiments

1. Measurement of the speed of sound in air.
2. Investigation of the variation of fundamental frequency of a stretched string with length.

LIGHT											
Content	Depth of Treatment	Activities	STS								
REFLECTION											
1. Laws of reflection		Demonstration using ray box <i>or</i> laser <i>or</i> other suitable method.									
2. Mirrors	<p>Images formed by plane and spherical mirrors. Knowledge that</p> $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \text{ and}$ $m = \frac{v}{u}$	<p>Real-is-positive sign convention. Simple exercises on mirrors by ray tracing <i>or</i> use of formula.</p>	<p>Practical uses of spherical mirrors</p> <table border="0"> <tr> <td>Concave</td> <td>Convex</td> </tr> <tr> <td>• dentists</td> <td>• supermarkets</td> </tr> <tr> <td>• floodlights</td> <td>• driving mirrors</td> </tr> <tr> <td>• projectors</td> <td></td> </tr> </table>	Concave	Convex	• dentists	• supermarkets	• floodlights	• driving mirrors	• projectors	
Concave	Convex										
• dentists	• supermarkets										
• floodlights	• driving mirrors										
• projectors											
REFRACTION											
1. Laws of refraction	Refractive index.	Demonstration using ray box <i>or</i> laser <i>or</i> other suitable method. Appropriate calculations.	Practical examples, e.g. real and apparent depth of fish in water.								
2. Total internal reflection	<p>Critical angle. Relationship between critical angle and refractive index. Transmission of light through optical fibres.</p>	Demonstration. Appropriate calculations.	<p>Reflective road signs. Mirages. Prism reflectors. Uses of optical fibres:</p> <ul style="list-style-type: none"> • telecommunications • medicine (endoscopes). 								
3. Lenses	<p>Images formed by single thin lenses. Knowledge that</p> $\frac{1}{f} = \frac{1}{u} + \frac{1}{v} \text{ and}$ $m = \frac{v}{u}$ <p>Power of lens: $P = \frac{1}{f}$ Two lenses in contact: $P = P_1 + P_2$ The eye: optical structure; short sight, long sight, and corrections.</p>	Simple exercises on lenses by ray tracing <i>or</i> use of formula.	<p>Uses of lenses.</p> <p>Spectacles.</p>								

LIGHT (CONTINUED)			
Content	Depth of Treatment	Activities	STS
WAVE NATURE OF LIGHT			
1. Diffraction and interference	Use of diffraction grating formula. $n\lambda = d\sin\theta$	Suitable method of demonstrating the wave nature of light. Appropriate calculations.	Interference colours • petrol film, soap bubbles.
2. Light as a transverse wave motion	Polarisation.	Demonstration of polarisation using polaroids <i>or</i> other suitable method.	Stress polarisation. Polaroid sunglasses.
3. Dispersion	Dispersion by a prism and a diffraction grating. Recombination by a prism.	Demonstration.	Rainbows, polished gemstones. Colours seen on surfaces of compact discs.
4. Colours	Primary, secondary and complementary colours. Addition of colours. Pigment colours need not be considered.	Demonstration.	Stage lighting, television.
5. Electromagnetic spectrum	Relative positions of radiations in terms of wavelength and frequency. Detection of UV and IR radiation.	Demonstration.	Ultraviolet and ozone layer. Infrared cameras: • medical applications • night vision. Greenhouse effect.
6. The spectrometer	The spectrometer and the function of its parts.	Demonstration.	

LIGHT: Experiments

1. Measurement of the focal length of a concave mirror.
2. Verification of Snell's law of refraction.
3. Measurement of the refractive index of a liquid *or* a solid.
4. Measurement of the focal length of a converging lens.
5. Measurement of the wavelength of monochromatic light.

ELECTRICITY			
Content	Depth of Treatment	Activities	STS
CHARGES			
1. Electrification by contact	Charging by rubbing together dissimilar materials. Types of charge: positive, negative. Conductors and insulators. Unit of charge: coulomb.	Demonstration of forces between charges.	Domestic applications: <ul style="list-style-type: none"> dust on television screen static on clothes. Industrial hazards <ul style="list-style-type: none"> in flour mills fuelling aircraft.
2. Electrification by induction		Demonstration using an insulated conductor and a nearby charged object.	
3. Distribution of charge on conductors	Total charge resides on outside of a metal object. Charges tend to accumulate at points. Point discharge.	Van de Graaff generator can be used to demonstrate these phenomena.	Lightning. Lightning conductors.
4. Electroscope	Structure.		Uses.
ELECTRIC FIELD			
1. Force between charges	Coulomb's law $F = \frac{1}{4\pi\epsilon} \frac{Q_1 Q_2}{d^2}$ an example of an inverse square law.		
2. Electric fields	Idea of lines of force. Vector nature of electric field to be stressed.	Demonstration of field patterns using oil and semolina <i>or</i> other method.	Precipitators. Xerography. Hazards: effect of electric fields on integrated circuits.
3. Potential difference	Definition of potential difference: work done per unit charge to transfer a charge from one point to another. Definition of volt. Concept of zero potential.	Appropriate calculations.	

ELECTRICITY (CONTINUED)			
Content	Depth of Treatment	Activities	STS
CAPACITANCE			
1. Capacitors and capacitance	<p>Definition: $C = Q/V$ Unit of capacitance.</p> <p>Parallel plate capacitor.</p> <p>Energy stored in a capacitor.</p> <p>Capacitors — conduct a.c. but not d.c.</p>	<p>Appropriate calculations.</p> <p>Charge capacitor — discharge through lamp or low-voltage d.c. motor.</p> <p>Demonstration.</p>	<p>Common uses of capacitors:</p> <ul style="list-style-type: none"> • tuning radios • flash guns • smoothing • filtering.
ELECTRIC CURRENT			
1. Electric current	Description of electric current as flow of charge $1 \text{ A} = 1 \text{ C s}^{-1}$		
2. Sources of emf and electric current	<p>Pd and voltage are the same thing; they are measured in volts. A voltage when applied to a circuit is called an emf.</p>		Sources of emf: mains, simple cells, lead-acid accumulator, car batteries, dry batteries, thermocouple.
3. Conduction in materials	<p>Conduction in</p> <ul style="list-style-type: none"> • metals • ionic solutions (active and inactive electrodes) • gases • vacuum • semiconductors. <p>References in each case to charge carriers.</p> <p>Conduction in semiconductors: the distinction between intrinsic and extrinsic conduction; p-type and n-type semiconductors.</p> <p>The p-n junction: basic principles underlying current flow across a p-n junction.</p>	<p>Interpretation of $I-V$ graphs.</p> <p>Demonstration of current flow across a p-n junction in forward and reverse bias, e.g. using a bulb.</p>	<p>Neon lamps, street lights.</p> <p>Electronic devices. LED, computers, integrated circuits.</p> <p>Rectification of a.c.</p>

ELECTRICITY (CONTINUED)			
Content	Depth of Treatment	Activities	STS
4. Resistance	Definition of resistance, unit. Ohm's law. Resistance varies with length, cross-sectional area, and temperature. Resistivity. Resistors in series and parallel.	Appropriate calculations. Use of ohmmeter. Appropriate calculations.	
5. Potential	LDR – light-dependent resistor. Thermistor. Potential divider.	Demonstration of LDR and thermistor. Demonstration.	Potentiometer as a variable potential divider.
6. Effects of electric current	Heating: $W = I^2Rt$ Chemical: an electric current can cause a chemical reaction. Magnetic effect of an electric current.	Demonstration of effect. Appropriate calculations. Demonstration of effect. Demonstration of effect.	Everyday examples. Advantage of use of EHT in transmission of electrical energy. Use of the chemical effect. Everyday examples.
7. Domestic circuits	Plugs, fuses, MCBs (miniature circuit breakers). Ring and radial circuits, bonding, earthing, and general safety precautions. No drawing of ring circuits required. RCDs (residual current devices). The kilowatt-hour. Uses.	Wiring a plug. Simple fuse calculations. Appropriate calculations.	Electricity at home: <ul style="list-style-type: none"> • fuse box • meter, etc. Electrical safety.
ELECTROMAGNETISM			
I. Magnetism	Magnetic poles exist in pairs. Magnetic effect of an electric current.	Demonstration using magnets, coils, and nails.	Electromagnets and their uses.

ELECTRICITY (CONTINUED)			
Content	Depth of Treatment	Activities	STS
2. Magnetic fields	Magnetic field due to <ul style="list-style-type: none"> • magnets • current in <ul style="list-style-type: none"> - a long straight wire - a loop - a solenoid. Description without mathematical details. Vector nature of magnetic field to be stressed.	Demonstrations.	Earth's magnetic field.
3. Current in a magnetic field	Current-carrying conductor experiences a force in a magnetic field. Direction of the force. Force depends on <ul style="list-style-type: none"> • the current • the length of the wire • the strength of the magnetic field. $F \propto I l B$ Magnetic flux density $B = \frac{F}{Il}$ Forces between currents (non-mathematical treatment).	Demonstration of the force on a conductor and coil in a magnetic field. Appropriate calculations.	Using Earth's magnetic field in navigation, i.e. compasses. Applications in motors, meters, and loudspeakers.
4. Electromagnetic induction	Magnetic flux: $\Phi = BA$ Faraday's law. Lenz's law. Change of mechanical energy to electrical energy.	Demonstration of the principle and laws of electromagnetic induction.	Application in generators.
5. Alternating current	Variation of voltage and current with time, i.e. alternating voltages and currents.	Use oscilloscope to show a.c.	National grid and a.c.
6. Concepts of mutual induction and self-induction	Structure and principle of operation of a transformer. Effects of inductors on a.c. (no mathematics or phase relations).	Demonstration. Appropriate calculations (voltage). Demonstration.	Uses of transformers. Dimmer switches in stage lighting — uses of inductors.

ELECTRICITY: Experiments

1. Verification of Joule's law (as $\Delta\theta \propto I^2$).
2. Measurement of the resistivity of the material of a wire.
3. To investigate the variation of the resistance of a metallic conductor with temperature.
4. To investigate the variation of the resistance of a thermistor with temperature.
5. To investigate the variation of current (I) with pd (V) for
 - (a) metallic conductor
 - (b) filament bulb
 - (c) copper sulfate solution with copper electrodes
 - (d) semiconductor diode.

MODERN PHYSICS			
Content	Depth of Treatment	Activities	STS
THE ELECTRON			
1. The electron	The electron as the indivisible quantity of charge. Reference to mass and location in the atom. Units of energy: eV, keV, MeV, GeV.		Electron named by G. J. Stoney. Quantity of charge measured by Millikan.
2. Thermionic emission	Principle of thermionic emission and its application to the production of a beam of electrons. Cathode ray tube, consisting of heated filament, cathode, anode, and screen. Deflection of cathode rays in electric and magnetic fields.	Use of cathode ray tube to demonstrate the production of a beam of electrons – deflection in electric and magnetic fields.	Applications <ul style="list-style-type: none"> • cathode ray oscilloscope • television. Use of CRO to display signals: <ul style="list-style-type: none"> • ECG and EEG.
3. Photoelectric emission	Photoelectric effect. The photon as a packet of energy: $E = hf$ Effect of intensity and frequency of incident light. Photocell (vacuum tube): structure and operation.	Demonstration, e.g. using zinc plate, electroscope, and different light sources. Demonstration of a photocell.	Applications of photoelectric sensing devices: <ul style="list-style-type: none"> • burglar alarms • automatic doors • control of burners in central heating • sound track in films.
4. X-rays	X-rays produced when high-energy electrons collide with target. Principles of the hot-cathode X-ray tube. X-ray production as inverse of photoelectric effect. Mention of properties of X-rays: <ul style="list-style-type: none"> • electromagnetic waves • ionisation • penetration. 		Uses of X-rays in medicine and industry. Hazards.

MODERN PHYSICS (CONTINUED)			
Content	Depth of Treatment	Activities	STS
THE NUCLEUS			
1. Structure of the atom	Principle of Rutherford's experiment. Bohr model, descriptive treatment only. Energy levels.	Experiment may be simulated using a large-scale model <i>or</i> a computer <i>or</i> demonstrated on a video.	
2. Structure of the nucleus	Emission line spectra: $hf = E_2 - E_1$	Demonstration of line spectra and continuous spectra.	Lasers. Spectroscopy as a tool in science.
3. Radioactivity	Atomic nucleus as protons plus neutrons. Mass number A , atomic number Z , A_ZX , isotopes.		
	Experimental evidence for three kinds of radiation: by deflection in electric or magnetic fields or ionisation or penetration. Nature and properties of alpha, beta and gamma emissions. Change in mass number and atomic number because of radioactive decay.	Demonstration of ionisation and penetration by the radiations using any suitable method, e.g. electroscopes, G-M tube.	Uses of radioisotopes: <ul style="list-style-type: none"> • medical imaging • medical therapy • food irradiation • agriculture • radiocarbon dating • smoke detectors • industrial applications.
	Principle of operation of a detector of ionising radiation. Definition of becquerel (Bq) as one disintegration per second.	Demonstration of G-M tube <i>or</i> solid-state detector. Interpretation of nuclear reactions.	
	Concept of half-life: $T_{1/2}$		
4. Nuclear energy	Principles of fission and fusion. Mass-energy conservation in nuclear reactions: $E = mc^2$	Interpretation of nuclear reactions.	Fusion: source of Sun's energy. Nuclear weapons.
	Nuclear reactor (fuel, moderator, control rods, shielding, and heat exchanger).	Audiovisual resource material.	Environmental impact of fission reactors. Development of fusion reactors.

MODERN PHYSICS (CONTINUED)			
Content	Depth of Treatment	Activities	STS
<p>5. Ionising radiation and health hazards</p>	<p>General health hazards in use of ionising radiations, e.g. X-rays, nuclear radiation.</p> <p>Environmental radiation: the effect of ionising radiation on humans depends on the type of radiation, the activity of the source (in Bq), the time of exposure, and the type of tissue irradiated.</p>	<p>Measurement of background radiation.</p> <p>Audiovisual resource material.</p>	<p>Health hazards of ionising radiations.</p> <p>Radon, significance of background radiation, granite.</p> <p>Medical and dental X-rays.</p> <p>Disposal of nuclear waste.</p> <p>Radiation protection.</p>

Mathematical Requirements

Black text is for Higher level only.

1. Use of calculators

Students will be expected to have an electronic calculator conforming to the examination regulations for the duration of the course and when answering the examination paper. It is recommended that students have available the following keys:

ORDINARY LEVEL

$+$, $-$, \times , \div , π , x^2 , \sqrt{x} , $\frac{1}{x}$, x^y , EE or EXP;
sine, cosine and tangent and their inverses in degrees and fractions of a degree; memory.

HIGHER LEVEL

as above and
 $\log_{10} x$, 10^x , $\ln x$.

In carrying out calculations, students should be advised to show clearly all expressions to be evaluated using a calculator. The number of significant figures given in the answer to a numerical problem should match the number of significant figures given in the question.

2. Mathematical requirements

The physics syllabus does not require Higher level mathematics. Higher level physics may include some of the optional work of Ordinary level mathematics. There is no requirement for the use of calculus techniques.

Arithmetic

Students should be able to

- understand the concept of significant figures
- recognise and use significant figures as appropriate
- recognise and use expressions in decimal and standard form (scientific) notation
- recognise and use prefixes indicating multiplication by 10^{-12} , 10^{-9} , 10^{-6} , 10^{-3} , 10^3 , 10^6 , 10^9
- use an electronic calculator for addition, subtraction, multiplication and division and for finding arithmetic means, reciprocals, squares, square roots, sines, cosines and tangents, exponentials, logarithms, and their inverses
- make approximate evaluations of numerical expressions and use such approximations to check calculator calculations.

Algebra

Students should be able to

- change the subject of an equation
- solve simple algebraic equations
- substitute for physical quantities in physical equations using consistent units
- formulate simple algebraic equations as mathematical models of physical situations
- comprehend and use the symbols $>$, $<$, \propto , $=$, x , Δx .

Geometry and Trigonometry

Students should be able to

- calculate the area of right-angled triangles, circumference and area of circles, surface area and volume of rectangular blocks, cylinders and spheres
- use Pythagoras' theorem, similarity of triangles, the angle sum of a triangle
- use sines, cosines and tangents in physical problems
- recall that $\sin \theta \approx \tan \theta \approx \theta/\text{radians}$, and $\cos \theta \approx 1$ for small θ
- translate between degrees and radians and ensure that the appropriate system is used.

Vectors

Students should be able to

- find the resultant of two perpendicular vectors, recognising situations where vector addition is appropriate
- obtain expressions for components of a vector in perpendicular directions, recognising situations where vector resolution is appropriate.

Graphs

Students should be able to

- translate information between numerical, algebraic, verbal and graphical forms
- select appropriate variables and scales for graph plotting
- determine the slope of a linear graph and allocate appropriate physical units to it
- choose by inspection a straight line that will serve as the best straight line through a set of data presented graphically.

Notations and Symbols

Standard units, signs and symbols should be used throughout the syllabus. In this section, selected abbreviations are given. The physical quantities, their symbols and units are given. The common electrical circuit symbols are shown.

Abbreviations

The following abbreviations should be used:

potential difference	pd	electromotive force	emf
light-emitting diode	LED	light-dependent resistor	LDR
proton	p	neutron	n
electron	e^-	positron	e^+
neutrino	ν		
quarks:			
up	u	down	d
strange	s	charmed	c
top	t	bottom	b
antiquarks:			
up	\bar{u}	down	\bar{d}
strange	\bar{s}	charmed	\bar{c}
top	\bar{t}	bottom	\bar{b}

Basic units

The international system of units (SI) should be used. The required base units are given in the table below.

Physical quantity	Name of SI base unit	Symbol for unit
length	metre	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K

Physical quantities, symbols, and units

The physical quantities, their units and the appropriate symbols required by the syllabus are shown below. Some non-SI units are required. These are indicated by an asterisk*.

Physical quantity	Symbol	Name of SI unit	Symbol for unit
mass	m	kilogram	kg
length	l	metre	m
distance	d		
radius	r, R		
diameter	d		

Physical quantity	Symbol	Name of SI unit	Symbol for unit
time	t	second	s
periodic time	T		
displacement	s	metre	m
speed, velocity	v, u	metre per second	m s^{-1}
acceleration	a	metre per second squared	m s^{-2}
acceleration of free fall (due to gravity)	g		
gravitational field strength	g	newton per kilogram	N kg^{-1}
momentum	p	kilogram metre per second	kg m s^{-1}
force	F	newton	N
angle	θ	*degree	°
		radian	rad
angular velocity	ω	radian per second	rad s^{-1}
weight	W	newton	N
gravitational constant	G	newton metre squared per kilogram squared	$\text{N m}^2 \text{kg}^{-2}$
area	A	square metre	m^2
volume	V	cubic metre	m^3
density	ρ	kilogram per cubic metre	kg m^{-3}
pressure	P, p	pascal newton per square metre	Pa N m^{-2}
moment of a force	M	newton metre	N m
torque, moment of a couple	T	newton metre	N m
work	W	joule	J
energy	E	joule *kilowatt-hour *electronvolt	J kW h eV
potential energy	E_p	joule	J
kinetic energy	E_k	joule	J
power	P	watt	W
temperature	T	kelvin	K
	t	degree Celsius	°C
	θ	degree Celsius	°C
temperature change	$\Delta\theta$	degree Celsius	°C
heat energy	Q	joule	J
heat capacity	C	joule per kelvin	J K^{-1}
specific heat capacity	c	joule per kilogram kelvin kilojoule per kilogram kelvin	$\text{J kg}^{-1} \text{K}^{-1}$ $\text{kJ kg}^{-1} \text{K}^{-1}$
latent heat	L	joule	J
specific latent heat	l	joule per kilogram kilojoule per kilogram	J kg^{-1} kJ kg^{-1}
frequency	f	hertz	Hz



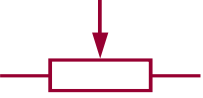










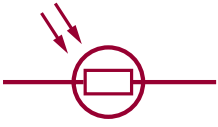

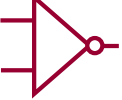



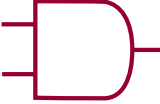
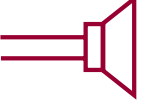

Physical quantity	Symbol	Name of SI unit	Symbol for unit
amplitude	A	metre	m
wavelength	λ	metre	m
velocity of a wave	c	metre per second	m s^{-1}
tension in a wire	T	newton	N
mass per unit length	μ	kilogram per metre	kg m^{-1}
sound intensity	I	watt per square metre	W m^{-2}
sound intensity level	$I.L.$	*decibel	dB
focal length	f	metre	m
object distance	u	metre	m
image distance	v	metre	m
magnification	m	no unit	
angle of incidence	i	degree	°
angle of reflection	r	degree	°
angle of refraction	r	degree	°
refractive index	n	no unit	
critical angle	C	degree	°
power of lens	P	per metre	m^{-1}
grating spacing	d	metre	m
slit separation	d	metre	m
speed of electromagnetic waves	c	metre per second	m s^{-1}
charge	Q, q	coulomb	C
permittivity	ϵ	farad per metre	F m^{-1}
permittivity of free space	ϵ_0	farad per metre	F m^{-1}
relative permittivity	ϵ_r	no unit	
electric field strength	E	newton per coulomb volt per metre	N C^{-1} V m^{-1}
potential difference	V	volt	V
capacitance	C	farad	F
electric current	I	ampere	A
emf	E	volt	V
resistance	R	ohm	Ω
resistivity	ρ	ohm metre	$\Omega \text{ m}$
electrical energy	W	joule	J
magnetic flux density	B	tesla	T
magnetic flux	Φ	weber	Wb
rms value of alternating emf	E_{rms}	volt	V
peak value of alternating emf	E_0	volt	V
rms value of alternating current	I_{rms}	ampere	A
peak value of alternating current	I_0	ampere	A
number of turns	N	no unit	
electronic charge	e	coulomb	C
Planck constant	h	joule second	J s

Physical quantity	Symbol	Name of SI unit	Symbol for unit
mass number	A	no unit	
atomic number	Z	no unit	
activity of radioactive source	A	becquerel	Bq
radioactive decay constant	λ	per second	s^{-1}
half-life	$T_{1/2}$	second	s

Electrical circuit symbols

The use of standard symbols (BS 3939) is recommended.
The common symbols required by the syllabus are given below.

	conductors crossing with no connection		neon lamp	
	junction of conductors		signal lamp	
	earth		filament lamp	
	normally open switch		voltmeter	
	normally closed switch		galvanometer	
	relay coil	} electro magnetic relay		ammeter
	relay contact			fuse
	primary or secondary cell		fixed resistor	
	battery of cells		variable resistor	
	power supply			

	thermistor		electric bell
	potential divider		motor
	capacitor		diode/rectifier
	electrolytic capacitor		p n p junction transistor
	inductor		n p n junction transistor
	inductor with ferromagnetic core		light-sensitive diode photodiode
	transformer with ferromagnetic core		light-dependent resistor LDR
	light-emitting diode LED		invert or NOT gate
	photo-voltaic cell		OR gate
	earphone		AND gate
	loudspeaker		
	microphone		

Reference: Association for Science Education.
Signs, Symbols and Systematics.
The ASE Companion to 5-16 Science.
 Hatfield: ASE, 1995.

Formulas

Students should know and be able to use the following formulas. At Ordinary level no derivations are required.

Equations in black text apply to Higher level only.

Those marked with † should be derived at Higher level.

Mechanics

Linear motion with constant acceleration:

$$\dagger v = u + at$$

$$\dagger s = ut + \frac{1}{2}at^2$$

$$\dagger v^2 = u^2 + 2as$$

Momentum of a particle = mu

$$\dagger F = ma$$

Conservation of momentum

$$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$$

Angle in radians

$$\theta = \frac{s}{r}$$

Angular velocity

$$\omega = \frac{\theta}{t}$$

† Relationship between linear velocity and angular velocity

$$v = r\omega$$

Centripetal acceleration

$$a = r\omega^2 = \frac{v^2}{r}$$

Centripetal force

$$F = mr\omega^2 = \frac{mv^2}{r}$$

Newton's law of gravitation

$$F = \frac{Gm_1m_2}{d^2}$$

Weight

$$W = mg$$

$$\dagger g = \frac{GM}{R^2}$$

$$\dagger T^2 = \frac{4\pi^2 R^3}{GM}$$

Density

$$\rho = \frac{m}{V}$$

Pressure: $p = \frac{F}{A}$

Pressure at a point in a fluid: $p = \rho gh$

Boyle's law

$$pV = \text{constant}$$

Moment = force \times perpendicular distance

Couple $T = Fd$

Hooke's law: $F = -ks$

Simple harmonic motion: $a = -\omega^2 s$

Periodic time

$$T = \frac{1}{f} = \frac{2\pi}{\omega}$$

Simple pendulum

$$T = 2\pi \sqrt{\frac{l}{g}}$$

Work

$$W = Fs$$

Potential energy: $E_p = mgh$

Kinetic energy: $E_k = \frac{1}{2}mv^2$

Mass-energy equivalence

$$E = mc^2$$

Power

$$P = \frac{W}{t}$$

$$\text{Percentage efficiency} = \frac{\text{Power output} \times 100}{\text{Power input}}$$

Heat and Temperature

Celsius temperature

$$t / ^\circ\text{C} = T / \text{K} - 273.15$$

Heat energy needed to change temperature

$$Q = mc\Delta\theta \quad Q = C\Delta\theta$$

Heat energy needed to change state

$$Q = ml \quad Q = L$$

Waves

Velocity of a wave

$$c = f\lambda$$

Doppler effect

$$f' = \frac{fc}{c \pm u}$$

Fundamental frequency of a stretched string

$$f = \frac{1}{2l} \sqrt{\frac{T}{\mu}}$$

Mirror and lens formula

$$\frac{1}{f} = \frac{1}{u} + \frac{1}{v}$$

Magnification

$$m = \frac{v}{u}$$

Power of a lens

$$P = \frac{1}{f}$$

Two lenses in contact

$$P = P_1 + P_2$$

Refractive index:

$$n = \frac{\sin i}{\sin r}$$

$$n = \frac{\text{real depth}}{\text{apparent depth}}$$

$$n = \frac{1}{\sin C}$$

$$n = \frac{c_1}{c_2}$$

†Diffraction grating

$$n\lambda = d \sin \theta$$

Electricity

Coulomb's law	$F = \frac{1}{4\pi\epsilon} \frac{Q_1 Q_2}{d^2}$	Capacitance	$C = \frac{Q}{V}$
Electric field strength	$E = \frac{F}{Q}$	Parallel-plate capacitor	$C = \frac{A\epsilon_0}{d}$
Potential difference	$V = \frac{W}{Q}$	Energy stored in capacitor	$W = \frac{1}{2} CV^2$
	$V = IR$	Resistivity	$\rho = \frac{RA}{l}$
†Resistors in series	$R = R_1 + R_2$	†Resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$
Wheatstone bridge	$\frac{R_1}{R_2} = \frac{R_3}{R_4}$		
Joule's law	$W = I^2 R t$	Power	$P = VI$
Force on a current carrying conductor	$F = I l B$	Magnetic flux	$\Phi = BA$
†Force on a charged particle	$F = qvB$		
Induced emf	$E = \frac{-d\Phi}{dt}$	Transformer	$\frac{V_i}{V_o} = \frac{N_p}{N_s}$
Alternating voltage and current	$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$	$I_{\text{rms}} = \frac{I_0}{\sqrt{2}}$	

Modern Physics

Energy of a photon	$E = hf$
Einstein's photoelectric equation	$hf = \Phi + \frac{1}{2}mv^2_{\text{max}}$
Law of radioactive decay	rate of decay = λN
Half-life	$T_{1/2} = \frac{\ln 2}{\lambda}$
Mass-energy equivalence	$E = mc^2$



Procedures for drawing up National Syllabuses

The NCCA's Course Committees for the Leaving Certificate (Established) have the following membership:

- *Association of Secondary Teachers, Ireland*
- *Teachers' Union of Ireland*
- *Joint Managerial Body*
- *Association of Community and Comprehensive Schools*
- *Subject Association*
- *Irish Vocational Education Association*
- *National Council for Educational Awards*
- *Conference of Heads of Irish Universities*
- *Department of Education and Science (Inspectorate).*

On the basis of a brief provided by Council, the NCCA's Course Committees prepare the syllabuses.

Recommendations of Course Committees are submitted to the Council of the NCCA for approval. The NCCA, having considered such recommendations, advises the Minister for Education and Science accordingly.

Further information may be obtained by contacting the NCCA at 24 Merrion Square, Dublin 2.



Published by The Stationery Office

To be purchased directly from:

Government Publications Sales Office,
Sun Alliance House,
Molesworth Street, Dublin 2.

Or by mail order from:

Government Publications, Postal Trade Section,
4-5 Harcourt Road, Dublin 2.

Tel: 01-647 6834/5 Fax: 01-475 2760

Or through any bookseller.