Level 3 International Foundation Diploma for Higher Education Studies
Ofqual Number: 603/0080/2 Quartz ID: 1125 / 1207

Component ID: 2371

Physics for University Study

SAMPLE EXAMINATION

This specimen assessment material is devised from previous past papers to reflect the single examination assessment approach now taken for this unit in the Level 3 International Foundation Diploma for Higher Education Studies.

Time allowed: 2 hours

Instructions:

- Answer **ALL** questions.
- Clearly cross out surplus answers.
- You must show your workings. Marks are awarded for these.
- Please refer to the formula sheet at the end of this examination paper.
- Any reference material brought into the examination room must be handed to the invigilator before the start of the examination.

Information:

- The maximum mark for this paper is 100.
- Graph paper will be provided by the centre.
- **You may use a scientific calculator during this examination.**
- Note: Scientific calculators permitted in the exam should not be able to carry out algebraic manipulation, differentiation or integration, language translation or communication with other devices of the internet. They should not have a QWERTY keyboard. There should not be retrievable information stored in the calculator, for example databanks, dictionaries, mathematical formulas or text.

Answer ALL questions

Marks

Question 1

a) A ball is dropped from a vertical height of 4.8 m above the ground as shown in figure 1. The ball was initially at rest and air resistance can be ignored.

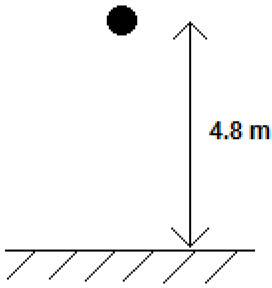

Figure 1

i) Describe the motion of the ball as it falls to the ground. **2**

ii) Calculate the speed of the ball just before it hits the ground. **2**

iii) On your answer paper, sketch a graph of velocity against time from the moment the ball is released until the moment before it hits the ground. Label your axes. **2**

Marks

b) A large rock of mass 240 kg is blown-up using dynamite. The explosion causes the rock to break into TWO (2) fragments, with one fragment having twice the mass of the other. The two fragments move in opposite directions after the explosion with velocities v_1 and v_2 respectively as shown in figure 2.

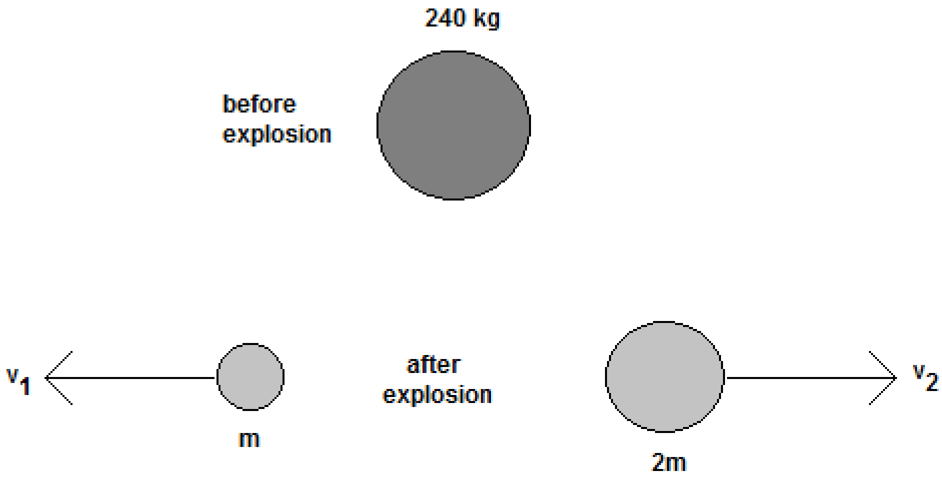

Figure 2

i) Calculate the ratio of the velocities v_1 / v_2. **2**

ii) State whether you expect the explosion to be elastic or inelastic and give a reason for your answer. **2**

Total 10 Marks

Marks

Question 2

a) THREE (3) cells of EMF 1.5 V, 2.2 V and 1.5 V respectively are connected in series with an ammeter and a 2.47 Ω resistor, as shown in figure 3. The cells have internal resistances of 0.88 Ω, 0.95 Ω and 0.88 Ω respectively.

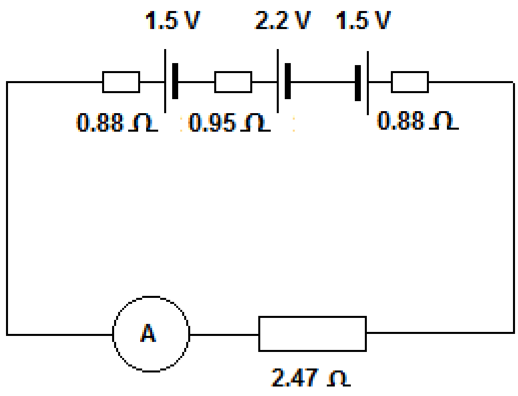

Figure 3

i) Calculate the reading on the ammeter. **2**

ii) Hence calculate the voltage across the cell whose EMF is 2.2 V. **2**

iii) State ONE (1) change that could be made to the circuit in figure 3 so the reading on the ammeter reduces. You must use all of the components shown, and no extra components can be added to the circuit. **1**

Marks

b) A student uses the circuit shown in figure 4 to produce the I - V characteristic graph of a metal conductor. The circuit has a 6.0 V power supply connected in series with a variable resistor and a metal conductor, and there are meters to obtain current and voltage values.

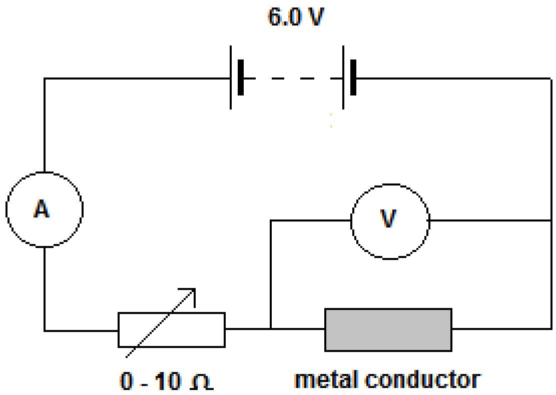

Figure 4

i) Explain how you could use the circuit in figure 4 to obtain sufficient readings to draw an I - V graph for the metal conductor, **and** state ONE (1) method you could use so that the metal conductor does not get hot. **2**

ii) On your answer paper, sketch the **I** - V graph for the metal conductor. Label your axes and ignore the effects of heating. **2**

iii) If the voltmeter reads 3.0 V when the variable resistor is set to 5.0 Ω, state the resistance of the metal conductor. You do not need to do any calculation. **1**

Total 10 Marks

Marks

Question 3

a) A small ball of mass 35 g is dropped into a container of water. The ball is travelling with a vertical velocity of 14 ms^{-1} when it hits the surface of the water and reaches terminal velocity 0.88 s later when at a depth of 18 cm below the surface as shown in figure 5.

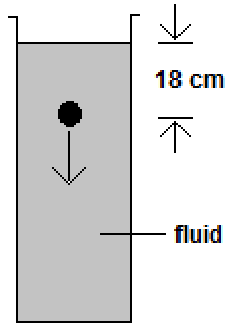

Figure 5

i) Calculate the deceleration of the ball before reaching terminal velocity when moving through the fluid. **2**

ii) State ONE (1) assumption that needs to be made about the motion of the ball in order to carry out the calculation in part i) above. **1**

iii) Calculate the upthrust force acting on the ball when moving through the fluid with terminal velocity. **2**

Marks

b) A vertical stone column in the shape of a cylinder forms part of an ancient building as shown in figure 6. The column has a height of 12 m and diameter of 2.3 m. The stone has a density of 2200 kgm^{-3}.

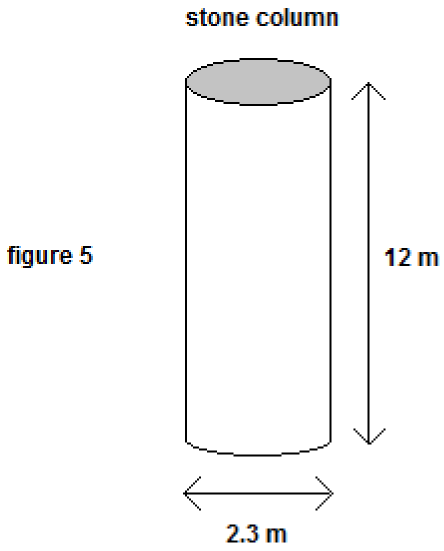

Figure 6

i) Calculate the weight of the stone column. **2**

ii) Calculate the pressure exerted by the stone column on the ground. **1**

iii) If the maximum compressive stress of this stone column is 14 MPa, state whether it will collapse under its own weight. Give a reason for your answer. **2**

Total 10 Marks

Marks

Question 4

a) A student makes a solenoid by winding a coil of copper wire onto a cardboard tube, and a direct current is passed through the solenoid as shown in figure 7.

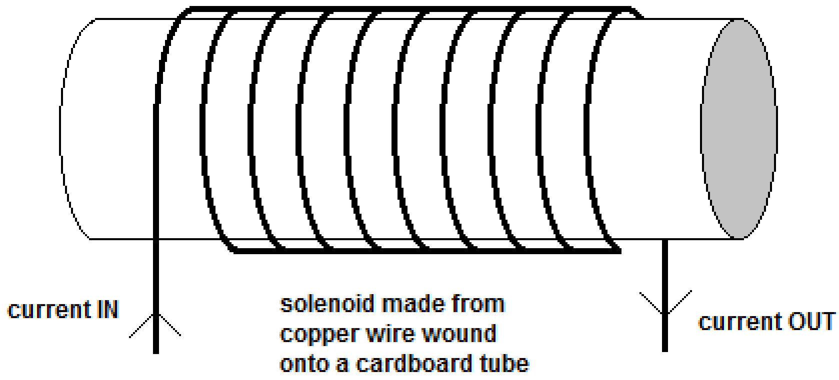

Figure 7

i) On your answer paper, sketch the solenoid and show the shape of the magnetic field pattern inside and at each end of the solenoid. Label each end North (N) and South (S) and use arrows on the magnetic field lines to indicate its direction. **2**

ii) If the magnetic flux density inside the solenoid is 3.7 mT and it has a cross-sectional area of 5.3 cm^2, calculate the magnetic flux passing through the solenoid. **2**

iii) State ONE (1) method the student could use to investigate the shape of the magnetic field inside the solenoid. **1**

Marks

b) A coil of wire with 1400 turns and cross-sectional area 7.1 cm^2 is situated in a uniform magnetic field of flux density 8.5×10^{-4} T as shown in figure 8. The coil is made to rotate at a constant rate of 200 revolutions s^{-1} in the direction shown, so that its axis remains in the plane of the paper.

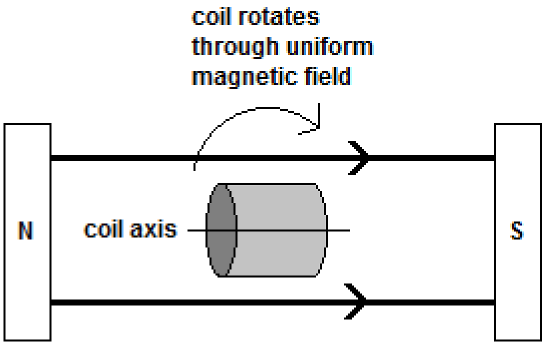

Figure 8

i) Calculate the angular speed of the rotating coil. **2**

ii) Calculate the maximum induced EMF in the coil as it rotates in the uniform magnetic field. **2**

iii) State the effect of Lenz's law as the rate of rotation of the coil is increased. **1**

Total 10 Marks

Marks

Question 5

Gas particles trapped inside a rigid well-insulated container are shown in figure 9. The particles are moving randomly and collide with other particles and the walls of the container.

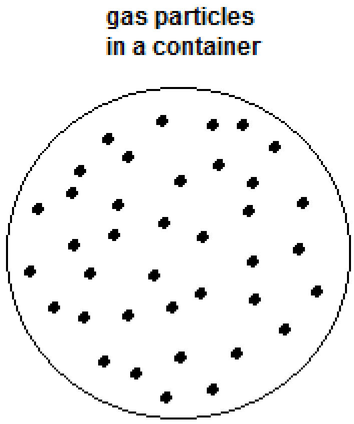

Figure 9

a) Explain what will happen to the energy of the gas particles as the temperature of the gas increases. Give a reason for your answer. **2**

b) Use Newton's second law to explain how the gas particles are able to exert pressure on the walls of the container. **2**

c) If the container has a volume of 0.05 m^3 and contains ONE (1) mole of gas that exerts a pressure of $1.2x10^5$ Pa, calculate the average speed of the gas particles. Assume the molar mass of gas in the container is 0.044 kg. **2**

d) Calculate the temperature of the gas in the container. **2**

e) The temperature of the gas is now slowly decreased until it is just above absolute zero. On your answer paper, sketch a graph of pressure against temperature during this change. **2**

Total 10 Marks

Marks

Question 6

a) A helium nucleus consists of TWO (2) protons and TWO (2) neutrons and has a diameter of approximately 3.02×10^{-15} m.

i) Apart from the electromagnetic force, state the name of ONE (1) other significant force that acts between the protons in the helium nucleus, and state which of these forces must be stronger. **2**

ii) Calculate the density of the helium nucleus. **2**

iii) Calculate the size of the electromagnetic force acting between protons in the helium nucleus. Assume the protons are separated by a distance of approximately 2.0×10^{-15} m. **2**

b) A helium nucleus has a mass of 4.002 atomic mass units (AMUs).

i) Calculate the binding energy per nucleon of the helium nucleus. **3**

ii) Explain why the binding energy per nucleon is an indication of the stability of a nucleus. **1**

Total 10 Marks

Marks

Question 7

a) A uniform wooden swing in a fairground has a mass of 43 kg and is connected by FOUR (4) rigid metal rods of length 8.5 m to a pivot point, as shown in figure 10. The swing is initially stationary and has a horizontal length of 4.7 m.

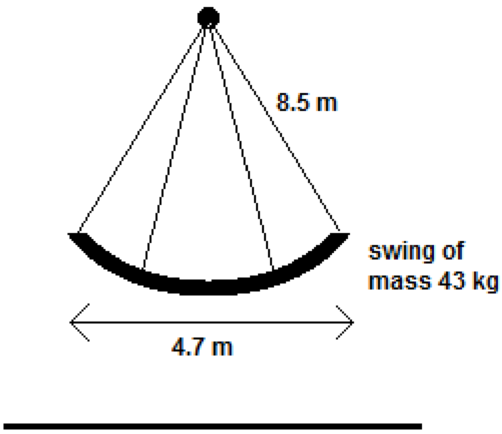

Figure 10

i) Calculate the tension in ONE (1) metal rod, assuming that the tension is equally distributed between the FOUR (4) rods. **2**

ii) If a child of mass 48 kg now sits at the left-hand end of the swing, calculate the moment of the system about the pivot point. Assume the swing is locked in the position shown in figure 10. **1**

iii) The swing is now unlocked so that it is free to move. On your answer paper, sketch a diagram showing the position of the swing relative to the pivot point with the child sitting at the left-hand end, when it is in equilibrium. **2**

b) Several more people now get in the swing so that their total mass is now 263 kg, and the swing is balanced as shown in figure 10. The swing is pulled to one side so that its centre of mass moves through a horizontal distance of 2.6 m and released so that it oscillates with a frequency of 0.03 Hz.

i) Calculate the maximum speed of the swing as it oscillates. **2**

ii) Calculate the maximum centripetal force acting on the swing as it oscillates. **2**

iii) Hence calculate the maximum resultant force acting on the swing. **1**

Total 10 Marks

Marks

Question 8

a) If sodium gas is excited by applying a high voltage across it, light is emitted at specific wavelengths. If this light is passed through a diffraction grating, the emission line spectrum for sodium can be observed. Part of this spectrum is shown in figure 11, where TWO (2) coloured lines can be seen at wavelengths of 589 nm and 590 nm respectively.

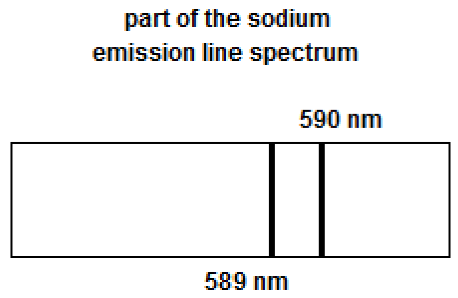

Figure 11

i) Calculate the energy of the photons emitted by the excited sodium gas, that give rise to each emission line in figure 11. **3**

ii) On your answer paper, sketch part of the energy level diagram for sodium showing the transitions that give rise to the light emitted in figure 11. Label each transition with the wavelength of light emitted. **2**

iii) Explain why the sodium emission spectrum provides evidence for discrete energy levels in the sodium atom. **1**

Marks

b) A photon of light falls onto the surface of sodium metal whose work function is 2.28 eV, resulting in the emission of an electron with kinetic energy 3.54 eV.

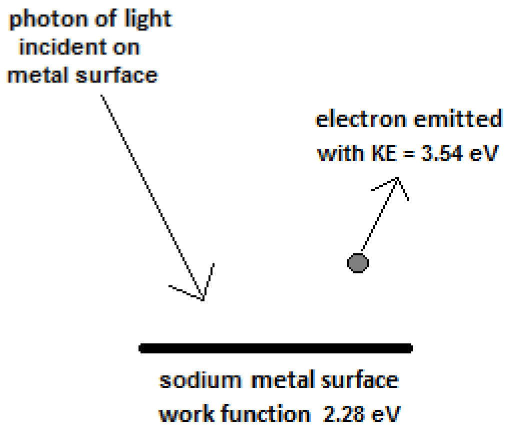

Figure 12

i) Calculate the energy of the photon that causes this electron to be emitted. **1**

ii) Define work function, and state ONE (1) assumption that has been made about the electron's kinetic energy value. **2**

iii) Calculate the threshold frequency of an incident photon so that electron emission will occur. **1**

Total 10 Marks

Marks

Question 9

a) A large rubber ball of mass 12 kg is dropped from a balloon and falls vertically through the air until it reaches terminal velocity of 78 ms^{-1}. There is a horizontal wind blowing with a constant velocity of 43 ms^{-1} as shown in figure 13.

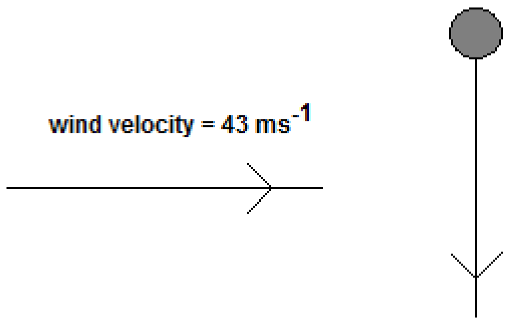

Figure 13

i) Calculate the magnitude and direction of the speed of the ball as it falls through the air at terminal velocity. **3**

ii) On your answer paper, sketch a graph of acceleration against time for the ball from the moment it is dropped from the balloon until just after it reaches terminal velocity. Label your axes. **2**

iii) Calculate the amount of gravitational potential energy lost by the ball from the moment it is dropped from the balloon until it reaches terminal velocity. **2**

b) When the ball hits the ground it deforms for 0.75 s before rebounding but does not break.

i) Calculate the average force acting on the ball while in contact with the ground. **2**

ii) State how the elastic potential energy of the rubber will change during the time when the ball is in contact with the ground. **1**

Total 10 Marks

Marks

Question 10

a) Two waveforms are shown in figure 14. The top waveform has double the frequency of the bottom waveform, and they move in opposite directions along the same line so at one moment in time they coincide with each other so that the top waveform is superimposed on the bottom waveform.

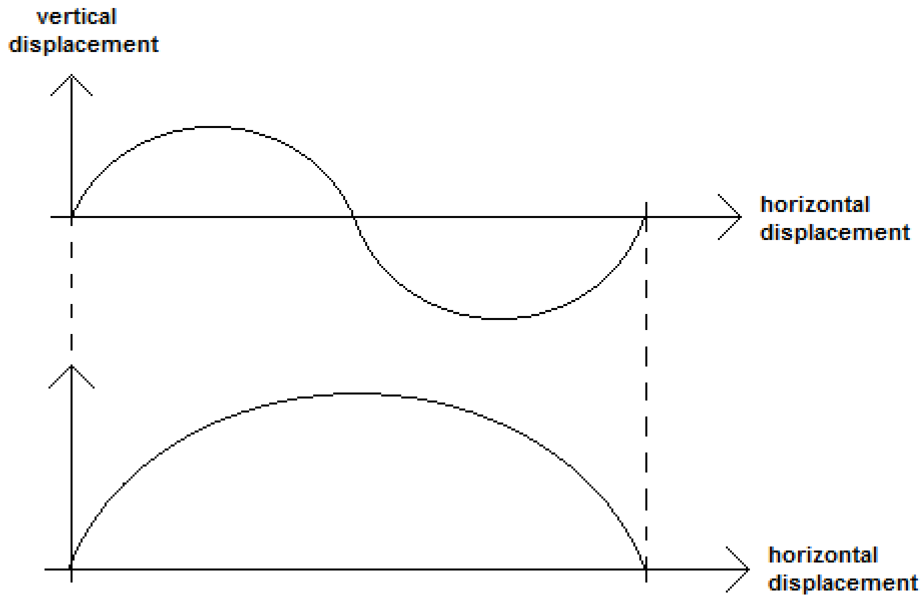

Figure 14

On your answer paper, use the principle of superposition to sketch the resulting waveform when the two waveforms shown in figure 14 coincide. **2**

b) A string is stretched between two points 0.72 m apart, as shown in figure 15. One end of the string vibrates with a frequency of 26 Hz so that a wave travels along the string to the fixed end and reflects back, forming the fundamental (first harmonic) stationary wave.

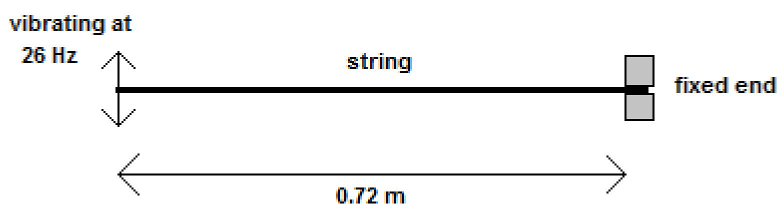

Figure 15

i) Calculate the wavelength of the stationary wave produced on the string. **1**

ii) On your answer paper, sketch the stationary wave that is formed and label the positions of any nodes and antinodes. **2**

Marks

iii) Explain why the principle of superposition cannot be used to explain the formation of the stationary wave on the string. **2**

c) A narrow beam of electrons can be diffracted by passing it through a thin piece of graphite. The electron beam consists of electrons travelling one after the other. The resulting diffraction pattern indicates that electrons are able to interfere with each other in the same way as light passing through a diffraction grating.

i) Describe a property of the electrons in the beam so they can interfere with each other. **1**

ii) If the electrons are travelling at a speed of 1.22×10^6 ms^{-1}, calculate their de Broglie wavelength. **2**

Total 10 Marks

End of paper

Formulae and data sheet

Fundamental constants and values

Quantity	Symbol	Value	Units
Speed of light in a vacuum	c	3.00×10^{8}	ms^{-1}
Permeability of free space	μ_o	$4\pi \times 10^{-7}$	Hm^{-1}
Permittivity of free space	ε_0	8.85×10^{-12}	Fm^{-1}
Magnitude of the charge of electron	e	1.60×10^{-19}	C
The Planck constant	h	6.63×10^{-34}	Js
Gravitational constant	G	6.67×10^{-11}	$Nm^{2}kg^{-2}$
Avogadro constant	N_A	6.02×10^{23}	Mol^{-1}
Molar gas constant	R	8.31	$JK^{-1}mol^{-1}$
The Boltzmann constant	k	1.38×10^{-23}	JK^{-1}
The Stefan constant	σ	5.67×10^{-8}	$Wm^{-2}K^{-4}$
The Wien constant	α	2.90×10^{-3}	mK
Electron rest mass	m_e	9.11×10^{-31}	Kg
Electron charge/mass ration	e / m_e	1.76×10^{11}	Ckg^{-1}
Proton rest mass	m_p	$1.67(3) \times 10^{-27}$	Kg
Proton charge/mass ratio	e/m_p	9.58×10^{7}	Ckg^{-1}
Neutron rest mass	m_n	$1.67(5) \times 10^{-27}$	Kg
Gravitational field strength	g	9.81	Nkg^{-1}
Acceleration due to gravity	g	9.81	ms^{-2}
Atomic mass unit	u	1.661×10^{-27}	Kg

Electricity

Current and pd	$I = \frac{\Delta Q}{\Delta t}$ $V = \frac{W}{Q}$	$R = \frac{V}{I}$
emf	$\varepsilon = \frac{E}{Q}$	$\varepsilon = I(R + r)$
resistors in series	$R = R_1 + R_2 + R_3 + \ldots\ldots\ldots$	
resistors in parallel	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \ldots$	
resistivity	$\rho = \frac{RA}{L}$	
power		$P = VI = I^2R = \frac{V^2}{R}$

Formulae and data sheet – Mechanics and Circular Motion

	Moments	moments = Fd
	Velocity and acceleration	$v = \frac{\Delta s}{\Delta t}$ $\quad a = \frac{\Delta v}{\Delta t}$
	Equation of motion	$v = u + at$ $\quad s = \frac{(u+v)}{2}t$
		$v^2 = u^2 + 2as$ $\quad s = ut + \frac{at^2}{2}$
	Force	$F = ma$
	Work, energy and power	$W = Fs\cos\theta$ $\quad E_k = {}^1/_2\, mv^2$
		$P = \frac{\Delta W}{\Delta t}$, $P = Fv$ $\quad \Delta E_p = mg\Delta h$
		$efficiency = \frac{useful\ output\ power}{input\ power}$
	Momentum	force $F = \frac{\Delta(mv)}{\Delta t}$
		Impulse $\quad F\Delta t = \Delta(mv)$
Circular Motion	angular velocity	$\omega = \frac{v}{r}$ $\quad \omega = 2\pi f$
	Centripetal acceleration	$a = \frac{v^2}{r} = \omega^2 r$
	Centripetal force	$F = \frac{mv^2}{r} = m\omega^2 r$
Materials	Young's modulus	$E = \frac{stress}{strain} = \frac{Fl}{eA}$
	Hooke's law	$F = k\,e$
	Elastic PE	$EPE = {}^1/_2\, k\, e$

Formulae and data sheet - Mechanical Oscillations, Thermal Physics, Gravitation

Oscillations	Acceleration	$a = -(2\pi f)^2 x$
	Displacement	$x = A\cos(2\pi f t)$
	Speed	$v = \pm 2\pi f\sqrt{A^2 - x^2}$
	Maximum speed	$v_{max} = 2\pi f A$
	Maximum acceleration	$a_{max} = (2\pi f)^2 \mathrm{A}$
	For a mass-spring system	$T = 2\pi\sqrt{\frac{m}{k}}$
	For a simple pendulum	$T = 2\pi\sqrt{\frac{l}{g}}$
Thermodynamics	First law of thermodynamics	$Q = \Delta U + W$
		$W = p\Delta V$
Gas laws and thermal physics	Isothermal change	$pV = constant$
	gas law	$pV = nRT \quad pV = NkT$
	Kinetic theory model	$pV = \frac{1}{3}Nm(c_{rms})^2$
	Kinetic energy of gas molecules	$\frac{1}{2}m(c_{rms})^2 = \frac{3}{2}kT = \frac{3RT}{2N_A}$
	Energy to change temperature	$Q = mc\Delta T$
	Energy to change state	$Q = ml$
Liquid pressure	Hydrostatic pressure	$p = \rho g h$

Gravitational Fields	Newton's law of gravitation	$F = G\frac{Mm}{r^2}$
	Gravitational field strength	$g = \frac{GM}{r^2}$
	Gravitational potential	$V = \frac{GM}{r}$
	Orbital period	$T = \frac{orbital\ circumference}{orbital\ speed}$

Formulae and data sheet - Capacitors, Electric and Magnetic Fields

Electric Fields and Capacitors	Force between two points charges	$F = \frac{1}{4\pi\varepsilon_o}\frac{Q_1 Q_2}{r^2}$
	Force on a charge	$F = EQ$
	Field strength for a uniform field	$E = \frac{V}{d}$
	Field strength for a radical field	$E = \frac{Q}{4\pi\varepsilon_0 r^2}$
	Electrical potential	$\Delta W = Q\Delta V$
		$V = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$
	Capacitance	$C = \frac{Q}{V}$
	Decay of charge	$Q = Q_o e^{\frac{-t}{RC}}$ $V = V_o e^{\frac{-t}{RC}}$
	Time constant	RC
	Capacitor energy stored	$E = \frac{1}{2}QV = \frac{1}{2}CV^2 = \frac{1}{2}\frac{Q^2}{C}$
	Capacitors in parallel	$C = C_1 + C_2 + C_3$
	Capacitors in series	$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3}$
Electrons in a field		$F = \frac{eV}{d}$ $F = Bev$ $r = \frac{mv}{Be}$
		$\frac{1}{2}mv^2 = eV$ $\frac{QV}{d} = mg$ $F = 6\pi\eta rv$
Magnetic field	Force on a current	$F = BIl$
	Force on a moving charge	$F = BQv$
	Magnetic flux	$\phi = BA$
	Magnetic flux linkage	$N\phi = BAN$
	Magnitude of induced emf	$\varepsilon = N\frac{\Delta\phi}{\Delta t}$
	Emf induced in a rotating coil	$N\phi = BANcos\theta$ $\varepsilon = BAN\omega \sin \omega t$
	Transformer equation	$\frac{N_s}{N_p} = \frac{V_s}{V_p}$ $efficiency = \frac{I_s V_s}{I_p V_p}$

Waves	Malus' law	$I = I_o \cos^2\Theta$
	Wave equation	$v = f\lambda$
	Young's double slit	$w = \lambda D/s$
	Diffraction grating	$d \sin\theta = n\lambda$
Radioactivity	Radioactive decay	$A = -\lambda N$
	Half-life	$T^1/_2 = ln2/\lambda$
	Activity	$A = A_0 e^{-\lambda t}$

Photon physics	Photon energy	$E = hf$
	Photoelectric effect	$hf = \Phi + E_{k\ max}$
	De Broglie wavelength	$\lambda = \frac{h}{mv}$
	Mass-energy relationship	$E = mc^2$