A Level H2 Physics (9479) Formulae

Formulae highlighted in yellow is given in the formula list.

Topic 1: Measurements

Absolute Uncertainty	$x \pm \Delta x$	Δx is the absolute uncertainty of x. Δx to 1 s.f. x to same d.p. as Δx
Fractional Uncertainty	$\frac{\Delta x}{x}$	Δx is the absolute uncertainty of x. Fractional and percentage uncertainty to 2 s.f.
Percentage uncertainty	$\frac{\Delta x}{x} \times 100\%$	
First Principles	$\Delta z \approx \frac{1}{2}(z_{max} - z_{min})$	Δz is the uncertainty of quantity z. z_{max} is the maximum value of z. z_{min} is the minimum value of z.

Topic 2: Kinematics

Velocity	$v = \frac{ds}{dt}$	v is the velocity (m s^{-1}) s is the displacement (m) t is the time (s)
Average velocity	$v_{av} = \frac{\Delta s}{t_{total}}$	
Acceleration	$a = \frac{dv}{dt}$	v is the velocity (m s^{-1}) a is the acceleration (m s^{-2}) t is the time (s)
Average acceleration	$a_{av} = \frac{\Delta v}{t_{total}}$	
Equations of motion	$v = u + at$	s is the displacement (m) u is the initial velocity (m s^{-1}) v is the final velocity (m s^{-1}) a is the acceleration (m s^{-2}) t is the time (s)
	$v^2 = u^2 + 2as$	
	$s = \frac{1}{2}(u + v)t$	
	$s = ut + \frac{1}{2}at^2$	

Topic 3: Dynamics

Linear Momentum	$p = mv$	p is the linear momentum (kg m s^{-1}) m is the mass of the object (kg) v is the velocity of the object (m s^{-1})
Newton's 2nd Law	$F_{net} = \frac{dp}{dt} = ma$	F_{net} is the resultant force (N) p is the linear momentum (kg m s^{-1}) t is the time taken for the object to change momentum (s) m is the mass of the object (kg) a is the acceleration of the object (m s^{-2})
Newton's 2nd Law involving Flowing Mass	$F_{net} = \frac{m}{t}\Delta v$	F_{net} is the resultant force (N) m is the mass of the object (kg) t is the time taken for the amount of mass to flow out (s) v is the velocity (m s^{-1})
Impulse	$\Delta p = \int F\, dt$	F_{net} is the resultant force (N) p is the linear momentum (kg m s^{-1}) t is the time taken for the object to change momentum (s)

Principle of Conservation of Linear Momentum	$m_1u_1 + m_2u_2 = m_1v_1 + m_2v_2$	m_1 and m_2 are the masses of the 2 colliding objects u_1 and u_2 are the velocities of the objects before collision v_1 and v_2 are the velocities of the objects after collision
Principle of Conservation of Kinetic Energy	$\frac{1}{2}m_1{u_1}^2 + \frac{1}{2}m_2{u_2}^2 = \frac{1}{2}m_1{v_1}^2 + \frac{1}{2}m_2{v_2}^2$	m_1 and m_2 are the masses of the 2 colliding objects u_1 and u_2 are the velocities of the objects before collision v_1 and v_2 are the velocities of the objects after collision
Speed of approach vs speed of separation	$u_1 - u_2 = v_2 - v_1$	u_1 and u_2 are the velocities of the objects before collision v_1 and v_2 are the velocities of the objects after collision

Topic 4: Forces

Hooke's Law	$F = kx$	F is the force applied (N) k is the elastic spring constant (N m^{-1}) x is the change in length (m)
Pressure	$p = \frac{F}{A}$	p is the pressure (N m^{-2}) F is the force (N) A is the area (m^2)
	$p = h\rho g$	p is the pressure (N m^{-2}) h is the height of the liquid (m) ρ is the density of the liquid (kg m^{-3}) g is the acceleration due to gravity (N kg^{-1})
Upthrust	$U = \rho V g = mg$	U is the upthrust exerted by fluid on an object (N) ρ is the density of the fluid (kg m^{-3}) V is the volume of the fluid (m^3) g is the acceleration due to gravity (N kg^{-1}) m is the mass of the fluid (kg)
	$U = F_{bottom} - F_{top}$	U is the upthrust exerted by fluid on an object (N) F is the force by fluid on object (N)
Moment of a Force	$M = Fs$	M is the moment of a force (Nm) F is the force causing a moment (N) s is the perpendicular distance to the pivot (m)
Torque of a couple	$T = Fd_{\perp}$	T is the torque (Nm) F are the forces in a couple. d is the perpendicular distance between the forces.

Topic 5: Work, Energy and Power

Work done	$W = Fs\cos\theta$	W is the work done (J) F is the force (N) s is the displacement in the direction of the force (m) θ is the angle between the 2 forces (°)
Work done by a varying force	$W = \int F\,ds$	W is the work done (J) F is the force (N) s is the displacement in the direction of the force (m)
Work done by an expanding gas	$W = p\Delta V$	W is the work done to push out the gas (J) p is the external pressure (N m^{-2}) V is the difference in volume (m^3)
Translational kinetic energy	$E_k = \frac{1}{2}mv^2$	E_k is the kinetic energy of the body (J) m is the mass of the body (kg) v is the translational velocity of the body (m s^{-2})

Gravitational potential energy near the Earth's surface	$\Delta E_{GP} = mg\Delta h$	E_{GP} is the gravitational potential energy change in a body (J) m is the mass of the body (kg) g is the acceleration due to gravity (m s^{-2}) h is the change in the height of a body
Elastic potential energy	$E_{EP} = \frac{1}{2}kx^2$	E_{EP} is the elastic potential energy (J) k is the elastic spring constant (N m^{-1}) x is the change in length (m)
Power	$P = \frac{W}{t}$	P is the power of the force (W) W is the work done by the force (J) t is the time taken (t)
Instantaneous power	$P = \boldsymbol{f} \cdot \boldsymbol{v} = \lvert\boldsymbol{f}\rvert\lvert\boldsymbol{v}\rvert \cos\theta$	P is the power of the force (W) f is the force (N) v is the velocity of the body (m s^{-1})
Efficiency	$Efficiency = \frac{useful\ work\ done}{energy\ input} \times 100\% = \frac{useful\ power\ output}{power\ input} \times 100\%$	

Topic 6: Circular Motion

Angular Displacement		$\theta = \frac{s}{r}$	θ is the angular displacement (rad) s is the arc length (m) r is the radius (m)
Angular velocity		$\omega = \frac{d\theta}{dt}$	ω is the angular velocity (rad s^{-1}) θ is the angular displacement (rad) t is the time taken for the angular displacement to be swept out.
Uniform circular motion		$\omega = \frac{2\pi}{T} = 2\pi f$	ω is the angular velocity (rad s^{-1}) T is the period (s) f is the frequency (Hz)
Relationship between angular and linear velocity		$v = r\omega$	v is the linear or tangential velocity (m s^{-1}) r is the radius of the circular path (m) ω is the angular velocity (rad s^{-1})
Centripetal acceleration		$a_c = \frac{v^2}{r} = r\omega^2$	a_c is the centripetal acceleration (m s^{-2}) v is the linear or tangential velocity (m s^{-1}) r is the radius of the circular path (m) ω is the angular velocity (rad s^{-1})
Centripetal force		$F_c = \frac{mv^2}{r} = mr\omega^2$	F_c is the centripetal force (N) v is the linear or tangential velocity (m s^{-1}) r is the radius of the circular path (m) ω is the angular velocity (rad s^{-1})
Vertical motion (swung by a string)	In general	$T = \frac{mv^2}{r} + mg\ \cos\theta$	T is the tension in the string (N) m is the mass of the object (kg) v is the velocity of the object (m s^{-1}) g is the acceleration due to gravity (m s^{-2}) r is the radius of the circular path (m) θ is the angular displacement from bottom (rad)
	At the bottom	$T = \frac{mv^2}{r} + mg$	
	At the top	$T = \frac{mv^2}{r} - mg$	

Topic 7: Gravitational Field

Newton's Law of Gravitation	$F = \frac{Gm_1m_2}{r^2}$	F is the gravitational force (N) G is the gravitational constant (N m^2 kg^{-2}) m_1 and m_2 are the respective masses (kg) r is the distance between the masses (m)

Gravitational Field Strength	$g = \frac{GM}{r^2}$	g is the gravitational field strength (m s^{-2} or N kg^{-1}) G is the gravitational constant (N m^2 kg^{-2}) M is the mass of the object providing the gravitational field. (kg) r is the distance between the centre of mass of the mass providing the gravitational field and the point. (m)
	$g = -\frac{d\phi}{dr}$	ϕ is the gravitational potential (J kg^{-1}) g is the gravitational field strength (m s^{-2} or N kg^{-1}) r is the distance between the centre of mass of the mass providing the gravitational field and the point. (m)
Gravitational potential	$\phi = -\frac{GM}{r}$	ϕ is the gravitational potential (J kg^{-1}) G is the gravitational constant (N m^2 kg^{-2}) M is the mass of the object providing the gravitational field. (kg) r is the distance between the centre of mass of the mass providing the gravitational field and the point. (m)
Gravitational potential energy from a large distance	$E_{GP} = m\phi = -\frac{GMm}{r}$	ϕ is the gravitational potential (J kg^{-1}) G is the gravitational constant (N m^2 kg^{-2}) M is the mass of the object providing the gravitational field. (kg) m is the mass that is placed inside the gravitational field. r is the distance between the centre of mass of the mass providing the gravitational field and the point. (m)
Escape velocity	$v_{esc} = \sqrt{\frac{2GM}{R}}$	V_{esc} is the velocity needed to escape the influence of the gravitational field. (m s^{-2}) G is the gravitational constant (N m^2 kg^{-2}) M is the mass of the object providing the gravitational field. (kg) R is the radius of the object providing the gravitational field (m).

Topic 8: Temperature and Ideal Gases

Empirical Centigrade Scale	$T_{unknown} = \frac{X_{unknown} - X_0}{X_{100} - X_0} \times 100°C$	$T_{unknown}$ is the unknown temperature (°C) $X_{unknown}$ is the length of the thermometric property at the unknown temperature (m) X_0 is the length of the thermometric property at ice point (m) X_{100} is the length of the thermometric property at steam point (m)
Kelvin to Celsius	$T/K = T/°C + 273.15$	T/K is the temperature in Kelvin (K) T/°C is the temperature in Celsius (°C)
Gas Law	$pV = nRT$ $pV = NkT$	p is the pressure of the gas (Pa or N m^{-2}) V is the volume of the gas (m^3) T is the thermodynamic temperature (K) n is the amount of gas (mol) R is the molar gas constant (J mol^{-1} K^{-1}) N is the number of gas particles k is the Boltzmann's Constant (J K^{-1})
Gas collisions against a container	$pV = \frac{1}{3}Nm\langle c^2\rangle$	p is the pressure of the gas (Pa or N m^{-2}) V is the volume of the gas (m^3) N is the number of gas molecules m is the mass of the gas molecules (kg)
	$p = \frac{1}{3}\rho\langle c^2\rangle$	ρ is the density of the gas molecules (kg m^{-3}) <c^2> is the mean square speed of the gas molecules (m^2 s^{-2})
Temperature and Kinetic Energy of gas particles	$\langle E_K\rangle = \frac{1}{2}m\langle c^2\rangle$	<E_K> is the mean translational kinetic energy (J) m is the mass of the gas molecules (kg)

	$$\langle E_K \rangle = \frac{3}{2}kT$$	<c^2> is the mean square speed of the gas molecules (m^2 s^{-2}) k is the Boltzmann's Constant (J K^{-1}) T is the thermodynamic temperature (K)
Root-Mean-Square Speed	$$c_{rms} = \sqrt{\langle c^2 \rangle} = \sqrt{\frac{3kT}{m}} = \sqrt{\frac{3RT}{M_r}}$$	c_{rms} is the root-mean-square speed (m s^{-1}) <c^2> is the mean square speed of the gas molecules (m^2 s^{-2}) k is the Boltzmann's Constant (J K^{-1}) T is the thermodynamic temperature (K) m is the mass of the gas molecules (kg) R is the molar gas constant (J mol^{-1} K^{-1}) M_r is the molar mass (kg mol^{-1})

Topic 9: First Law of Thermodynamics

Specific Heat Capacity	$$Q = mc\Delta T$$ $$c = \frac{Q}{m\Delta T}$$	Q is the quantity of thermal energy (J) m is the mass of the substance (kg) ΔT is the change in temperature (K) c is the specific heat capacity (J kg^{-1} K^{-1})
Specific latent heat	$$Q = mL$$ $$L = \frac{Q}{m}$$	L is the specific latent heat (J kg^{-1}) Q is the quantity of thermal energy (J) m is the mass of the substance (kg)
Internal energy of an internal gas	$$U = \sum E_K + \sum E_P$$ $$U_{ideal\ gas} = \sum E_K = N\langle E_K \rangle = \frac{3}{2}NkT = \frac{3}{2}nRT = \frac{3}{2}pV$$	U is the internal energy (J) E_K is the translational kinetic energy of the molecules (J) E_P is the potential energy of the molecules (J) p is the pressure of the gas (Pa or N m^{-2}) V is the volume of the gas (m^3) T is the thermodynamic temperature (K) n is the amount of gas (mol) R is the molar gas constant (J mol^{-1} K^{-1}) N is the number of gas molecules k is the Boltzmann's Constant (J K^{-1})
First Law of Thermodynamics	$$\Delta U_{increase} = Q_{to} + W_{on}$$	ΔU is the increase in internal energy (J) Q_{to} is the heat supplied to the system (J) W_{on} is the work done on system (J)
Work done **on** gas	$$W = -p_{ext}\Delta V = -p_{ext}\left(V_{final} - V_{initial}\right)$$ $$W_{by\ gas} = -W_{on\ gas}$$	W is the work done on gas (J) p_{ext} is the external pressure (N m^{-2}) ΔV is the change in volume (m^3)

Topic 10: Oscillations

Frequency	$$f = \frac{1}{T}$$	f is the frequency of the wave (Hz) T is the period (s)
Angular frequency	$$\omega = \frac{2\pi}{T} = 2\pi f$$	ω is the angular frequency (rad s^{-1}) T is the period (s) f is the frequency (Hz)
Simple Harmonic Motion	$$a = -\omega^2 x$$	a is the acceleration (m s^{-2}) ω is the angular frequency (rad s^{-1}) x is the displacement from equilibrium (m)

Angular frequency of a spring-mass system	$\omega = \sqrt{\frac{k}{m}}$	ω is the angular frequency (rad s^{-1}) k is the elastic spring constant (N m^{-1}) m is the mass (kg)
Natural frequency of a spring-mass system	$f = \frac{1}{2\pi}\sqrt{\frac{k}{m}}$	f is the natural frequency (Hz) k is the elastic spring constant (N m^{-1}) m is the mass (kg)
Period of a spring-mass system	$T = 2\pi\sqrt{\frac{m}{k}}$	T is the period (s) k is the elastic spring constant (N m^{-1}) m is the mass (kg)
Angular frequency of a pendulum	$\omega = \sqrt{\frac{g}{L}}$	ω is the angular frequency (rad s^{-1}) g is the acceleration due to gravity (m s^{-2}) L is the length of the string (m)
Natural frequency of a pendulum	$f = \frac{1}{2\pi}\sqrt{\frac{g}{L}}$	f is the natural frequency (Hz) g is the acceleration due to gravity (m s^{-2}) L is the length of the string (m)
Period of a pendulum	$T = 2\pi\sqrt{\frac{L}{g}}$	T is the period (s) g is the acceleration due to gravity (m s^{-2}) L is the length of the string (m)
Phase Angle	$\theta = \omega t$	θ is the phase angle (rad) ω is the angular frequency (rad s^{-1}) t is the time (s)
Displacement (if starting from equilibrium)	$x = x_0 \sin \omega t$	x is the displacement (m) x_0 is the amplitude (m) ω is the angular frequency (rad s^{-1}) t is the time (s)
Displacement (if starting from amplitude)	$x = x_0 \cos \omega t$	
Velocity (if starting from equilibrium)	$v = \omega x_0 \cos \omega t$	v is the velocity (m s^{-1}) x_0 is the amplitude (m) ω is the angular frequency (rad s^{-1}) t is the time (s)
Velocity (if starting from amplitude)	$v = -\omega x_0 \sin \omega t$	
Acceleration (if starting from equilibrium)	$a = -\omega^2 x_0 \sin \omega t$	a is the acceleration (m s^{-2}) x_0 is the amplitude (m) ω is the angular frequency (rad s^{-1}) t is the time (s)
Acceleration (if starting from amplitude)	$a = -\omega^2 x_0 \cos \omega t$	
Velocity (with respect to displacement)	$v = \pm\omega\sqrt{x_0^2 - x^2}$	v is the velocity (m s^{-1}) x_0 is the amplitude (m) x is the displacement (m) ω is the angular frequency (rad s^{-1})
Total energy (free oscillation)	$E_{total} = \frac{1}{2} m\omega^2 x_0^2$	E_{total} is the total energy (J) m is the mass of the oscillator (kg). x_0 is the amplitude (m) ω is the angular frequency (rad s^{-1})
Kinetic energy (free oscillation)	$E_K = \frac{1}{2} m\omega^2 (x_0^2 - x^2)$	E_K is the kinetic energy (J) m is the mass of the oscillator (kg) x_0 is the amplitude (m) x is the displacement (m) ω is the angular frequency (rad s^{-1})
Potential energy (free oscillation)	$E_P = \frac{1}{2} m\omega^2 x^2$	E_P is the potential energy (J) m is the mass of the oscillator (kg). x is the displacement (m) ω is the angular frequency (rad s^{-1})

Topic 11: Waves

Frequency	$f = \frac{1}{T}$	f is the frequency of the wave (Hz) T is the period (s)

Speed of a progressive wave	$v = f\lambda$	v is the speed of wave (m s^{-1}) f if the frequency of wave (Hz) λ is the wavelength of wave (m)
Phase difference	$\Delta\phi = \frac{(2\pi)\Delta t}{T} = \frac{(2\pi)\Delta s}{\lambda}$	Δϕ is the phase difference (rad or °) Δt is the duration of time it takes for a 2nd oscillation to reach the same phase as the first (s) T is the period of the wave (s) Δs is the difference in distance when comparing between particles that are in the same phase. (m) λ is the wavelength of wave (m)
Intensity	$I = \frac{P}{A}$	I is the intensity (W m^{-2}) P is the power of the energy flow (W) A is the area that is normal to the wave propagation (m^2)
Intensity and amplitude	$I \propto x_0^2$	I is the intensity (W m^{-2}) x_0 is the amplitude (m)
Intensity (spherical wavefronts)	$I \propto \frac{1}{r^2}$	I is the intensity (W m^{-2}) r is the radius of the imaginary sphere (m)
Intensity (circular wavefronts)	$I \propto \frac{1}{r}$	I is the intensity (W m^{-2}) r is the radius of the imaginary circumference (m)
Malus' Law	$I = I_0 \cos^2\theta$	I is the intensity of light after passing the polariser (W m^{-2}) I_0 is the intensity of incident polarised light before the polariser (W m^{-2}) θ is the relative angle between the polarisation of the incident light and that of the polariser (°)

Topic 12: Superposition

Single slit diffraction	$\sin\theta = \frac{\lambda}{b}$	θ is the angle between the first minima and the line of the most intensity (°) λ is the wavelength of light (m) b is the slit width (m)
Rayleigh Criterion	$\theta \approx \frac{\lambda}{b}$	θ is the angular separation between the 2 objects, using small angle approximation (°) λ is the wavelength of light (m) b is the slit width (m)
Double slit interference	$x = \frac{\lambda D}{a}$	x is the fringe separation (m) a is the slit separation (m) D is the distance between the double slit and the screen (m) λ is the wavelength of light (m)
Diffraction grating	$d\sin\theta = n\lambda$	D is the separation between adjacent slits (m) N is the order of diffraction (no units) θ is the angle between the nth order beam and the normal to the grating (°) λ is the wavelength of the incident beam (m)

Topic 13: Electric Field

Electric field strength of a point charge	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$	E is the electric field strength (N C^{-1}) ε_0 is the permittivity of free space (F m^{-1}) * Q is the charge of the point charge (C) r is the distance from the point to the point charge (m) *F: Farad. F = Q/V where Q is charge (C) and V is volt (V). ε_0 is about 8.85 x10^{-12} F m^{-1}.
Electric field strength of a uniform electric field between charged parallel plates	$E = \frac{\Delta V}{d}$	E is the electric field strength (V m^{-1}) ΔV is the potential difference between the charged plates (V) d is the distance between the two plates (m)

Electric Force	$F_E = qE$	F_E is the electric force (N) q is the electric charge (C) E is the electric field strength at a point (N C^{-1})
Coulomb's Law	$F = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r^2}$	F is the electric force between the two charges (N) Q_1 and Q_2 are the charges of the two point charges (C) ε_0 is the permittivity of free space (F m^{-1}) r is the distance of separation (m)
Electric Potential	$V = \frac{Q}{4\pi\varepsilon_0 r}$	V is the electric potential (J C^{-1} or V) Q is the charge of the point charge (C) ε_0 is the permittivity of free space (F m^{-1}) r is the distance of separation (m)
Electric potential energy of a charge	$U = QV$ $\Delta U = Q(V_{final} - V_{initial})$	U is the electric potential energy (J) Q is the charge of the point charge (C) V is the electric potential (J C^{-1} or V)
Electric potential energy of a system of 2 point charges	$U = \frac{Q_1 Q_2}{4\pi\varepsilon_0 r}$	U is the electric potential energy (J C^{-1} or V) Q_1 and Q_2 are the charges of the two point charges (C) ε_0 is the permittivity of free space (F m^{-1}) r is the distance of separation (m)
Electric potential of a system of multiple point charges	$V_{total} = \left(\frac{1}{4\pi\varepsilon_0}\right)\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3}\right)$	V_{total} is the total electric potential (J C^{-1} or V) Q_1, Q_2, Q_3… are the respective charges of the point charges (C) ε_0 is the permittivity of free space (F m^{-1}) r_1, r_2, r_3 are the respective distances of separation (m)
Electric potential energy of a system of multiple point charges	$U = qV_{total} = q\left(\frac{1}{4\pi\varepsilon_0}\right)\left(\frac{Q_1}{r_1} + \frac{Q_2}{r_2} + \frac{Q_3}{r_3}\right)$	V_{total} is the total electric potential (J C^{-1} or V) Q_1, Q_2, Q_3… are the respective charges of the point charges (C) ε_0 is the permittivity of free space (F m^{-1}) r_1, r_2, r_3 are the respective distances of separation (m)
Electric field strength and electric potential	$E = -\frac{dV}{dr}$	E is the electric field strength (V m^{-1}) V is the electric potential (V) r is the distance of separation (m)
Electric force and electric potential energy	$F = -\frac{dU}{dr}$	F is the electric force experienced by a charged particle (N) U is the electric potential energy of a charge (J) r is the distance of separation (m)

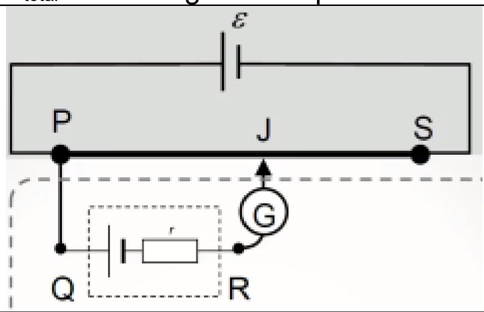
Topic 14: Current of Electricity

Electric current	$I = \frac{dQ}{dt}$	I is the current (A) Q is the charge in a circuit (C) t is the time (s)
Constant electric current	$I = \frac{Q}{t}$	I is the current (A) Q is the charge in a circuit (C) t is the time (s)
Total charge going through a point in the circuit	$Q = \int I\, dt$	I is the current (A) Q is the charge in a circuit (C) t is the time (s)
Drift velocity	$I = nAvq$	I is the current (A) n is the number density of charge carriers (m^{-3}) A is the cross-sectional area (m^2) v is the drift velocity (m s^{-1}) q is the charge (C)
Potential difference	$V = \frac{W}{Q}$	V is the potential difference (V) W is the work done (J) Q is the charge (C)

Power	$$P = IV = I^2R = \frac{V^2}{R}$$	P is the power (W) I is the current (A) V is the potential difference / e.m.f. (V) R is the resistance (Ω)
Resistance	$$R = \frac{V}{I}$$	I is the current (A) V is the potential difference (V) R is the resistance (Ω)
Resistivity	$$R = \frac{\rho L}{A}$$	R is the resistance (Ω) ρ is the resistivity (Ω m) L is the length (m) A is the cross-sectional area (m^2)
Terminal Resistance	$$V_T = \varepsilon - Ir$$	V_T is the terminal potential difference (V) ε is the electromotive force (V) I is the current (A) r is the internal resistance (Ω)
Efficiency	$$Efficiency = \frac{P_{load}}{P_{source}} = \frac{I^2R_{load}}{I^2R_{total}} = \frac{R_{load}}{R_{load} + r}$$	P_{load} is the power dissipated by a load (W) P_{source} is the power produced by a source (W) I is the current (A) R_{load} is the resistance of the load (Ω) R_{total} is the total resistance (Ω) r is the internal resistance (Ω) A load is a device that converts electrical energy into other forms of energy e.g. resistors, bulbs, speakers. Maximum power transfer is when efficiency is 50%.

Topic 15: DC Circuits

Circuits in series	$$I = I_1 = I_2 = I_3 = \cdots$$ $$V = V_1 + V_2 + V_3 + \cdots$$ $$R = R_1 + R_2 + R_3 + \cdots$$	I is the current (A) V is the potential difference / e.m.f. (V) R is the resistance (Ω)
Circuits in parallel	$$I = I_1 + I_2 + I_3 + \cdots$$ $$V = V_1 = V_2 = V_3 = \cdots$$ $$R = \left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \cdots\right)^{-1}$$	I is the current (A) V is the potential difference / e.m.f. (V) R is the resistance (Ω)
2 resistors in parallel	$$R_{eff} = \frac{R_1R_2}{R_1 + R_2}$$	R_{eff} is the effective resistance (Ω) R_1 and R_2 are the resistance of the resistors in parallel (Ω)
Identical resistors	$$R_{eff} = \frac{R}{N}$$	R_{eff} is the effective resistance (Ω) R is the resistance of the identical resistors (Ω) N is the number of identical resistors.
Junction Law	$$I_1 + I_2 = I_3 + I_4$$	I_1 and I_2 are the currents flowing into a junction. I_3 and I_4 are the currents flowing out of a junction.

Potential divider rule	$$\frac{V}{V_{total}} = \frac{R}{R_{total}}$$	V is the potential difference of a component (V) V_{total} is the total potential difference across components (C) R is the resistance of the component (Ω) R_{total} is the total resistance across all components (Ω)
Potentiometer	$$\frac{V_{tapped}}{V_{total}} = \frac{R_{tapped}}{R_{total}} = \frac{L_{tapped}}{L_{total}}$$	V_{tapped} is the potential difference of the length tapped by the jockey (V) V_{total} is the potential difference of the potentiometer (V) R_{tapped} is the resistance of the length tapped by the jockey (Ω) R_{total} is the resistance across the potentiometer (Ω) L_{tapped} is the length tapped by the jockey (m) L_{total} is the length of the potentiometer (m)
Balanced length	At the balanced length: $$V_{PJ} = V_{QR}$$ $$0 = I_{PQ} = I_{RJ}$$	 V is the voltage (V) I is the current (A)

Topic 16: Electromagnetism

Magnetic flux density **(current in long straight wire)**	$$B = \frac{\mu_0 I}{2\pi d}$$	B is the magnetic flux density (T) μ_0 is the permeability of free space ($H\ m^{-1}$) * I is the current in the wire (A) d is the distance from the wire (m) T: Tesla. 1 T = 1 kg s^{-2} A^{-1} H: Henry. H = Vt / I where V is the potential difference, t is the time and I is the current. μ_0 is about $4\pi \times 10^{-7}$ $H\ m^{-1}$ or 1.2566×10^{-6} $H\ m^{-1}$
Magnetic flux density **(Flat circular coil)**	$$B = \frac{\mu_0 N I}{2r}$$	B is the magnetic flux density (T) μ_0 is the permeability of free space ($H\ m^{-1}$) N is the number of turns I is the current in the conductor (A) R is the radius of the coil (m)
Magnetic flux density **(Long solenoid)**	$$B = \mu_0 n I$$	B is the magnetic flux density (T) μ_0 is the permeability of free space ($H\ m^{-1}$) n is the number of turns per unit length (m^{-1}) I is the current in the conductor (A)
Magnetic force **(straight current-carrying conductor)**	$$F = BIL\sin\theta$$	F is the magnetic force (N) B is the magnetic flux density (T) I is the current flowing through the conductor (A) L is the length of the current-carrying conductor in the magnetic field (m) θ is the angle between the magnetic flux density and the current (°)
Magnetic force **(moving charged particle in magnetic field)**	$$F = BQv\sin\theta$$	F is the magnetic force (N) B is the magnetic flux density (T) Q is the charge of the moving charged particle (C) v is the speed of the moving charged particle ($m\ s^{-1}$) θ is the angle between the magnetic flux density and the current (°)
Magnetic flux density **(current in long straight wire normal to the magnetic field)**	$$B = \frac{F}{IL\sin 90°}$$	F is the magnetic force (N) B is the magnetic flux density (T) I is the current flowing through the conductor (A) L is the length of the current-carrying conductor in the magnetic field (m)

Topic 17: Electromagnetic Induction

Induced e.m.f. of a straight conductor when **magnetic force and electric force are balanced**	$\varepsilon_{induced} = BLv$	$\varepsilon_{induced}$ is the induced electromotive force (V) B is the magnetic flux density (T) L is the length of the conductor (m) v is the speed of the conductor (m s^{-1})
Magnetic Flux	$\Phi = B_{\perp}A = BA\cos\theta$	Φ is the magnetic flux (Wb) B is the magnetic flux density (T) A is the area (m^2) θ is the angle between the magnetic flux density and the **normal** of the area (°)
Magnetic Flux Linkage	$N\Phi = N(B_{\perp}A)$ $= NBA\cos\theta$	N is the number of turns Φ is the magnetic flux (Wb) B is the magnetic flux density (T) A is the area (m^2) θ is the angle between the magnetic flux density and the **normal** of the area (°)
Faraday's Law	$\varepsilon_{induced} = -\frac{d(N\Phi)}{dt}$ $= -\frac{d}{dt}(NBA\cos\theta)$	$\varepsilon_{induced}$ is the induced electromotive force (V) NΦ is the magnetic flux linkage (Wb) t is the time (s) N is the number of turns B is the magnetic flux density (T) A is the area (m^2) θ is the angle between the magnetic flux density and the **normal** of the area (°)

Topic 18: Alternating Current

Alternating Current	$x = x_0 \sin\omega t$	x is the current/potential difference (A or V) x_0 is the peak value (A or V) ω is the angular frequency (rad s^{-1}) t is the time (s)
Root-Mean-Square Value (for **sinusoidal** and **cosinusoidal** a.c.)	$I_{rms} = \frac{I_0}{\sqrt{2}}$	I_{rms} is the r.m.s. current (A) I_0 is the peak current (A)
	$V_{rms} = \frac{V_0}{\sqrt{2}}$	V_{rms} is the r.m.s. voltage (V) V_0 is the peak voltage (V)
	$P_{mean} = \frac{1}{2}P_{max}$	P_{mean} is the mean power (W) P_{max} is the maximum power (W)
	$P_{mean} = I_{rms}V_{rms} = \frac{{V_{rms}}^2}{R} = {I_{rms}}^2 R$	P_{mean} is the mean power (W) I_{rms} is the r.m.s. current (A) V_{rms} is the r.m.s. voltage (V) R is the resistance (Ω)
	$R = \frac{V_{rms}}{I_{rms}}$	R is the resistance (Ω) V_{rms} is the r.m.s. voltage (V) I_{rms} is the r.m.s. current (A)
Root-Mean-Square Value (for **half-waved rectified**	$I_{rms} = \frac{I_0}{2}$	I_{rms} is the r.m.s. current (A) I_0 is the peak current (A)
	$V_{rms} = \frac{V_0}{2}$	V_{rms} is the r.m.s. voltage (V) V_0 is the peak voltage (V)

sinusoidal and **cosinusoidal** a.c.)	$$P_{mean} = \frac{1}{4}P_{max}$$	P_{mean} is the mean power (W) P_{max} is the maximum power (W)
Transformers	$$\frac{N_S}{N_P} = \frac{V_S}{V_P}$$	P_{input} is the input power (W) P_{output} is the output power (W) N_S is the number of turns in the secondary coil N_P is the number of turns in the primary coil V_S is the voltage in the secondary coil (V) V_P is the voltage in the primary coil (V) I_{pri} is the current in the primary coil (A) I_{sec} is the current in the secondary coil (A)
Ideal transformers	$$P_{input} = P_{output}$$ $$\frac{N_S}{N_P} = \frac{V_S}{V_P} = \frac{I_{pri}}{I_{sec}}$$	

Topic 19: Quantum Physics

Energy of a photon	$$E = hf = \frac{hc}{\lambda}$$ $$E_{total} = nhf = \frac{nhc}{\lambda}$$	E is the energy of **one** photon (J) h is the Planck constant (J s) f is the frequency of the photon (Hz) n is the number of photons c is the speed of the photon (m s^{-1}) λ is the wavelength (m)
Photoelectric equation	$$hf = \Phi + \frac{1}{2}mv_{max}^2$$	h is the Planck constant (J s) f is the frequency of the photon (Hz) Φ is the work function energy of a particular metal (eV) m is the mass of a photoelectron (kg) v_{max} is the maximum speed of a photoelectron (m s^{-1})
Threshold Frequency	$$\Phi = hf_0$$	Φ is the work function energy of a particular metal (eV) h is the Planck constant (J s) f_0 is the threshold frequency of the photon (Hz)
Threshold Wavelength	$$\Phi = \frac{hc}{\lambda_0}$$	Φ is the work function energy of a particular metal (eV) h is the Planck constant (J s) c is the speed of the photon (m s^{-1}) λ_0 is the threshold wavelength (m)
Stopping Potential	$$\frac{1}{2}mv_{max}^2 = eV_s$$ $$V_s = \frac{h}{e}f - \frac{\Phi}{e}$$	m is the mass of a photoelectron (kg) v_{max} is the maximum speed of a photoelectron (m s^{-1}) e is the elementary charge (C) V_s is the stopping potential (V) Φ is the work function energy of a particular metal (eV) h is the Planck constant (J s)
Relationship between intensity and current	$$I_{EMR} = \frac{N\,hf}{t\,A}$$ Thus, $I_{EMR} \propto I_{current}$	I_{EMR} is the intensity of electromagnetic radiation (W m^{-2}) $I_{current}$ is the photoelectric current (A) t is the time (s) A is the area (m^2) N is the number of photons h is the Planck constant (J s) f is the frequency of the photon (Hz)

De-excitation of electrons	$hf = E_{high} - E_{low}$	E is the energy of **one** photon (J) h is the Planck constant (J s) f is the frequency of the photon (Hz)
Excitation of electron in atoms	$hf = E_{final} - E_{initial}$	
de Broglie wavelength	$\lambda = \frac{h}{p}$	λ is the de Broglie wavelength (m) h is the Planck constant (J s) p is the momentum of the particle (kg m s^{-1})
Heisenberg Uncertainty Principle	$\Delta p \Delta x \gtrsim h$	Δp is the uncertainty of the momentum (kg m s^{-1}) Δx is the uncertainty of the measurement of position (m) h is the Planck constant (J s)

Topic 20: Nuclear Physics

Mass-energy equivalence	$E = mc^2$	E is the energy (J) m is the mass (kg) c is the speed of light in a vacuum (m s^{-1})
Mass defect	$\Delta m = [Zm_p + (A - Z)m_n] - m_{nucleus}$	Δm is the mass defect of a nucleus (kg) Z is the proton number m_p is the mass of a proton (kg) A is the nucleon number m_n is the mass of a neutron (kg) $m_{nucleus}$ is the mass of the nucleus (kg)
Nuclear binding energy	$E = (\Delta m)c^2$	E is the nuclear binding energy (J) Δm is the mass defect of a nucleus (kg) c is the speed of light in a vacuum (m s^{-1})
Decay constant	$A = \lambda N = -\frac{dN}{dt}$	A is the activity- number of radioactive decays per unit time (Bq) λ is the decay constant (s^{-1}) N is the number of radioactive nuclei t is the time (s)
Half-life and decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$	λ is the decay constant (s^{-1}) $t_{1/2}$ is the half life of a radioactive nuclide (s)
Radioactive decay	$N = N_0 \cdot e^{-\lambda t}$ $A = A_0 \cdot e^{-\lambda t}$	N is the number of radioactive nuclei N_0 is the initial number of radioactive nuclei λ is the decay constant (s^{-1}) t is the time (s) A is the activity (Bq) A_0 is the initial activity (Bq)