Year 12 Physics Curriculum

Unit:	Core knowledge/skill development:	Sequence:	Assessment:	Literacy, numeracy, PSHE, FBV, other links	ACP and VAA development:	Home learning and enrichment
3.1 Measurements and their errors	Content in this section is a continuing study for a student of physics. A working knowledge of the specified fundamental (base) units of measurement is vital. Likewise, practical work in the subject needs to be underpinned by an awareness of the nature of measurement errors and of their numerical treatment. The ability to carry through reasonable estimations is a skill that is required throughout the course and beyond.	3.1.1 Use of SI units and their prefixes Fundamental (base) units. Use of mass, length, time, amount of substance, temperature, electric current and their associated SI units. SI units derived. Knowledge and use of the SI prefixes, values and standard form. The fundamental unit of light intensity, the candela, is excluded. Students are not expected to recall definitions of the fundamental quantities.	Common to all by topic) Isaac Physics for physics and maths, Exam Questions Block assessment / EOY assessment – exam questions / past papers Practical's: CPAC	PS 2.3 Students should be able to identify random and systematic errors and suggest ways to reduce or remove them. PS 3.3 Students should understand the link between the number of significant figures in the value of a quantity and its associated uncertainty. MS 1.5 Students should be able to combine uncertainties in cases where the measurements	In A level Physics the ACPS in general order of application are: 1. Analysing, 2. Linking, 3. Meta-thinking, 4. Creating and 5. Realising. VAA	(Common to all by topic) Flip learning, revision, homework by Isaac Physics, Exam Questions. School trips. Isaac Physics mentoring. Stretch to pre-University content. Differentiate via topic challenge in question setting

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		Dimensional analysis is not required. Students should be able to use the prefixes: T, G, M, k, c, m, μ, n, p, f, Students should be able to convert between different units of the same quantity, eg J and eV, J and kW h. 3.1.2 Limitation of physical measurements Random and systematic errors. Precision, repeatability, reproducibility, resolution and accuracy. Uncertainty: Absolute, fractional and percentage uncertainties represent		that give rise to the uncertainties are added, subtracted, multiplied, divided, or raised to powers. Combinations involving trigonometric or logarithmic functions will not be required MS 1.4 Students should be able to estimate approximate values of physical quantities to the nearest order of magnitude. Students should be able to use these estimates together with their knowledge of physics to produce further		

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		uncertainty in the final answer for a quantity. Combination of absolute and percentage uncertainties. Represent uncertainty in a data point on a graph using error bars. Determine the uncertainties in the gradient and intercept of a straight-line graph. Individual points on the graph may or may not have associated error bars. 3.1.3 Estimation of physical quantities Orders of magnitude.		derived estimates also to the nearest order of magnitude.		

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		Estimation of approximate values of physical quantities.				
3.2 Particles and radiation	This section introduces students both to the fundamental properties of matter, and to electromagnetic radiation and quantum phenomena. Teachers may wish to begin with this topic to provide a new interest and knowledge dimension beyond GCSE. Through a study of these topics, students become aware of the way ideas develop and evolve in physics. They will appreciate the importance of international collaboration in the development of new	3.2.1.1 Constituents of the atom Simple model of the atom, including the proton, neutron and electron. Charge and mass of the proton, neutron and electron in SI units and relative units. The atomic mass unit (amu) is included in the A-level Nuclear physics section. Specific charge of the proton and the electron, and of nuclei and ions. Proton number Z, nucleon number A, nuclide notation.		AT i Demonstration of the range of alpha particles using a cloud chamber, spark counter or Geiger counter. MS 0.2 Use of prefixes for small and large distance measurements. AT i Detection of gamma radiation. MS 1.1, 2.2 Students could determine the frequency and wavelength of the two gamma		

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	experiments and theories in this area of fundamental research.	Students should be familiar with the X ZA notation. Meaning of isotopes and the use of isotopic data. 3.2.1.2 Stable and unstable nuclei The strong nuclear force; its role in keeping the nucleus stable; short-range attraction up to approximately 3 fm, very-short range repulsion closer than approximately 0.5 fm. Unstable nuclei; alpha and beta decay. Equations for alpha decay, β− decay including the need for the neutrino. The existence of the neutrino was		photons produced when a 'slow' electron and a 'slow' positron annihilate each other. The PET scanner could be used as an application of annihilation. PS 1.2 Momentum transfer of a heavy ball thrown from one person to another. AT k Use of computer simulations of particle collisions. ATl Cosmic ray showers as a source of high energy particles including pions		

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		hypothesised to account for conservation of energy in beta decay. 3.2.1.3 Particles, antiparticles and photons For every type of particle, there is a corresponding antiparticle. Comparison of particle and antiparticle masses, charge and rest energy in MeV. Students should know that the positron, antiproton, antineutron and antineutrino are the antiparticles of the electron, proton, neutron and neutrino respectively.		and kaons; observation of stray tracks in a cloud chamber; use of two Geiger counters to detect a cosmic ray shower. PS 3.2 / MS 2.3 Demonstration of the photoelectric effect using a photocell or an electroscope with a zinc plate attachment and UV lamp. AT j / MS 0.1, 0.2 Observation of line spectra using a diffraction grating. PS 1.2 Demonstration using an electron diffraction tube. MS 1.1, 2.3		

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		Photon model of electromagnetic radiation, the Planck constant. *E* = *h f* = *hc* · Knowledge of annihilation and pair production and the energies involved. The use of *E* = *mc2* is not required in calculations. 3.2.1.4 Particle interactions Four fundamental interactions: gravity, electromagnetic, weak nuclear, strong nuclear. (The strong nuclear force may be referred to as the strong interaction.) The concept of exchange particles to explain forces between elementary particles.		Use prefixes when expressing wavelength values.		

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		Knowledge of the gluon, Z0 and graviton will not be tested. The electromagnetic force; virtual photons as the exchange particle. The weak interaction limited to β−and β+ decay, electron capture and electron–proton collisions; W+ and W− as the exchange particles. Simple diagrams to represent the above reactions or interactions in terms of incoming and outgoing particles and exchange particles. 3.2.1.5 Classification of particles				

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		Hadrons are subject to the strong interaction. The two classes of hadrons: baryons (proton, neutron) and antibaryons (antiproton and antineutron) mesons (pion, kaon). Baryon number as a quantum number. Conservation of baryon number. The proton is the only stable baryon into which other baryons eventually decay. The pion as the exchange particle of the strong nuclear force.				

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		The kaon as a particle that can decay into pions. Leptons: electron, muon, neutrino (electron and muon types only) and their antiparticles. Lepton number as a quantum number; conservation of lepton number for muon leptons and for electron leptons. The muon as a particle that decays into an electron. Strange particles Strange particles as particles that are produced through the strong interaction and decay through the weak interaction (eg kaons).				

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		Strangeness (symbol s) as a quantum number to reflect the fact that strange particles are always created in pairs. Conservation of strangeness in strong interactions. Strangeness can change by 0, +1 or -1 in weak interactions. Appreciation that particle physics relies on the collaborative efforts of large teams of scientists and engineers to validate new knowledge. 3.2.1.6 Quarks and antiquarks Properties of quarks and antiquarks: charge, baryon				

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		number and strangeness. Combinations of quarks and antiquarks required for baryons (proton and neutron only), antibaryons (antiproton and antineutron only) and mesons (pion and kaon only). Only knowledge of up (u), down (d) and strange (s) quarks and their antiquarks will be tested. The decay of the neutron should be known. 3.2.1.7 Applications of conservation laws Change of quark character in β− and in β+ decay. Application of the conservation laws				

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		for charge, baryon number, lepton number and strangeness to particle interactions. The necessary data will be provided in questions for particles outside those specified. Students should recognise that energy and momentum are conserved in interactions. 3.2.2 Electromagnetic radiation and quantum phenomena **3.2.2.1 The photoelectric effect** Threshold frequency; photon explanation of threshold frequency.				

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		Work function ·, stopping potential. Photoelectric equation: $h f =$ · + Ek (max Ek (max is the maximum kinetic energy of the photoelectrons. The experimental determination of stopping potential is not required. 3.2.2.2 Collisions of electrons with atoms Ionisation and excitation; understanding of ionisation and excitation in the fluorescent tube. The electron volt. Students will be expected to be able to convert eV into J and vice versa.				

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		3.2.2.3 Energy levels and photon emission Line spectra (eg of atomic hydrogen) as evidence for transitions between discrete energy levels in atoms. $h f = E1 - E2$ In questions, energy levels may be quoted in J or eV. 3.2.2.4 Wave-particle duality Students should know that electron diffraction suggests that particles possess wave properties and the photoelectric effect suggests that electromagnetic waves have a particulate nature. Details of particular methods of particle				

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		diffraction are not expected. de Broglie wavelength $\lambda = \frac{h}{mv}$ where mv is the momentum. Students should be able to explain how and why the amount of diffraction changes when the momentum of the particle is changed. Appreciation of how knowledge and understanding of the nature of matter changes over time. Appreciation that such changes need to be evaluated through peer review and validated by the scientific community.				

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3.3 Waves	GCSE studies of wave phenomena are extended through a development of knowledge of the characteristics, properties, and applications of travelling waves and stationary waves. Topics treated include refraction, diffraction, superposition and interference. **Required practical 1:** Investigation into the variation of the frequency of stationary waves on a string with length, tension and mass per unit length of the string. **Required practical 2:** Investigation of interference effects to include the Young's slit experiment and	3.3.1 Progressive and stationary waves 3.3.1.1 Progressive waves Oscillation of the particles of the medium; amplitude, frequency, wavelength, speed, phase, phase difference, $c = f \cdot f$ $= 1T$ Phase difference may be measured as angles (radians and degrees) or as fractions of a cycle. 3.3.1.2 Longitudinal and transverse waves Nature of longitudinal and transverse waves.		PS 2.3 / MS 0.1, 4.7 / AT a, b Laboratory experiment to determine the speed of sound in free air using direct timing or standing waves with a graphical analysis. PS 2.2, 2.4 / MS 1.2, 3.2, 3.4, 3.5 / AT i Students can investigate the factors that determine the speed of a water wave. MS 4.7 / PS 1.2, 2.1 / AT i Students can investigate the factors that determine the frequency of stationary wave		

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	interference by a diffraction grating.	Examples to include: sound, electromagnetic waves, and waves on a string. Students will be expected to know the direction of displacement of particles/fields relative to the direction of energy propagation and that all electromagnetic waves travel at the same speed in a vacuum. Polarisation as evidence for the nature of transverse waves. Applications of polarisers to include Polaroid material and the alignment of aerials for		patterns of a stretched string. AT i Investigation of two-source interference with sound, light and microwave radiation. MS 0.6, 4.1		

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		transmission and reception. Malus's law will not be expected. 3.3.1.3 Principle of superposition of waves and formation of stationary waves Stationary waves. Nodes and antinodes on strings. $f = 1\ 2l\ T$ · for first harmonic. The formation of stationary waves by two waves of the same frequency travelling in opposite directions. A graphical explanation of formation of stationary waves will be expected.				

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		Stationary waves formed on a string and those produced with microwaves and sound waves should be considered. Stationary waves on strings will be described in terms of harmonics. The terms fundamental (for first harmonic) and overtone will **not** be used. 3.3.2 Refraction, diffraction and interference 3.3.2.1 Interference Path difference. Coherence. Interference and diffraction using a laser as a source of monochromatic light. Young's double-slit experiment: the use				

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		of two coherent sources or the use of a single source with double slits to produce an interference pattern. Fringe spacing, *w* = ·*Ds* Production of interference pattern using white light. Students are expected to show awareness of safety issues associated with using lasers. Students will not be required to describe how a laser works. Students will be expected to describe and explain interference produced with sound and				

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		electromagnetic waves. Appreciation of how knowledge and understanding of nature of electromagnetic radiation has changed over time. 3.3.2.2 Diffraction Appearance of the diffraction pattern from a single slit using monochromatic and white light. Qualitative treatment of the variation of the width of the central diffraction maximum with wavelength and slit width. The graph of intensity against angular separation is not required.				

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		Plane transmission diffraction grating at normal incidence. Derivation of *d*sin · = *n* · Use of the spectrometer will not be tested. Applications of diffraction gratings. 3.3.2.3 Refraction at a plane surface Refractive index of a substance, *n* = *c cs* Students should recall that the refractive index of air is approximately 1. Snell's law of refraction for a boundary *n*1sin ·1 = *n*2sin ·2 Total internal reflection sin ·c = *n*2 *n*1				

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		Simple treatment of fibre optics including the function of the cladding. Optical fibres will be limited to step index only. Material and modal dispersion. Students are expected to understand the principles and consequences of pulse broadening and absorption.				
3.4 Mechanics and materials	Vectors and their treatment are introduced followed by development of the student's knowledge and understanding of forces, energy and momentum. The section continues with a study of materials	3.4.1 Force, energy and momentum 3.4.1.1 Scalars and vectors Nature of scalars and vectors. Examples should include: velocity/speed, mass, force/weight,		MS 0.6, 4.2, 4.4, 4.5 / PS 1.1 Investigation of the conditions for equilibrium for three coplanar forces acting at a point using a force board.		

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	considered in terms of their bulk properties and tensile strength. As with earlier topics, this section and also the following section Electricity would provide a good starting point for students who prefer to begin by consolidating work. Required practical 3: Determination of g by a freefall method. Required practical 4: Determination of the Young modulus by a simple method.	acceleration, displacement/distance. Addition of vectors by calculation or scale drawing. Calculations will be limited to two vectors at right angles. Scale drawings may involve vectors at angles other than 90 °. Resolution of vectors into two components at right angles to each other. Examples should include components of forces along and perpendicular to an inclined plane. Problems may be solved either by the use of resolved		MS 3.6, 3.7 / PS 1.1, 3.1 Distinguish between instantaneous velocity and average velocity. MS 3.5, 3.6 Measurements and calculations from displacement–time, velocity–time and acceleration–time graphs. MS 0.5, 2.2, 2.3, 2.4 Calculations involving motion in a straight line MS 0.3, 1.2, 3.7 / AT d Students should be able to identify random		

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		forces or the use of a closed triangle. Conditions for equilibrium for two or three coplanar forces acting at a point. Appreciation of the meaning of equilibrium in the context of an object at rest or moving with constant velocity. 3.4.1.2 Moments Moment of a force about a point. Moment defined as *force × perpendicular distance from the point to the line of action of the force*. Couple as a pair of equal and opposite coplanar forces. Moment of couple defined as *force ×*		and systematic errors in the experiment and suggest ways to remove them. MS 3.9 Determine g from a graph. PS 2.2, 3.1 Investigation of the factors that determine the motion of an object through a fluid PS 4.1 / MS 0.5, 3.2 / AT a, b, d Students can verify Newton's second law of motion. MS 4.1, 4.2 Students can use free-body diagrams MS 2.2, 2.3		

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		perpendicular distance between the lines of action of the forces. Principle of moments. Centre of mass. Knowledge that the position of the centre of mass of uniform regular solid is at its centre. 3.4.1.3 Motion along a straight line Displacement, speed, velocity, acceleration. $v = \Delta s \Delta t$ $a = \Delta v \Delta t$ Calculations may include average and instantaneous speeds and velocities. Representation by graphical methods		Students can apply conservation of momentum and rate of change of momentum to a range of examples MS 0.3 / PS 3.3, 4.1 / AT a, b, f. Investigate the efficiency of an electric motor being used to raise a mass through a measured height. Students should be able to identify random and systematic errors in the experiment and suggest ways to remove them. MS 0.4, 2.2 Estimate the energy that can be derived from		

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		of uniform and non-uniform acceleration. Significance of areas of velocity–time and acceleration–time graphs and gradients of displacement–time and velocity–time graphs for uniform and non-uniform acceleration eg graphs for motion of bouncing ball. Equations for uniform acceleration: $v = u + at$ $s = u + v 2 t$ $s = ut + at2 2$ $v2 = u2 + 2as$ Acceleration due to gravity, g. 3.4.1.4 Projectile motion		food consumption. MS 0.2, 4.3 / PS 3.3, 4.1 Students can compare the use of analogue and digital meters. MS 0.4, 4.3 / AT e Estimate the volume of an object leading to an estimate of its density.		

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		Independent effect of motion in horizontal and vertical directions of a uniform gravitational field. Problems will be solvable using the equations of uniform acceleration. Qualitative treatment of friction. Distinctions between static and dynamic friction will not be tested. Qualitative treatment of lift and drag forces. Terminal speed. Knowledge that air resistance increases with speed. Qualitative understanding of				

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		the effect of air resistance on the trajectory of a projectile and on the factors that affect the maximum speed of a vehicle. 3.4.1.5 Newton's laws of motion Knowledge and application of the three laws of motion in appropriate situations. $F = ma$ for situations where the mass is constant. 3.4.1.6 Momentum *momentum* = *mass* × *velocity* Conservation of linear momentum. Principle applied quantitatively to problems in one dimension.				

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		Force as the rate of change of momentum, $F = \Delta mv \Delta t$ Impulse = change in momentum $F\Delta t = \Delta mv$, where F is constant. Significance of the area under a force–time graph. Quantitative questions may be set on forces that vary with time. Impact forces are related to contact times (eg kicking a football, crumple zones, packaging). Elastic and inelastic collisions; explosions. Appreciation of momentum conservation issues				

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		in the context of ethical transport design. 3.4.1.7 Work, energy and power Energy transferred, $W = Fs\cos\theta$ *rate of doing work = rate of energy transfer*, $P = \frac{\Delta W}{\Delta t} = Fv$ Quantitative questions may be set on variable forces. Significance of the area under a force–displacement graph. *efficiency = useful output power input power* Efficiency can be expressed as a percentage. 3.4.1.8 Conservation of energy				

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		Principle of conservation of energy. ΔEp = mgΔh and Ek = 12mv2 Quantitative and qualitative application of energy conservation to examples involving gravitational potential energy, kinetic energy, and work done against resistive forces. 3.4.2 Materials 3.4.2.1 Bulk properties of solids Density, · = mV Hooke's law, elastic limit, F = kΔL , k as stiffness and spring constant.				

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		Tensile strain and tensile stress. Elastic strain energy, breaking stress. *energy stored* = $12F\Delta L$ = *area under force–extension graph* Description of plastic behaviour, fracture and brittle behaviour linked to force–extension graphs. Quantitative and qualitative application of energy conservation to examples involving elastic strain energy and energy to deform. Spring energy transformed to kinetic and				

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		gravitational potential energy. Interpretation of simple stress–strain curves. Appreciation of energy conservation issues in the context of ethical transport design. 3.4.2.2 The Young modulus *Young modulus = tensile stress tensile strain = FL A Δ L* Use of stress–strain graphs to find the Young modulus. (One simple method of measurement is required.)				
3.5 Electricity	This section builds on and develops earlier study of these phenomena from GCSE. It provides	3.5.1 Current electricity 3.5.1.1 Basics of electricity		AT b, f Students can construct circuits from the range of components		

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	opportunities for the development of practical skills at an early stage in the course and lays the groundwork for later study of the many electrical applications that are important to society. Required practical 5: Determination of resistivity of a wire using a micrometer, ammeter and voltmeter. Required practical 6: Investigation of the emf and internal resistance of electric cells and batteries by measuring the variation of the terminal pd of the cell with current in it.	Electric current as the rate of flow of charge; potential difference as work done per unit charge. $I = \Delta Q / \Delta t$, $V = W/Q$ Resistance defined as $R = V/I$ 3.5.1.2 Current–voltage characteristics For an ohmic conductor, semiconductor diode, and filament lamp. Ohm's law as a special case where $I \propto V$ under constant physical conditions. Unless specifically stated in questions, ammeters and voltmeters should be treated as ideal		MS 3.2, 4.3 / PS 1.2 / AT a, b, f, g Investigation of the variation of resistance of a thermistor with temperature. MS 0.3 / PS 4.1 / AT a, b, f, g Students can construct circuits with various component configurations and measure currents and potential differences. MS 3.2 / PS 4.1 / AT f Students can investigate the behaviour of a potential divider circuit. MS 3.2 / AT g		

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		(having zero and infinite resistance respectively). Questions can be set where either I or V is on the horizontal axis of the characteristic graph. 3.5.1.3 Resistivity Resistivity, $\cdot = RA\ L$ Description of the qualitative effect of temperature on the resistance of metal conductors and thermistors. Only negative temperature coefficient (ntc) thermistors will be considered. Applications of thermistors to include temperature sensors and		Students should design and construct potential divider circuits to achieve various outcomes. MS 3.1, 3.3 / PS 2.2, 3.1 / AT f		

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		resistance–temperature graphs. Superconductivity as a property of certain materials which have zero resistivity at and below a critical temperature which depends on the material. Applications of superconductors to include the production of strong magnetic fields and the reduction of energy loss in transmission of electric power. Critical field will not be assessed. 3.5.1.4 Circuits Resistors: *in series*, $R_T = R_1 + R_2 + R_3 + \ldots$				

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		in parallel, 1 *RT* = 1 *R*1 + 1 *R*2 + 1 *R*3 + … *Energy and power equations*: *E* = *IVt*; *P* = *IV* = *I*2*R* = *V*2 *R* The relationships between currents, voltages and resistances in series and parallel circuits, including cells in series and identical cells in parallel. Conservation of charge and conservation of energy in dc circuits. 3.5.1.5 Potential divider The potential divider used to supply constant or variable potential difference from a power supply. The use of the potentiometer as a				

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		measuring instrument is not required. Examples should include the use of variable resistors, thermistors, and light dependent resistors (LDR) in the potential divider. 3.5.1.6 Electromotive force and internal resistance $\cdot = EQ$, $\cdot = I R + r$ Terminal pd; emf Students will be expected to understand and perform calculations for circuits in which the internal resistance of the supply is not negligible.				