

WJEC A-LEVEL PHYSICS

PHYSICS



EXAM QUESTION PACK

UNIT PH1 OLD SPECIFICATION PAPERS

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Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A Level

1321/01 – **LEGACY**



PHYSICS – PH1 Motion, Energy and Charge

A.M. TUESDAY, 24 May 2016

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	12	
4.	15	
5.	11	
6.	11	
7.	11	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

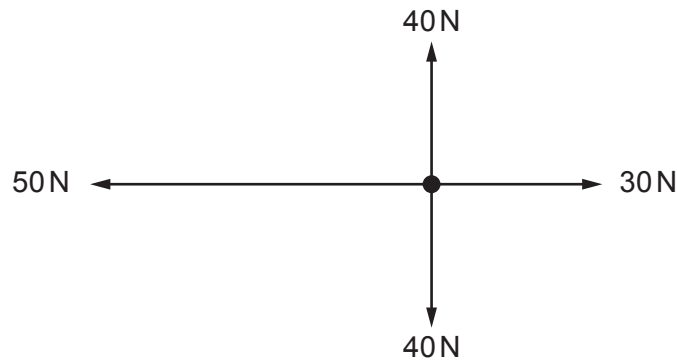
Answer **all** questions.

1. (a) Newton's second law of motion can be expressed by the equation:

$$\Sigma F = ma$$

Showing your reasoning, determine ΣF in the free body diagram below.

[2]

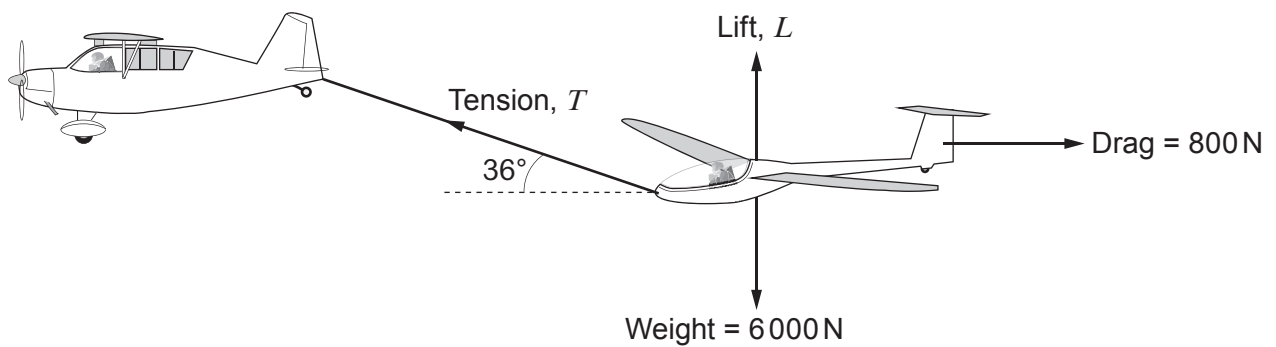


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- (b) A glider is being towed **horizontally** through the air **at constant velocity**. The diagram shows the forces acting on the glider.



- (i) Calculate the tension, T , in the tow line.

[2]

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(ii) Calculate the lift force, L , on the glider.

[3]

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(c) The power used to tow the glider is 40 kW. Determine the horizontal velocity of the towing aircraft.

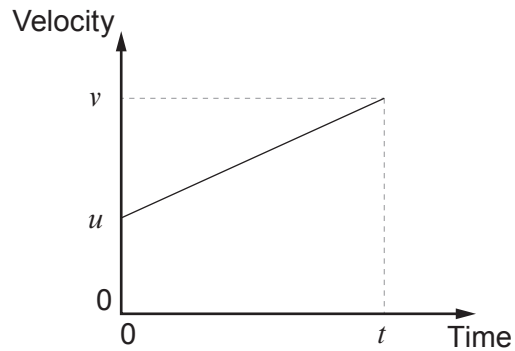
[2]

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2. (a) A velocity-time graph is given for a body which is accelerating.



Using the symbols given on the graph, show that:

$$v = u + at$$

[2]

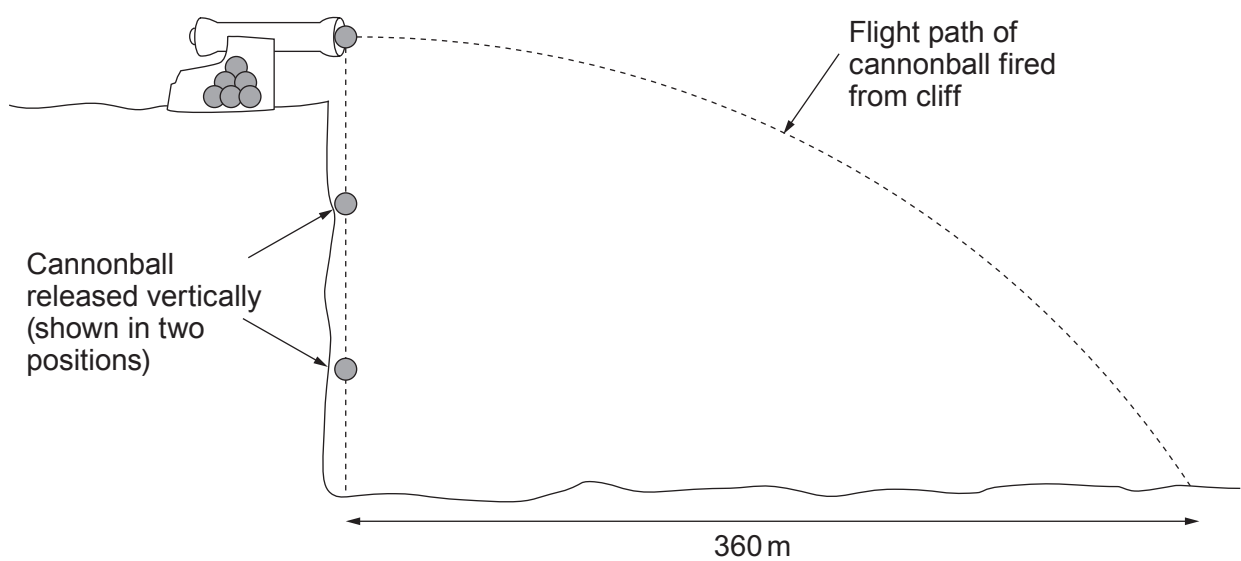
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- (b) The flight path for a cannonball fired horizontally from the top of a cliff is shown. **At the same instant**, a second cannonball is released and falls vertically from the same initial height. The second cannonball is shown at two positions during its descent.



- (i) Draw on the diagram the expected positions of the fired cannonball at the same instants as **each** of the positions indicated by the dropped cannonball. Explain your reasoning. Ignore air resistance. [3]

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- (ii) The cannonball fired from the cannon impacts with the ground 3.20s after being fired.

- I. Calculate the height from which the cannonball was fired. [2]

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- II. Calculate the velocity with which the **fired** cannonball impacts with the ground. [4]

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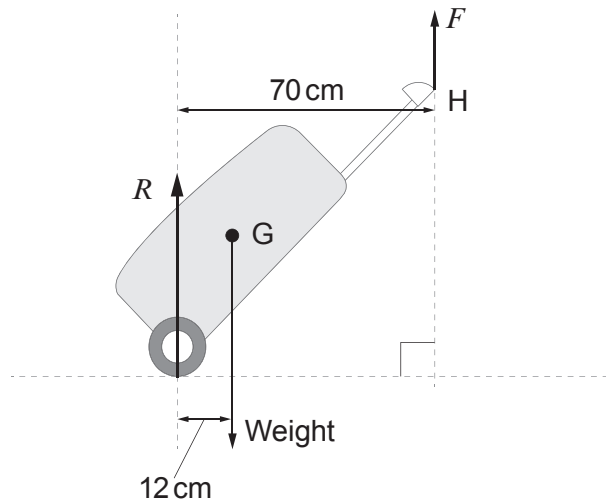
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3. A passenger at an airport pulls a travel case as shown.



- (a) When the passenger is stationary, a free body diagram for the travel case is shown below. It is held at rest by the passenger's hand at H and its centre of gravity is at G. The mass of the case is 8.5 kg.



- (i) Define the *moment of a force*.

[1]

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- (ii) Calculate the size of the upward pull, F , of the hand on the case.

[3]

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- (iii) Calculate the value of R , the force of the ground on the case.

[1]

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- (iv) Explain how repacking the case so as to move the centre of gravity further away from the wheel would affect the size of force F . [2]

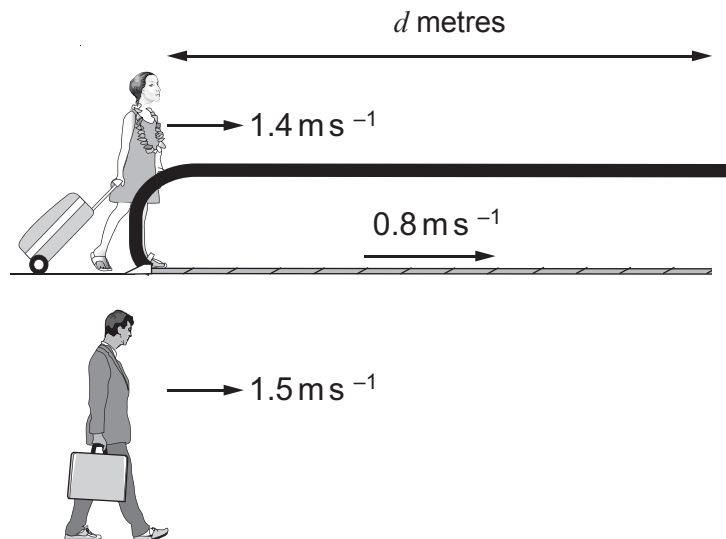
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- (b) The passenger now walks at 1.4 m s^{-1} onto a walkway of length d metres which is itself moving at 0.8 m s^{-1} . At the instant she steps on the walkway, another passenger initially alongside decides not to take the walkway, but instead walks alongside it at a speed of 1.5 m s^{-1} . The passenger on the walkway takes a time, t , to reach the end. The passenger walking alongside takes an **additional 14 seconds** before reaching the end of the walkway.



- (i) Write down an expression for the distance, d , travelled by the passenger on the walkway. [1]

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- (ii) Write down an expression for the distance, d , travelled by the passenger walking alongside the walkway. [1]

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- (iii) Hence, determine the length, d , of the walkway. [3]

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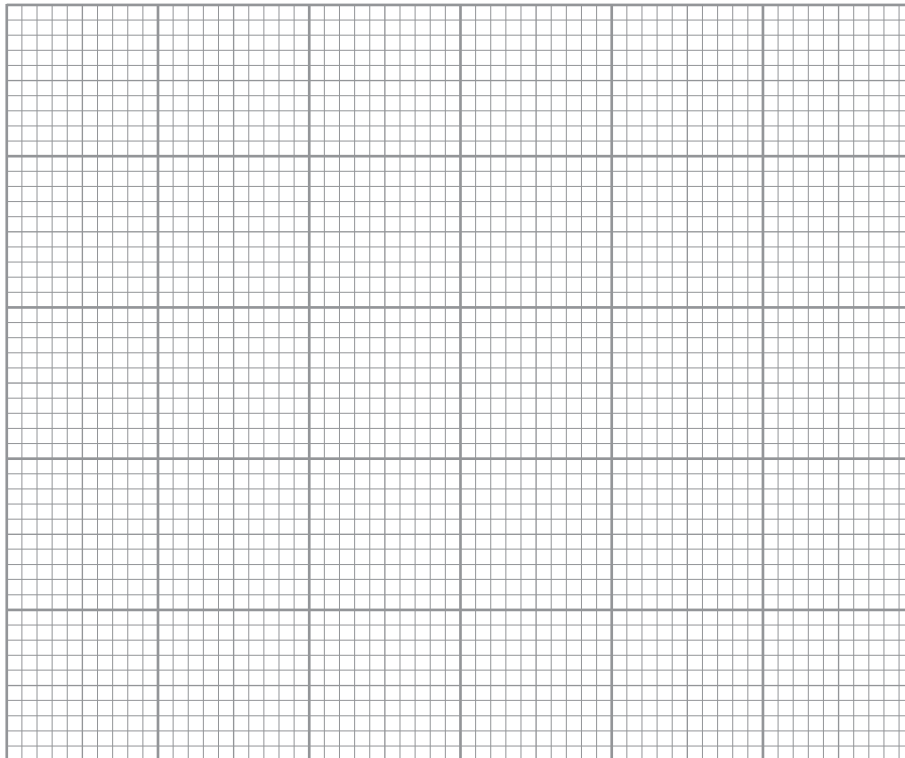
4. (a) A student is asked to carry out an experiment to determine the resistivity of tin in the form of a wire.

As a first step the student takes readings of the current in the wire against applied potential difference. The results are shown in the table.

Applied pd / V	0.10	0.20	0.30	0.40	0.50	0.60
Current / A	0.08	0.16	0.24	0.32	0.40	0.48

- (i) Draw a circuit diagram of the arrangement that could have been used to obtain the readings. [2]

- (ii) Plot a graph of current (y -axis) against potential difference (x -axis). [2]



- (iii) The student measures the length of the wire to be 1.45 m and the **diameter** to be 4.0×10^{-4} m. Show that the resistivity of tin is approximately $1 \times 10^{-7} \Omega \text{ m}$. [3]

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- (iv) **Draw on the same grid** (opposite) the current against potential difference graph for a metal wire of the same length and diameter but with **double** the resistivity of tin. [1]

- (b) (i) Calculate the mass of wire used in the experiment given that the density of tin is 7310 kg m^{-3} . [2]

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- (ii) Determine the total number of free electrons in this wire given that an atom of tin has a mass of $1.97 \times 10^{-25} \text{ kg}$ and each atom contributes 4 free electrons. [2]

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- (iii) Calculate the mean drift velocity of the electrons in the wire when the current in it is 0.32 A. [3]

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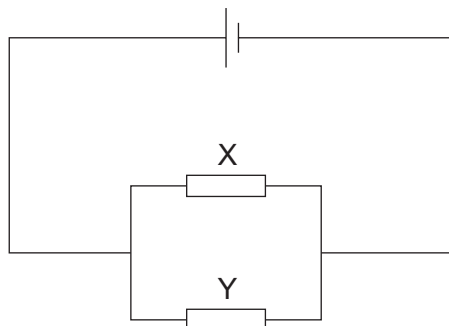
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5. (a) In the following circuits the resistance of X is **greater than** the resistance of Y.

Circuit A



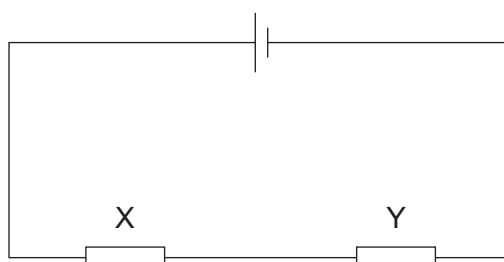
- (i) For Circuit A, compare the current through, and the potential difference across X and Y. [1]

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(ii)

Circuit B

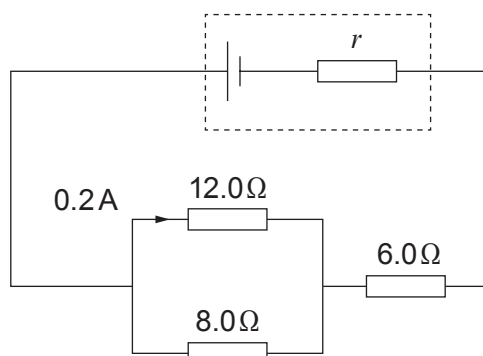


For Circuit B, compare the current through, and the potential difference across X and Y. [1]

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- (b) The diagram below shows three resistors connected together as part of a circuit. The internal resistance, r , of the cell is also shown.



- (i) Show in clear steps that the current in the $8.0\ \Omega$ resistor is 0.3 A . [2]

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- (ii) Show that the potential difference across the combination of three resistors is 5.4 V . [3]

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- (iii) Explain why the potential difference across the combination of three resistors is less than the emf of the cell. [2]

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- (iv) Calculate the internal resistance, r , of the cell given that its emf is 6.0 V . [2]

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6. (a) (i) Compare the movement of free electrons in a metal **before** and **after** a potential difference is applied to the metal. [4]

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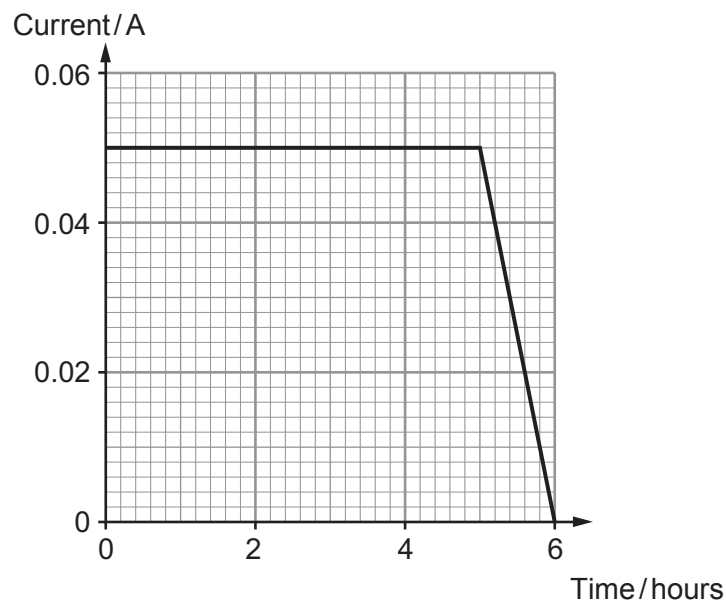
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- (ii) Hence explain how resistance arises in a metal when a potential difference is applied to it. [1]

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- (b) A resistor is connected for many hours to a cell. The graph shows the variation of current, I , through the resistor with time, t .



- (i) Calculate the charge which passes through the resistor:
- I. during the first 5 hours; [2]

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II. in the last hour.

[1]

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- (ii) Calculate the energy dissipated by the resistor during the first 5 hours given that the cell has an emf of 3.2 V. [Assume internal resistance = $0\ \Omega$.] [2]

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- (iii) Calculate the rate at which the resistor dissipates energy during the first 5 hours. [1]

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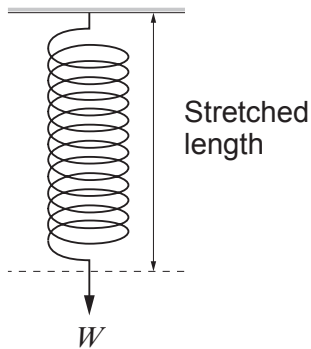
7. (a) (i) State what is meant by the spring constant, k .

[1]

- (ii) Show that the unit of k may be written as kg s^{-2} .

[2]

- (b) A brief experiment is carried out in order to determine k for a spring. The following results are obtained.



Weight, W , attached to spring / N	Stretched length of spring / m
1.0	0.25
5.0	0.45

- (i) Determine the value of k , stating any assumptions you make.

[3]

- (ii) Determine the unstretched length of the spring. Show your reasoning.

[2]

- (iii) Calculate the elastic potential energy stored in the spring when $W = 5.0\text{ N}$.

[3]

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GCE AS/A level

1321-1325/01-A – **LEGACY**



S16-1321-01A

PHYSICS – Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k\text{max}} = hf - \phi$$

$$\lambda_{\text{max}} = WT^{-1}$$

$$P = A\sigma T^4$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)		up (u)	down (d)
charge (e)	- 1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A \omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3}\rho\overline{c^2}$$

$$U = \frac{3}{2}nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2}QV$$

$$Q = Q_0 e^{-t/\tau_c}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

A2**Fields**

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2} \quad E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \quad V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} \quad W = q\Delta V_E$$

$$F = G \frac{M_1 M_2}{r^2} \quad g = \frac{GM}{r^2} \quad V_g = \frac{-GM}{r} \quad W = m\Delta V_g$$

Orbiting Bodies

Centre of mass: $r_1 = \frac{M_2}{M_1 + M_2} d$;

Period of Mutual Orbit: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$

Options

A: $\frac{V_1}{N_1} = \frac{V_2}{N_2}$; $E = -L \frac{\Delta I}{\Delta t}$; $X_L = \omega L$; $X_C = \frac{1}{\omega C}$; $Z = \sqrt{X^2 + R^2}$; $Q = \frac{\omega_0 L}{R}$

B: Electromagnetism and Space-Time

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

B: The Newtonian Revolution

$$\frac{1}{T_P} = \frac{1}{T_E} - \frac{1}{t_{\text{opp}}}$$

$$\frac{1}{T_P} = \frac{1}{T_E} + \frac{1}{t_{\text{inf conj}}}$$

$$r_P = a(1 - \epsilon)$$

$$r_A = a(1 + \epsilon)$$

$$r_P v_P = r_A v_A$$

C: $\epsilon = \frac{\Delta I}{I}$; $Y = \frac{\sigma}{\epsilon}$; $\sigma = \frac{F}{A}$; $U = \frac{1}{2} \sigma \epsilon V$

D: $I = I_0 \exp(-\mu x)$; $Z = c\rho$

E: $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}$; $U = \frac{K}{\Delta x}$; $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$; Carnot efficiency = $\frac{(Q_1 - Q_2)}{Q_1}$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

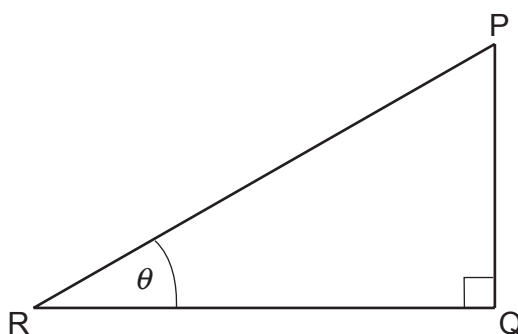
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

SUMMER 2016

**PHYSICS PH1 - (LEGACY)
1321/01**

INTRODUCTION

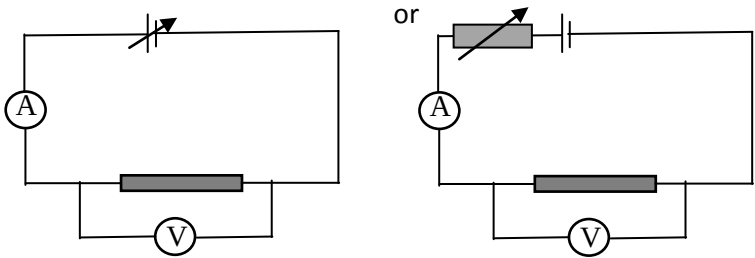
This marking scheme was used by WJEC for the 2016 examination. It was finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conference was held shortly after the paper was taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conference was to ensure that the marking scheme was interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conference, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about this marking scheme.

**WJEC GCE PHYSICS PH1 - (LEGACY)
SUMMER 2016 MARK SCHEME**

Question				Marking details	Marks Available
1	(a)			Vertical forces considered correctly e.g. 40 N forces cancel or $\Sigma F = 0$ in vertical plane (1) Horizontally, $\Sigma F = 20$ [N] <u>to the left</u> (1) Allow -20 [N]	[2]
	(b)	(i)		$T \cos 36^\circ = 800$ (1) $T = 989$ [N] (1) Accept 990 N but not 1 000 N	[2]
		(ii)		Vertical component of tension, $T_v = 800 \tan 36^\circ = 581$ N Or $T \sin 36^\circ = 581$ N (1) $L = 6\,000 - 581$ or: $T \sin 36^\circ + L = 6\,000$ (or equivalent seen) (1) $= 5\,419$ [N] (1) (ecf on T_v)	[3]
	(c)			$v = \frac{40000}{800}$ [Sub into $P = Fv$] (1) $v = 50$ [m s ⁻¹] (1) Question 1 total	[2] [9]
2	(a)			Gradient (or acceleration) shown to be $= \frac{v-u}{t}$ (1) At least one algebraic step shown towards derivation of $v = u + at$ (1) Accept correct comparison with $y = mx + c$ and m equivalent to a stated (1) logical use of symbols to show $v = u + at$ (1)	[2]
	(b)	(i)		Two 'circles' positioned correctly on 'fired' flight-path- by eye (1) Initial vertical velocity of both fired and dropped balls = 0 (1) Accept "same" Vertical plane - acceleration at '9.81 m s ⁻² ', same as 'dropped' ball (1) Accept "same vertical acceleration" Don't accept the only force acting on them is weight	[3]
		(ii)	I	Substitution into $s = \frac{1}{2} at^2$ [$\frac{1}{2} \times 9.81 \times 3.2^2$] (1) $s = 50.2$ [m] (1)	[2]
			II	Vertical velocity = 31.4 [m s ⁻¹] (1) Horizontal velocity = 112.5 [m s ⁻¹] (1) Resultant velocity $[31.4^2 + 112.5^2]^{1/2} = 116.8$ [m s ⁻¹] (ecf) (1) At 15.6° below horizontal or 74.4° to the vertical or shown by diagram (ecf) (1) Question 2 total	[4] [11]

Question			Marking details	Marks Available
3	(a)	(i)	Force $\times$ perpendicular distance <u>from pivot</u> or equivalent	[1]
		(ii)	$F \times 70 = 83.4 \times 12$ [2 $\times$ 1 marks for correct clockwise and anti-clockwise moments] $F = 14.3$ [N] (1)	[3]
		(iii)	$83.4 - 14.3 = 69.1$ [N] ecf on both mass and F	[1]
		(iv)	F needs to increase [to counteract this change/increase anti-clockwise moment] (1) C of G moved to right resulting in greater clockwise moment (1) Don't accept increased clockwise force	[2]
	(b)	(i)	$d = 2.2t$	[1]
		(ii)	$d = 1.5(t + 14)$	[1]
		(iii)	$2.2t = 1.5(t + 14)$ (1) ecf from (i) + (ii) $t = 30$ [s] (1) $d = 2.2 \times 30$ ecf (1) $= 66$ [m]	[3]
			Or substitute $t = \left(= \frac{d}{2.2} \right)$ from (i) into (ii) (1) Clear algebraic step (1) $d = 66$ [m] (1)	
			Question 3 Total	[12]
4	(a)	(i)	Method of varying voltage (1) Ammeter and voltmeter positioned correctly and circuit correct (1)	[2]
				

Question			Marking details	Marks Available
		(ii)	Suitable scales on both axes (0.1 intervals and start at origin) and axes labelled (1) All points plotted correctly (no tolerance) and line through all points and origin ($\pm \frac{1}{2}$ small square tolerance) (1)	[2]
		(iii)	Resistance of conductor = 1.25Ω or $\frac{V}{I}$ used in $\rho = \frac{RA}{l}$ (1) CSA calculated correctly or shown as πr^2 or equivalent (1) Sub: $\rho = \frac{1.25 \times \pi \times (2 \times 10^{-4})^2}{1.45}$ ($10.8 \times 10^{-8} [\Omega \text{ m}]$ seen) (1)	[3]
		(iv)	Accurately straight to (0.60, 0.24) from origin	[1]
	(b)	(i)	Mass = $7310 \times 1.45 \times \pi \times (2 \times 10^{-4})^2$ correct manipulation and substitution (1) ecf on A $M = 1.33 \times 10^{-3} [\text{kg}]$ (1)	[2]
		(ii)	$\frac{1.33 \times 10^{-3}}{1.97 \times 10^{-25}}$ (1) (ecf on M) ($= 6.76 \times 10^{21}$) $6.76 \times 10^{21} \times 4 = 2.7 \times 10^{22}$ (1)	[2]
		(iii)	n calculated ($= 1.48 \times 10^{29}$) ecf on N from (ii) or used as $\frac{2.7 \times 10^{22}}{\pi (2 \times 10^{-4})^2 \times 1.45}$ ecf on A or $\frac{7310}{1.97 \times 10^{-25}} \times 4$ (1) $v = \frac{I}{nAe}$ and substitution (1) $v = 1.07 \times 10^{-4} [\text{m s}^{-1}]$ (1) Alternative: Use (from algebra) of $v = \frac{Il}{eN}$ ($N = 2.7 \times 10^{22}$) (2) ecf on N from (ii) Answer as above (1)	[3]
			Question 4 Total	[15]

Question			Marking details	Marks Available
5	(a)	(i)	Diagram A: Current through X less than current through Y (or vice-versa) <i>pd</i> across X same as than <i>pd</i> across Y [Both statements correct for 1 mark]	[1]
		(ii)	Diagram B: Current through X same as current through Y <i>pd</i> across X greater than <i>pd</i> across Y [Both statements correct for 1 mark]	[1]
	(b)	(i)	Resistance has decreased by factor 1.5 (or reduced to 2/3 original value) or other correct quantitative comparison. Do not accept reduced by 4 Ω (1) Therefore current increases by same factor (or $\times 1.5$) etc. (1) Accept answers based on calculation: V across $12.0 \Omega = 2.4 \text{ [V]}$ (1) I through $8.0 \Omega = \frac{2.4}{8.0} (= 0.3 \text{ A})$ (1)	[2]
		(ii)	Current = 0.5 [A] (1) Total resistance = 10.8 [Ω] (1) 0.5×10.8 seen (1) Alternative – pd across parallel combination = $0.2 \times 12 = 2.4 \text{ [V]}$ (1) pd across $6.0 \Omega = (0.2 + 0.3) \times 6 = 3.0 \text{ [V]}$ (1) Total $pd = 2.4 + 3.0$ (1) = [5.4 V]	[3]
		(iii)	Some voltage (accept energy) is lost/ given out as heat (1) in the internal resistance of the cell (1)	[2]
		(iv)	Substitution into $E = V + Ir$ (e.g. $r = \frac{6 - 5.4}{0.5}$) (1) $r = 1.2 \text{ [}\Omega\text{]}$ (1) deduct 1 mark for incorrect sign	[2]
		Question 5 Total		[11]

Question				Marking details	Marks Available
6	(a)	(i)		Before pd applied: [Free] electrons move randomly (vibrate)/no overall velocity/mean velocity zero/vector average velocity zero (1) reference to thermal velocity needs to be explained don't accept zero drift velocity only [Free] electrons move very quickly/magnitude approx. 10^6 m s^{-1} (1) After pd applied: [Free] electrons accelerated by pd/drift velocity/overall velocity due to pd (1) - Drift velocity is small/magnitude approx. 10^{-3} or 10^{-4} m s^{-1} (1)	[4]
		(ii)		Collisions between [free] electrons and lattice atoms/atoms /ions of metal. Don't accept molecules	[1]
	(b)	(i)	I	Use of $Q = It$ or area under graph: $(0.05 \times 5) (= 0.25)$ (1) $\times 3600$ Therefore $Q = 900 \text{ [C]}$ (1) [Accept 0.25 Amp-Hours] for second mark Deduct 1 mark for power of 10 slip	[2]
			II	$Q = \frac{1}{2} \times 1 \times 0.05 \times 3600$ $= 90 \text{ [C]}$ ecf on t and I	[1]
		(ii)		Substitution into $E = QV$ (900×3.2) ecf on 900 (1) $E = 2880 \text{ [J]}$ (1)	
				Or Substitution into I^2Rt or $\frac{V^2t}{R}$ (must include R given as $\frac{3.2}{0.05}$ or 64Ω) (1) ecf on 0.05 and t $E = 2880 \text{ [J]}$ (1)	[2]
		(iii)		$\frac{2880(\text{ecf})}{5 \times 3600} = 0.16 \text{ W}$ or $\frac{0.25 \times 3.2}{5} = 0.16 \text{ W}$ or $3.2 \times 0.05 = 0.16 \text{ W}$ unit mark Accept J s^{-1} or correct equivalent ecf on t and I	[1]
				Question 6 Total	[11]

Question			Marking details	Marks Available	
7	(a)	(i)	Force per unit extension. Accept $\frac{F}{e}$ (or x) only if e (or x) defined as extension.	[1]	
		(ii)	Base units of F shown: kg m s^{-2} (1) $\frac{\text{kg m s}^{-2}}{\text{m}}$ seen (1) Alternative: Base units of W shown: $\text{kg m}^2 \text{s}^{-2}$ (1) $\frac{\text{kg m s}^{-2}}{\text{m}}$ seen (1) Alternative: Rearrangement of $T = 2\pi\sqrt{\frac{m}{k}}$ to show that $k = 4\pi^2 \frac{m}{T^2}$ (1) Units of k shown to be kg s^{-2} (1)	[2]	
		(b)	(i)	4.0 N extends the spring by 0.20 m seen (1) award extension mark if 0.45 – 0.25 is seen (or 0.20) Or $k = \frac{4.0}{0.20}$ (gains first 2 marks) $k = 20 [\text{N m}^{-1}]$ (1) Assumption: Hooke's law obeyed or force proportional to extension or elastic limit not reached (1)	[3]
			(ii)	1.0 N produces an extension of 0.05 m (or any other well-reasoned comment) (1) Original length = 0.20 [m] (1) Award 1 mark only for unsupported answer	[2]
	(b)	(iii)	Extension = 0.25 [m] ecf from (ii) (1) Either: Correct substitution into $W = \frac{1}{2}Fx$ ($\frac{1}{2} \times 5.0 \times 0.25$) (1) $W = 0.625 [\text{J}]$ (1) Or: Correct substitution into $W = \frac{1}{2}kx^2$ ($\frac{1}{2} \times 20 \text{ ecf } \times 0.25^2$) (1) $W = 0.625 [\text{J}]$ (1) Use of 0.45 m award 0 marks	[3]	
		Question 7 Total			[11]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01



S15-1321-01

PHYSICS – PH1

Motion, Energy and Charge

A.M. TUESDAY, 19 May 2015

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	15	
4.	11	
5.	9	
6.	8	
7.	17	
Total	80	

1321
010001

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

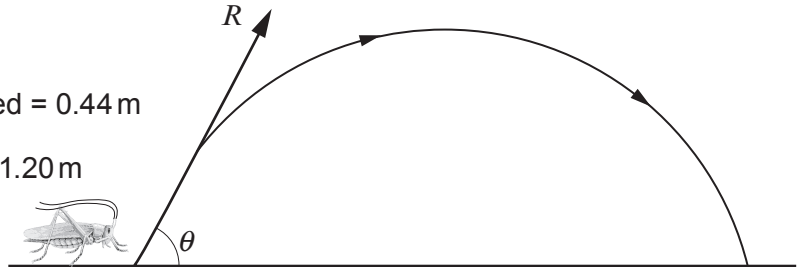
Answer all questions.

1. A science student is investigating the jump characteristics of a grasshopper. She makes the following observations when analysing one particular jump.

Maximum vertical height obtained = 0.44 m

Maximum horizontal distance = 1.20 m

Time of flight = 0.60 s



Air resistance can be ignored for parts (a) to (c).

- (a) Use the information to calculate:

- (i) the horizontal component of the velocity of the grasshopper;

[1]

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- (ii) the initial vertical component of the velocity of the grasshopper.

[2]

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- (b) Hence calculate:

- (i) the magnitude of the velocity at take-off, marked R in the diagram;

[2]

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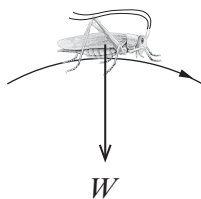
- (ii) the angle of take-off, marked θ in the diagram.

[1]

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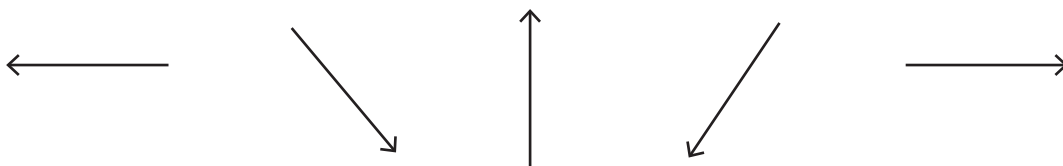
- (c) The diagram below shows the grasshopper of mass $3.0 \times 10^{-5} \text{ kg}$ at the instant when it is at its maximum height above the ground.



- (i) The arrow labelled W represents the force of gravity on the grasshopper due to the Earth. Identify the Newton third law 'equal and opposite' force to W . [1]

- (ii) Calculate the magnitude of the force you identified in (c)(i). [1]

- (d) Assume air resistance does act. **Circle the arrow** which correctly shows the direction of the force due to air resistance on the grasshopper at the instant it is at its maximum height. [1]



2. (a) The unit of electrical resistance is the ohm (Ω). Two of the following are correct alternative units to the ohm. **Circle the correct two.** [2]

VA^{-1}

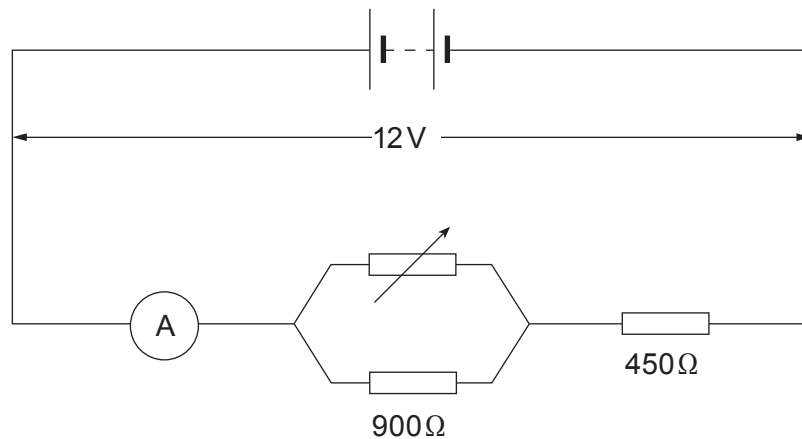
V^{-1}A

WA^{-2}

Cs^{-1}

Space for working if needed.

- (b) The circuit shows a variable resistor connected to two fixed resistors, an ammeter and a battery of emf 12V. The battery has negligible internal resistance.



The variable resistor is adjusted so that the ammeter reads 0.01 A.

- (i) Calculate the potential difference across the 450Ω resistor. [1]

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- (ii) Calculate the potential difference across the 900Ω resistor. [1]

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- (iii) Calculate the resistance of the parallel combination of the 900Ω resistor and the variable resistor. [2]

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(iv) Calculate the resistance of the variable resistor.

[2]

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(c) The variable resistor is adjusted so that its resistance decreases. Explain in clear steps what happens to the potential difference across the 900Ω resistor. [3]

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3. (a) (i) The current in a wire depends on its **resistance**. Explain, in terms of free electrons, how this resistance arises when a potential difference is applied across the wire.

[2]

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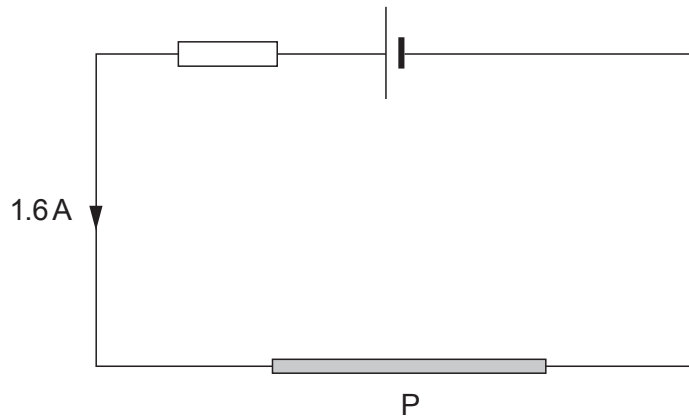
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- (ii) The wire (labelled P in the diagram) is connected to a fixed voltage source and a resistor to limit the current as shown. The wire is 0.4 m long and has a cross-sectional area of $2.0 \times 10^{-6} \text{ m}^2$. When the current is 1.6 A it dissipates 1.8 J of energy in 1 minute. Calculate its resistivity.

[4]



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- (b) (i) The current, I , in a wire of cross-sectional area, A , is given by the formula:

$$I = nAve$$

Derive the formula. You may include a clearly labelled diagram.

[4]

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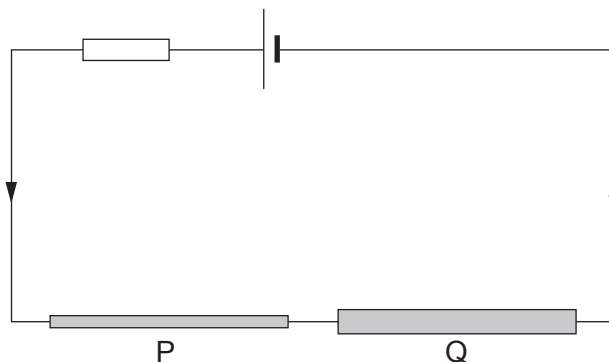
- (ii) Calculate the drift velocity of the free electrons in the wire in (a)(ii) when the current through it is 1.6 A. [$n = 6.4 \times 10^{28} \text{ m}^{-3}$] [2]

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- (iii) Wire P is now connected to another wire, Q, of the same material but with **twice** the cross-sectional area. The wires are connected to the same fixed voltage source and resistor.



Complete the following sentences by **circling the correct option** given in brackets.

- (I) The current in the circuit containing both wires is
[less than 1.6 A] [equal to 1.6 A] [more than 1.6 A]. [1]
- (II) The current in P is **[less than] [the same as] [greater than]** the current in Q. [1]
- (III) The electron drift velocity in Q is **[half] [the same as] [twice] [four times]** the electron drift velocity in P. [1]

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4. (a) (i) Draw a labelled diagram of a suitable arrangement that would enable a student to investigate how the resistance of a metal wire changes between a temperature of **0°C** and **100°C**. [3]

- (ii) Describe how the student would:

- obtain measurements of resistance across the full temperature range;
- ensure accurate results;
- analyse the data obtained.

[5]

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- (b) (i) A certain metal alloy has a *superconducting transition temperature* of -163°C . Explain what is meant by the words in italics. [2]

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- (ii) State how this alloy can be kept below its superconducting transition temperature. [1]

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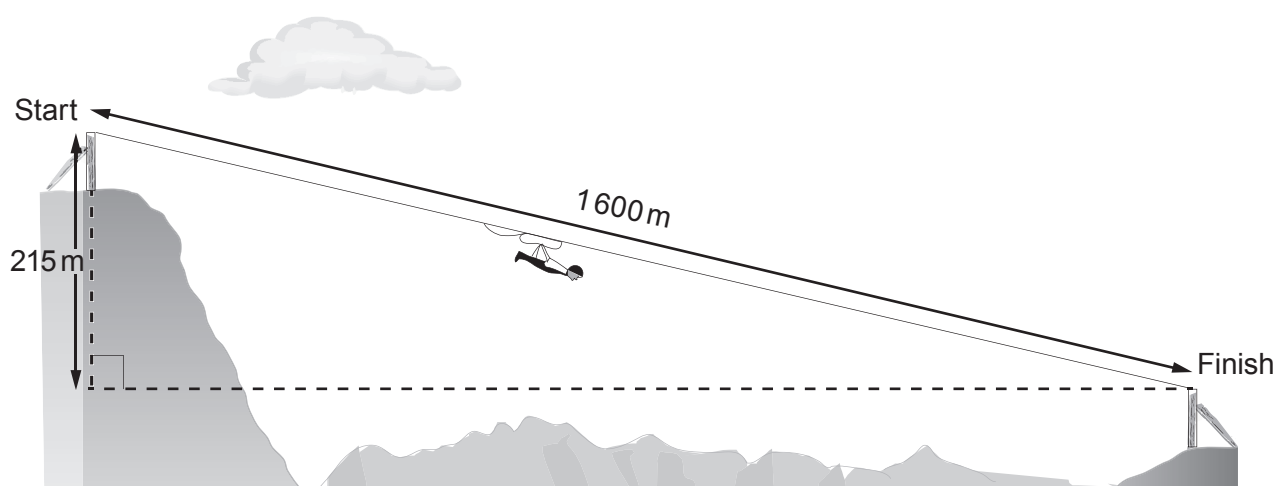
5. (a) (i) Define *power*.

[1]

- (ii) Show how the unit **W** can be expressed in terms of the SI base units **kg**, **m** and **s**.

[2]

- (b) The longest zip-wire ride in the UK is in Snowdonia, North Wales. It is 1600 m long and the vertical drop from start to finish is 215 m as shown. The diagram is not to scale.



- (i) A person of mass 70 kg arrives at the finish travelling at 35 m s^{-1} , having started from rest. Use this data and information from the diagram opposite to determine the mean force opposing the motion of the person. [4]

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- (ii) The time taken to travel from start to finish is 46 s. Calculate the mean rate at which energy is transferred to the surroundings during the journey. [2]

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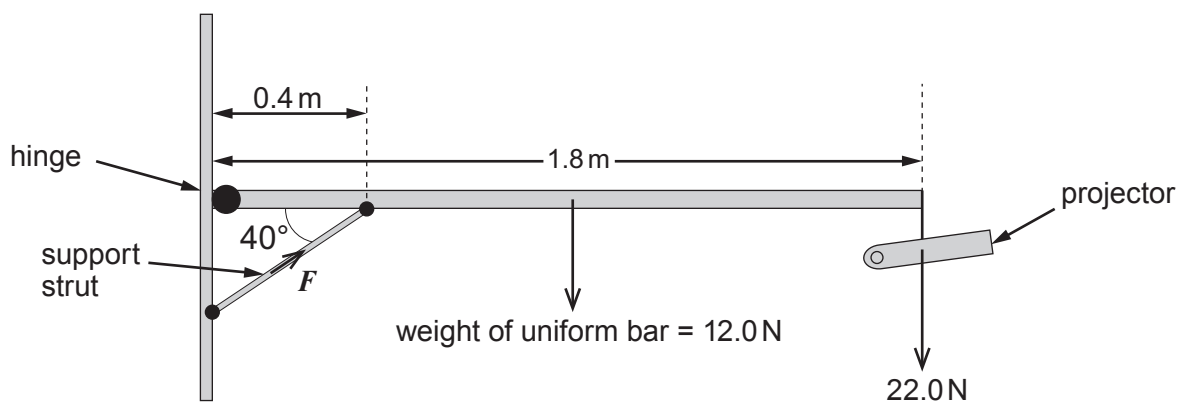
6. (a) Explain, with the aid of a diagram, what is meant by the moment of a force about a point. [2]

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- (b) A classroom projector is set up as shown.



- (i) By taking moments about the hinge, show that the force, F , exerted by the support strut on the uniform bar is approximately 200 N. [3]

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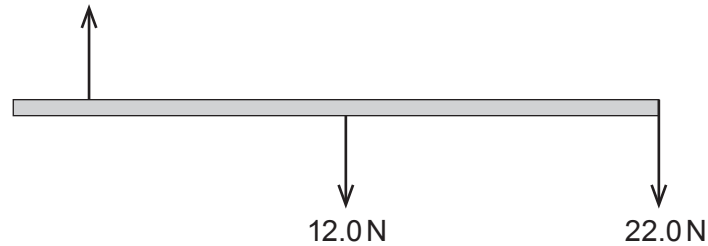
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- (ii) The free body diagram below shows **some of the vertical forces** acting on the uniform bar.

vertical component of
force exerted by the strut
on the bar



- (I) Calculate the value of the **vertical component** of the force exerted by the strut on the bar. [1]

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- (II) Indicate, with an arrow **on the diagram**, the direction of the vertical force on the bar due to the hinge. [1]

- (III) Calculate the size of the vertical force on the bar due to the hinge. [1]

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7. (a) (i) Define *displacement*.

[1]

- (ii) The distance between two towns A and B is 300 km. A train travels from A to B at a mean speed of 40 km/h and then back from B to A at a mean speed of 60 km/h.

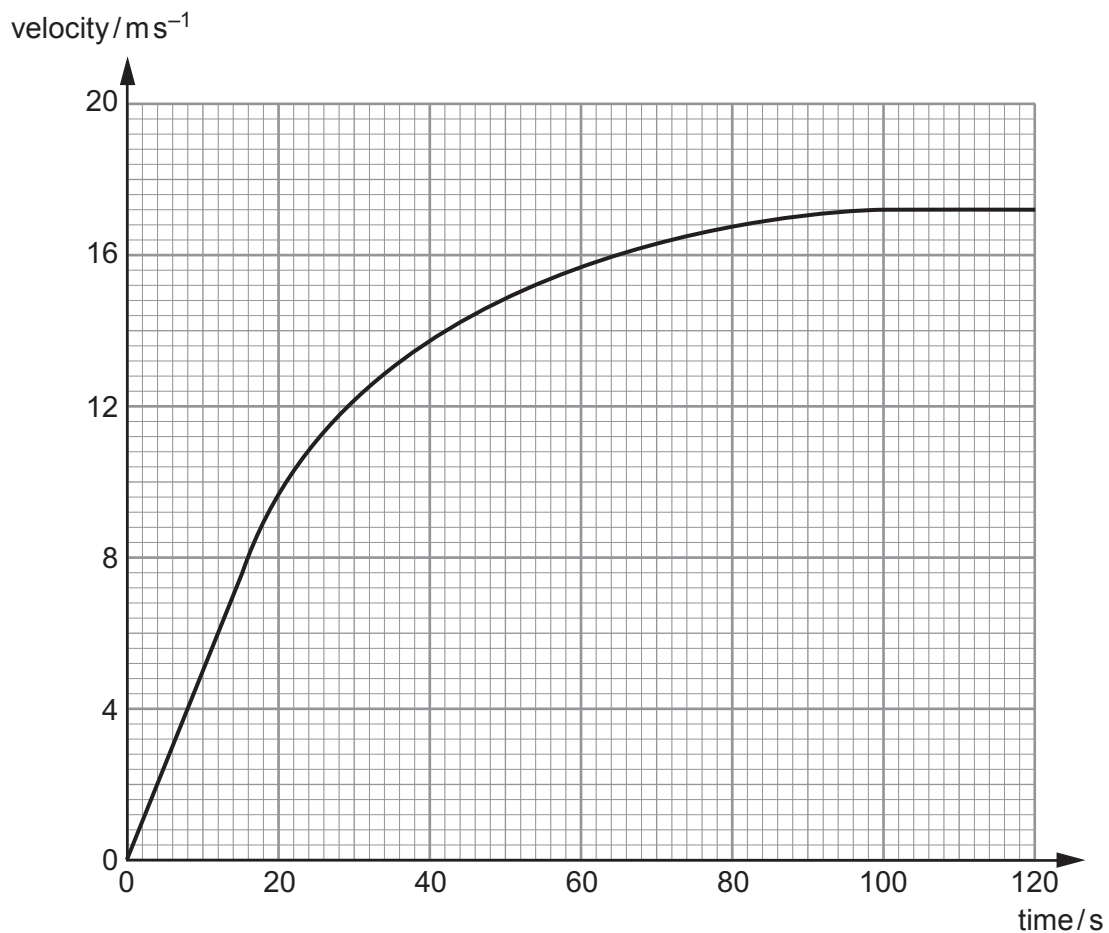
- (I) Calculate the mean speed for the **whole** journey.

[3]

- (II) What is the mean velocity for the whole journey? Explain your answer.

[2]

- (b) The graph represents the motion of the train over a 120 second period as it departs from a station.



- (i) By drawing a suitable tangent, determine the resultant force (ΣF) acting on the train at $t = 40$ s. [Mass of train = 1.2×10^6 kg.] [3]

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- (ii) Label clearly on the graph a time when $\Sigma F = 0$. [1]

- (iii) Describe and explain the motion of the train when $\Sigma F = 0$. [2]

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- (c) (i) The useful power output, P , of the engine is 4.5 MW. Show that:

$$P = Fv$$

where F is the driving force and v is the instantaneous velocity. [1]

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- (ii) Calculate the driving force when $\Sigma F = 0$. [2]

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- (d) Using your answers to (b)(i) and (c)(ii) and the assumption that the driving force remains constant throughout the motion, calculate the resistive force acting on the train at $t = 40$ s. [2]

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GCE AS/A level

1321-1325/01-A



S15-1321-01A

PHYSICS – Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k\text{max}} = hf - \phi$$

$$\lambda_{\text{max}} = WT^{-1}$$

$$P = A\sigma T^4$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e ⁻)	electron neutrino (ν _e)		up (u)	down (d)
charge (e)	-1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A \omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3}\rho\overline{c^2}$$

$$U = \frac{3}{2}nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2}QV$$

$$Q = Q_0 e^{-\gamma t}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

A2**Fields**

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2} \quad E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \quad V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} \quad W = q\Delta V_E$$

$$F = G \frac{M_1 M_2}{r^2} \quad g = \frac{GM}{r^2} \quad V_g = \frac{-GM}{r} \quad W = m\Delta V_g$$

Orbiting Bodies

Centre of mass: $r_1 = \frac{M_2}{M_1 + M_2} d$;

Period of Mutual Orbit: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$

Options

A: $\frac{V_1}{N_1} = \frac{V_2}{N_2}$; $E = -L \frac{\Delta I}{\Delta t}$; $X_L = \omega L$; $X_C = \frac{1}{\omega C}$; $Z = \sqrt{X^2 + R^2}$; $Q = \frac{\omega_0 L}{R}$

B: Electromagnetism and Space-Time

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

B: The Newtonian Revolution

$$\frac{1}{T_P} = \frac{1}{T_E} - \frac{1}{t_{\text{opp}}}$$

$$\frac{1}{T_P} = \frac{1}{T_E} + \frac{1}{t_{\text{inf conj}}}$$

$$r_P = a(1 - \epsilon)$$

$$r_A = a(1 + \epsilon)$$

$$r_P v_P = r_A v_A$$

C: $\epsilon = \frac{\Delta I}{I}$; $Y = \frac{\sigma}{\epsilon}$; $\sigma = \frac{F}{A}$; $U = \frac{1}{2} \sigma \epsilon V$

D: $I = I_0 \exp(-\mu x)$; $Z = c\rho$

E: $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}$; $U = \frac{K}{\Delta x}$; $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$; Carnot efficiency = $\frac{(Q_1 - Q_2)}{Q_1}$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

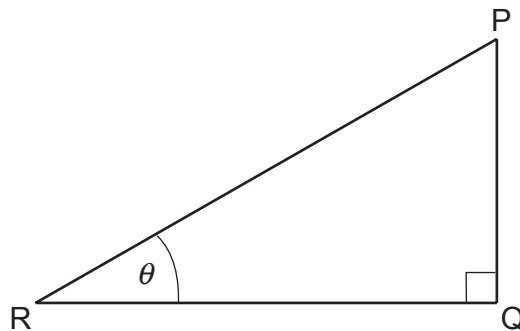
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2015

INTRODUCTION

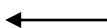
The marking schemes which follow were those used by WJEC for the Summer 2015 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

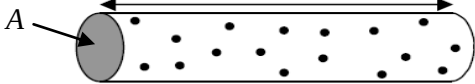
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
PH1	1
PH2	7
PH3	12
PH4	17
PH5	24
PH6	39

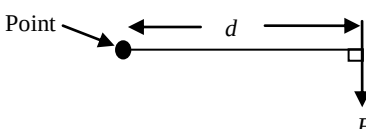
PH1

Question			Marking details	Marks Available
1	(a)	(i)	Horizontal velocity = $\frac{1.20}{0.60} = 2[.0 \text{ m s}^{-1}]$	1
		(ii)	$0 = u^2 - 2 \times 9.81 \times 0.44$ [correct substitution into $v^2 = u^2 + 2ax$] (1) $u = 2.94 [\text{m s}^{-1}]$ (1) or $0 = u - 9.81 \times 0.30$ [correct substitution into $v = u + at$] (1) $u = 2.94 [\text{m s}^{-1}]$ (1) [Other solutions possible]	2
	(b)	(i)	$R = (4 + 8.64)^{1/2}$ (1) [ecf from (a)(i) and/or (a)(ii)] $R = 3.56 [\text{m s}^{-1}]$ (1)	2
		(ii)	$\theta = 55.8^\circ$ ecf	1
	(c)	(i)	<u>Force of gravity on earth due to grasshopper</u>	1
		(ii)	$F = 3 \times 10^{-5} \times 9.81 = 2.9 \times 10^{-4} [\text{N}]$ Accept 0.3 m[N]	1
	(d)			1
			Question 1 Total	[9]
2	(a)		$V \text{ A}^{-1}$ and $W \text{ A}^{-2}$ $2 \times (1)$	2
	(b)	(i)	$V = 0.01 \times 450 = 4.5 [\text{V}]$	1
		(ii)	$12 \text{ V} - 4.5 \text{ V}$ [ecf] = $7.5 [\text{V}]$	1
	(iii)		$R = \frac{7.5}{0.01}$ (1 for correct use of 7.5 or ecf) = $750 [\Omega]$ (1) or correct alternative	2
		(iv)	$\frac{1}{750} = \frac{1}{900} + \frac{1}{R}$ (1) (substitution) $R_{\text{variable resistor}} = 4500 [\Omega]$ (1)	2
			Alternative solution to (iii) and (iv) $I \text{ through } 900 \Omega = \frac{7.5}{900} = 0.0083 [\text{A}]$ (1) $I \text{ through variable resistor} = 0.0017 [\text{A}]$ (1) $R_{\text{variable resistor}} = \frac{7.5}{0.0017} = 4500 [\Omega]$ (1) Use of resistors in parallel formula to find total parallel resistance = $750 [\Omega]$ (1)	

Question			Marking details	Marks Available
	(c)		[No mark for stating circuit resistance decreases] Current in circuit increases (1) [accept explanation based on potential divider. Hence pd across $450\ \Omega$ increases (1) Hence pd across $900\ \Omega$ decreases (1) this mark can't be awarded unless it is correctly substantiated Alternative solutions: Resistance of parallel combination decreases (1) pd across parallel combination decreases (1) pd across $900\ \Omega$ decreases (1) OR current through the variable resistor increases (1) current through the $900\ \Omega$ decreases (1) pd across the $900\ \Omega$ decreases (1) Question 2 total	3 [11]

Question			Marking details	Marks Available
3	(a)	(i)	[Free] electrons forced to move by applied pd (Need a reference to drift velocity or electron flow but does not need to be explicitly stated) (1) They collide with atoms/nuclei/ions/lattice of the wire (1) don't accept particles or molecules	2
		(ii)	$\text{Power} = \frac{1.8}{60} = 0.03 [\text{W}] \quad (1)$ $R = \frac{0.03(\text{ecf})}{1.6^2} = 0.0117 [\Omega] \quad (1)$ Alternative solution possible for the first 2 marks using $V = \frac{W}{Q}$ and $R = \frac{V}{I}$ $\rho = \frac{0.0117 \times 2 \times 10^{-6}}{0.4} \quad (1) \text{ [ecf on R]}$ $= 5.9 \times 10^{-8} [\Omega \text{ m}] \quad (1)$	4
	(b)	(i)	l or (vt) [accept v if stated dist travelled in 1 s]  [NB free electrons not required to be labelled] Number of free electrons = $nAvt$ [or nAl] (1) Total change = $nAvte$ [or $nAle$] (1) $I = \frac{nAvte}{t}$ with cancelling shown [or $\frac{nAle}{t}$, where $\frac{l}{t} = v$ shown] (1) Volume defined either from diagram [e.g. A and l labelled as shown] or in body of derivation [e.g. $\text{vol} = Al$] and n identified correctly– for the first mark	4
		(ii)	$1.6 = 6.4 \times 10^{28} \times 2 \times 10^{-6} \times v \times 1.6 \times 10^{-19} \quad (1: \text{substitution})$ $v = 7.8 \times 10^{-5} [\text{m s}^{-1}] \quad (1)$	2
		(iii)	(I) less than 1.6 A identified/circled (1) (II) the same as identified/circled (1) (III) half identified/circled (1)	3
			Question 3 Total	[15]

Question			Marking details	Marks Available
4	(a)	(i)	Water bath or method of heating shown. Wire [coiled or uncoiled] shown (1). Voltmeter and ammeter and power supply correctly connected or ohmmeter only shown (1) Thermometer clearly identifiable. (1) Subtract 1 mark for poorly drawn diagrams. Method of cooling water to 0 °C not credited here.	3
		(ii)	<u>Method</u> of cooling water to 0 °C (1) [Can be credited from (i)] Resistance values taken [or V and I values taken and R calculated](1) ..at different temperatures [minimum 5 implied or implication that a number of temperatures considered] (1) Method to reduce experimental error/ ensure accuracy e.g. water stirred/ resistance of leads/heat slowly/remove heat to allow temperature to settle (1) Accept repeat the experiment again or obtain readings whilst cooling down or using a digital thermometer. Don't accept just repeat readings. Graph of R vs θ drawn (1)	5
	(b)	(i)	[-163 °C] is the temperature at which <u>a sudden decrease in resistance</u> occurs and the metal [alloy] (1) ...becomes a <u>superconductor</u> or resistance becomes zero (1)	2
		(ii)	<u>Liquid nitrogen</u> [Accept liquid helium, liquid oxygen, liquid hydrogen]	1
	Question 4 Total			[11]

Question				Marking details	Marks Available
5	(a)	(i)		$\text{power} = \frac{\text{work done or energy transferred}}{\text{time}}$ [Accept rate of doing work/ rate of energy transfer]	1
		(ii)		$\text{kg m s}^{-2} \times \text{m} \times \text{s}^{-1}$ (1) [Evidence of full correct methodology] $\text{kg m}^2 \text{s}^{-3}$ (1)	2
	(b)	(i)		$E_p = 70 \times 9.81 \times 215$ (1) [= 147 641 J] $E_k = \frac{1}{2} (70)(35)^2$ (1) [= 42 875 J] $E_{\text{lost}} = 147\,641 - 42\,875$ (1) [= 104 766](ecf on both E_p and E_k) $F = \frac{104766}{1600} = 65.5$ [N] (1) (ecf on E_{lost}) Alternative solution: using $v^2 = u^2 + 2ax$	4
		(ii)		$P = \frac{104766}{46}$ ecf (1) = 2 277 J s ⁻¹ or W (1) UNIT mark Question 5 total	2 [9]
6	(a)			 (1)	2
				Moment = Fd (1) [award only if clear diagram shown] / if no right angle in diagram then perpendicular must be included in definition	
	(b)	(i)		$(F (\sin 40^\circ)(1) \times 0.4)$ (1) = $((12 \times 0.9) + (22 \times 1.8))$ (1) $F = 196$ [N] shown	3
		(ii)	(I) Vertical component of force in strut = 126 [N] (1) Accept 128 [N] or 129 [N] if $F = 200$ N is used. (II) Vertical downward arrow shown at hinge. (1) (III) Vertical force on bar due to hinge = 92 [N] (1) ecf Question 6 Total	3 [8]	

Question				Marking details	Marks Available
7	(a)	(i)		[Vector] distance between two locations measured along the shortest path joining them.	1
		(ii)	(I)	Time for outward journey = 7.5 hrs and homeward journey = 5 hrs calculated (1) Speed = $\frac{600}{12.5}$ (1) = 48 [km h ⁻¹] (1)	3
			(II)	0 km h ⁻¹ (1) displacement = 0 stated (1)	2
		(b)	(i)	Suitable tangent drawn (1) = 0.15 (accept range 0.12 to 0.18) (1) $\Sigma F = 1.2 \times 10^6 \times 0.15 = 180$ [kN] (1) [ecf on gradient value] ΣF range = 144 kN to 216 kN	3
	(b)	(ii)		Line (or time axis) labelled at ≥ 92 or 94 seconds	1
		(iii)		Constant speed (1) Driving force balanced [equal to] resistive forces (1) [Do not accept $\Sigma F = 0$]	2
		(c)	(i)	(I) $F = \frac{Wx}{t}$ and $\frac{x}{t}$ shown to be = v	1
	(c)		(II)	v (from graph) = 17.2 m s ⁻¹ (1) $F = \frac{4.5 \times 10^6}{17.2} = 262$ [kN] (1)	2
		(ii)		180 000 = 262 000 – F_{drag} (1) [ecf on both forces] $F_{\text{drag}} = 82$ [kN] (1)	2
				Question 7 Total	[17]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01

PHYSICS – PH1

Motion Energy and Charge

A.M. TUESDAY, 20 May 2014

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	9	
4.	14	
5.	13	
6.	14	
7.	10	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Answer all questions.

1. (a) (i) State the principle of conservation of energy. [1]

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- (ii) Explain how the principle applies to an object falling from rest **through the air**. [3]

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- (b) A child of mass 16 kg starts from rest at the top of a playground slide and reaches the bottom of the slide with a speed of 6.0 ms^{-1} . The slide is 4.0 m long and there is a difference in height of 2.4 m between the top and the bottom.

- (i) Calculate the work done against friction. [3]

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- (ii) Use your answer to (b)(i) to calculate the mean frictional force acting on the child. [2]

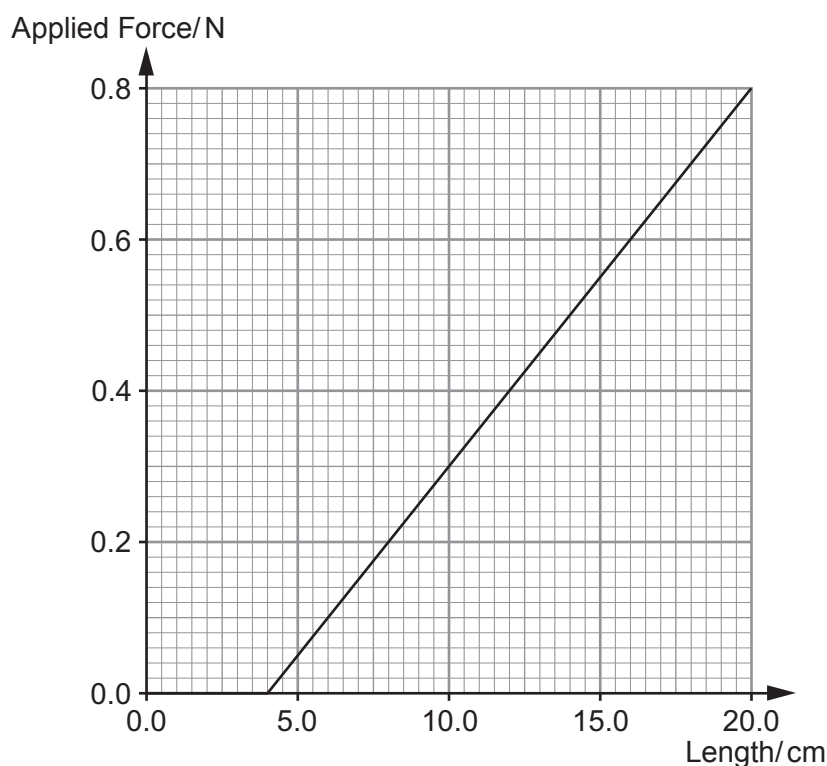
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2. The following graph shows how the length of a spring varies with the applied force. Hooke's law is obeyed throughout.



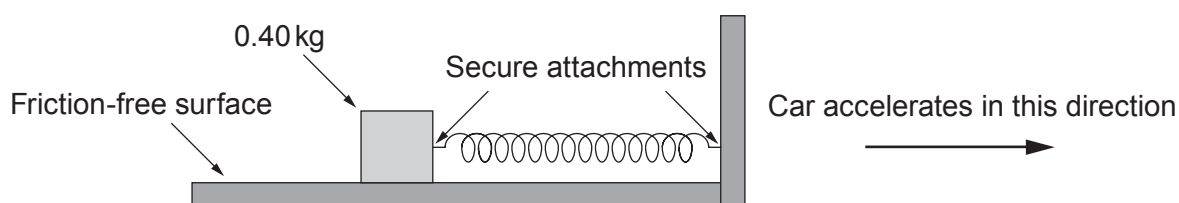
- (a) (i) State Hooke's law.

[1]

- (ii) Determine the spring's unstretched length.

[1]

- (b) The spring is used in a simple accelerometer (a device for measuring acceleration). The spring is attached to a 0.40 kg mass which is placed on a friction-free surface as shown. The device is installed in a car.



The car accelerates uniformly from rest. During the acceleration the spring is **extended** by 12.0 cm. Use this information and the graph to calculate the car's acceleration. [2]

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(c) Calculate the elastic potential energy stored in the spring when:

(i) the car's acceleration is the same as in (b);

[2]

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(ii) the car travels at constant velocity. Explain your answer.

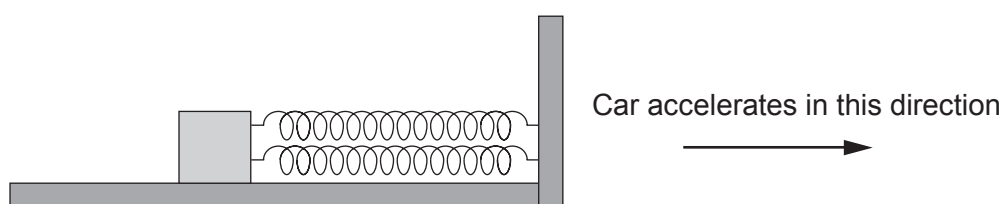
[2]

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(d) The accelerometer is now modified by attaching a second identical spring to the mass as shown.



Explain the effect that adding the second spring has on the **extension** and **total elastic potential energy** when the car's acceleration is the same as in (b). [3]

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3. (a) A list of electrical units is given below:

VA^{-1} Cs^{-1} Js^{-1} JC^{-1} As

From the list, choose the unit for:

(i) electrical power; [1]

(ii) electrical resistance; [1]

(iii) electrical charge. [1]

- (b) A torch battery converts 6480 J of chemical energy into electrical energy while supplying a current of 0.15 A for 2 hours. In this time only 5832 J of this energy is supplied to the bulb. Calculate:

(i) the charge that flows; [2]

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(ii) the emf of the battery; [1]

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(iii) the potential difference across the bulb; [1]

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(iv) the battery's internal resistance. [2]

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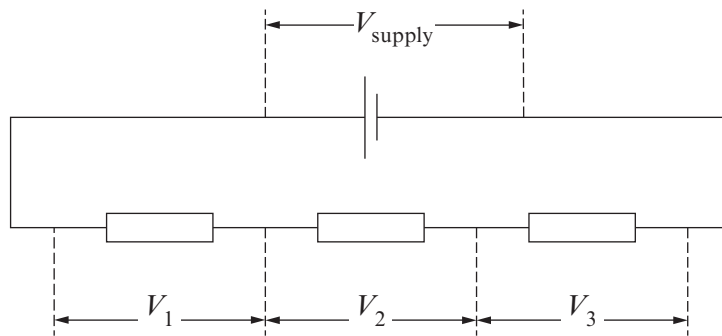
4. (a) Define the *potential difference* between two points in an electric circuit. [2]

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- (b) Three resistors are connected as shown.



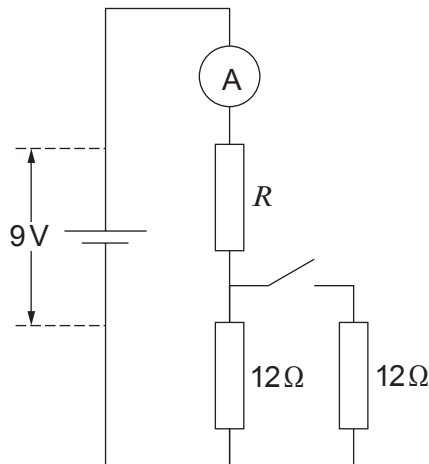
- (i) Complete the equation that relates **all** of the potential differences in the circuit: [1]

$V_{\text{supply}} = \dots\dots\dots$

- (ii) The equation you wrote down in (b)(i) is an example of which conservation law? [1]

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(c)



- (i) In the circuit shown, with the **switch open**, the ammeter reads 0.5A. Show that $R = 6\Omega$. [2]

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- (ii) The switch is now **closed**.

- (I) Calculate the (new) potential difference across R . [2]

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- (II) Calculate the (new) current through the ammeter. [2]

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- (III) More 12Ω resistors can be connected in parallel with the 12Ω resistors. Determine the **total** number of 12Ω resistors needed for the current through the ammeter to be 1.2A. [4]

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5. (a) (i) Draw a **labelled** diagram of the apparatus you would use to determine the relationship between the resistance and length of a metal wire.

[3]

Examiner
only

- (ii) Sketch a graph of your expected results.

[1]



- (iii) Explain how you would use an accurately drawn graph of resistance against length, as well as any other measurements, to obtain a value for the *resistivity* of the metal in the wire. [3]

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- (b) (i) A simple heater is made of a metallic wire of resistivity $48 \times 10^{-8} \Omega \text{m}$ and cross-sectional area $4.0 \times 10^{-8} \text{m}^2$. When it is in use the potential difference across the heater is 12.0V and its power is 32W. Calculate the length of the wire in the heater. [3]

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- (ii) Calculate the drift velocity of the electrons in the wire when the heater is in use. [The number of free electrons per unit volume is $3.4 \times 10^{28} \text{m}^{-3}$ for the material in the wire.] [3]

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6. (a) (i) Show that $v = u + at$ is consistent with the definition of acceleration. [2]

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- (ii) $x = \frac{1}{2} (u + v)t$ is another equation of uniformly accelerated motion. Use this equation and $v = u + at$ to show clearly that:

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

[2]

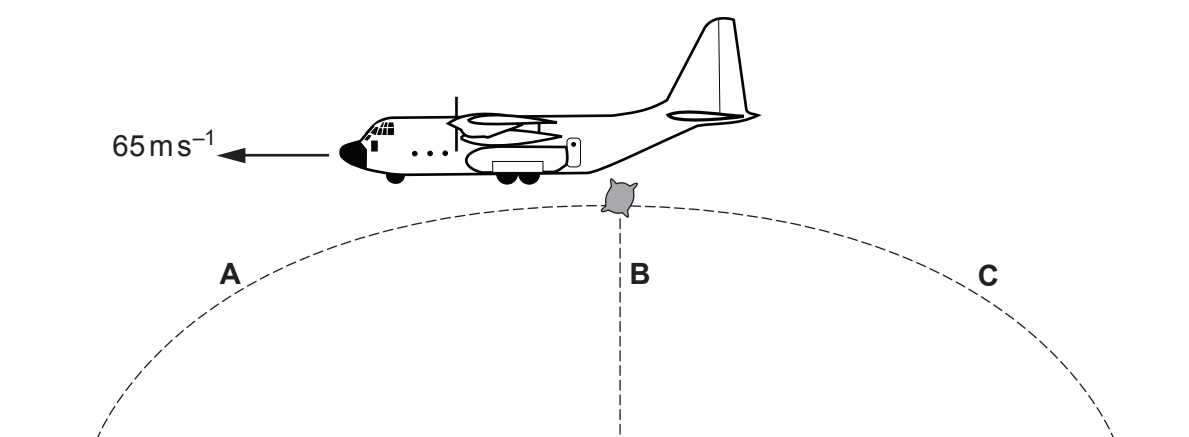
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- (b) The aeroplane shown below is travelling **horizontally** at 65 m s^{-1} . It is used to drop sacks of flour as emergency supplies. A sack is shown at the instant it is released from the low flying aeroplane. Ignore air resistance for this question. The diagram is not to scale.



- (i) A villager standing to the side observes the flight path of the sack. Which path, **A**, **B** or **C** shows the path of the sack? Explain your answer. [3]

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- (ii) (I) To avoid damaging the sack, the maximum **vertical** component of the sack's velocity must not exceed 30 m s^{-1} . Show that the maximum height from which the sack can be dropped is about 46 m. [2]

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- (II) Calculate the time taken for the sack to reach the ground if it is dropped from a height of 46 m. [2]

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- (iii) Calculate the resultant velocity of the sack on impact with the ground when it is dropped from 46 m. [3]

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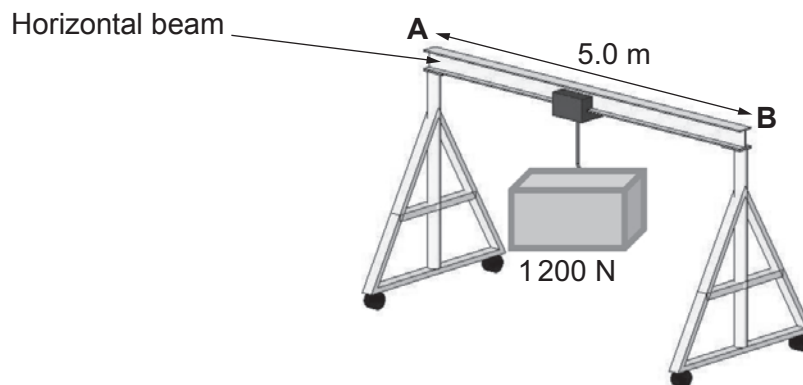
7. (a) A student gives the following **incorrect** and **incomplete** definition of the moment of a force about a point.

$$\text{Moment of a force about a point} = \text{mass} \times \text{distance}$$

Correct the definition.

[2]

- (b) A simple gantry crane is used to transport heavy loads. It consists of a horizontal beam (**AB**) of length 5.0 m fixed at each end to a vertical pillar as shown. It is possible to move the load along the horizontal beam.



When the gantry crane supports a load of 1200 N **at its centre**, a force of 700 N is exerted on each pillar. Calculate the weight of the horizontal beam. [2]

(c) The same load is now **moved 1.0 m towards B**.

(i) Draw arrows on the diagram below to show the forces now acting on the beam. [2]



(ii) By taking moments about a suitable point, calculate the force on the beam at **B**. [3]

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(iii) Hence calculate the force on the beam at **A**. [1]

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END OF PAPER



GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ ms}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ Js}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ JK}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ ms}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ mK}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k\text{max}} = hf - \phi$$

$$\lambda_{\text{max}} = WT^{-1}$$

$$P = A\sigma T^4$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)		up (u)	down (d)
charge (e)	- 1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A \omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3}\rho\overline{c^2}$$

$$U = \frac{3}{2}nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2}QV$$

$$Q = Q_0 e^{-t/\tau_c}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

A2**Fields**

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2} \quad E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \quad V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} \quad W = q\Delta V_E,$$

$$F = G \frac{M_1 M_2}{r^2} \quad g = \frac{GM}{r^2} \quad V_g = \frac{-GM}{r} \quad W = m\Delta V_g$$

Orbiting Bodies

Centre of mass: $r_1 = \frac{M_2}{M_1 + M_2} d;$

Period of Mutual Orbit: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$

Options

A: $\frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$

B: Electromagnetism and Space-Time

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

B: The Newtonian Revolution

$$\frac{1}{T_P} = \frac{1}{T_E} - \frac{1}{t_{\text{opp}}}$$

$$\frac{1}{T_P} = \frac{1}{T_E} + \frac{1}{t_{\text{inf conj}}}$$

$$r_P = a(1 - \epsilon)$$

$$r_A = a(1 + \epsilon)$$

$$r_P v_P = r_A v_A$$

C: $\epsilon = \frac{\Delta I}{I}; \quad Y = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \epsilon V$

D: $I = I_0 \exp(-\mu x); \quad Z = c\rho$

E: $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x} \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

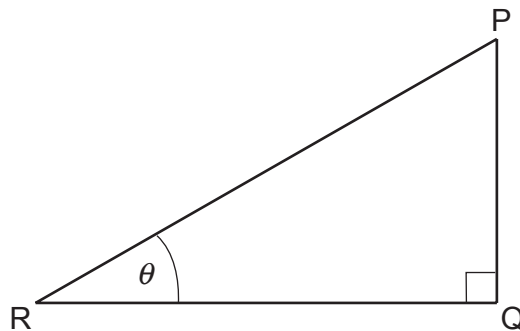
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2014 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
PH1	1
PH2	6
PH3	10
PH4	13
PH5	20
PH6	36

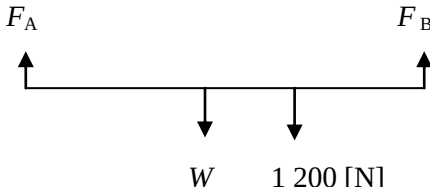
PH1

Question			Marking details	Marks Available
1	(a)	(i)	<u>Energy cannot be created or destroyed; it can only change from one form to another.</u> Don't accept can only be conserved.	[1]
		(ii)	$E_p \rightarrow E_k$ (1) can be implied Some energy lost as heat or due to air resistance or due to friction with air - general statement (1) Air molecules gain E_k and/or molecules of object gain E_k - specific statement (1)	[3]
	(b)	(i)	mgh calculated correctly = 376.7 [J] (1) accept g as 9.8 or 9.81 but not 10 $\frac{1}{2}mv^2$ calculated correctly = 288 [J] (1) $E_p - E_k = 88.7$ [J] [ecf from calculated values of E_p and/or E_k] (1)	[3]
		(ii)	<u>Correct substitution</u> into $W = Fd$ i.e. 88.7 (ecf) = $F \times 4.0$ (1) $F = 22[.2\text{N}]$ (1) If either E_p or E_k substituted in for W then award 1 mark only Alternative Solution: Force down slope = $16 \times 9.81 \times \frac{2.4}{4}$ [$F = mgsin\theta$] = 94.2 [N] Resultant Force $\Sigma F = 16 \times \left(\frac{6^2}{8}\right) = 72$ [N] Mean Frictional Force = $94.2 - 72 = 22[.2\text{N}]$ Award 1 mark for either force values correct (or both) Award 2 marks for correct solution	[2]
			Question 1 total	[9]
2	(a)	(i)	Force $\propto$ extension [provided elastic limit is not exceeded] Accept $F \propto x$ but x must be defined	[1]
		(ii)	4.0 [cm]	[1]
	(b)		F (from graph) = 0.6 [N] (1) Correct application of $a = \frac{\Sigma F}{m}$ i.e. $\frac{0.6}{0.4} = 1.5 \text{ ms}^{-2}$ (1) UNIT mark (ecf on F)	[2]
		(c)	(i) substitution into $\frac{1}{2}Fx$ (or area under graph or $\frac{1}{2}kx^2$) (1) ecf on F $E_{\text{spring}} = 3.6 \times 10^{-2}$ [J] (1)	[2]
		(ii)	$E_{\text{spring}} = 0$ [J] (1) $\Sigma F = 0$ or acceleration = 0 <u>so extension = 0</u> (1)	[2]
	(d)		New extension = $\frac{1}{2} \times$ original (1) Force in each spring = $\frac{1}{2} \times$ original or spring constant of system = $2 \times$ original or energy in each spring = $\frac{1}{4} \times$ original (1) Total energy (in both springs) = $\frac{1}{2} \times$ original (1) Accept algebraic equivalents	[3]
			Question 2 total	[11]

Question			Marking details	Marks Available
3	(a)	(i)	J s^{-1}	[3×1]
		(ii)	V A^{-1}	
		(iii)	A s	
	(b)	(i)	$t = 2 \times 3600$ or 7200 s (1) $Q = 0.15 \times 7200 = 1080 [\text{C}]$ (1)	[2]
		(ii)	$\frac{6480}{1080} = 6 [\text{V}]$ (ecf on Q)	[1]
		(iii)	$\frac{5832}{1080} = 5.4 [\text{V}]$ (ecf on Q)	[1]
		(iv)	$6 - 5.4 = 0.6 [\text{V}]$ (1) (ecf from (b)(ii) & (iii)) $\frac{0.6}{0.15} = 4 [\Omega]$ (1) (ecf on 0.6 [V])	[2]
			Or Correct substitution into $V=E - Ir$ (i.e. $5.4 = 6.0 - 0.15r$) (1) $r = 4 [\Omega]$ (1) (ecf from (b)(ii) & (iii))	
			Alternative Solution: $\frac{(6480 - 5832)}{7200} = 0.09 \text{ J s}^{-1}$ (Lost energy in cell per second) (1) $I^2 r = 0.09$ and $r = 4 [\Omega]$ (1)	
			Question 3 Total	[9]

Question			Marking details	Marks Available		
4	(a)		<u>Electrical</u> energy (or work done) transferred [to other forms passing] <u>between two points (1) per coulomb of charge (1)</u> Definition of 1 V award 1 mark only	[2]		
	(b)	(i)	$V_{\text{supply}} = V_1 + V_2 + V_3$	[1]		
		(ii)	Energy	[1]		
	(c)	(i)	$R_1 + 12 = \frac{9}{0.5}$ (1) Clear manipulation seen to show $R_1 = 6[\Omega]$ (1)	[2]		
		(ii) (I)	$\frac{1}{R} = \frac{1}{R_1} + \frac{1}{R_2}$ to show effective parallel combination = 6Ω (1) this can be implied V across upper 6Ω resistor shown = $4.5[\text{V}]$ (ecf on parallel combination) (1)	[2]		
			(II)	Total resistance = 12Ω (1) $I = \frac{9.0}{12} = 0.75[\text{A}]$ (1) (accept $\frac{4.5}{6} = 0.75[\text{A}]$)	[2]	
			(III)	$1.2 = \frac{9}{(6 + R_{\text{parallel}})}$ (1) $R_{\text{parallel}} = 1.5[\Omega]$ (1) $n \times (\frac{1}{12}) = \frac{1}{1.5}$ (1) ecf on $1.5[\Omega]$ $n = 8$ (1) Full marks for correct answer based on trial and error Alternative solution: $\frac{9}{1.2} = 7.5[\Omega]$ (1) $7.5 - 6 = 1.5[\Omega]$ (1) $\frac{12}{n} = 1.5[\Omega]$ (1) $n = 8$ (1)	[4]	
		Question 4 Total			[14]	

Question			Marking details	Marks Available
5	(a)	(i)	Ruler and wire shown and labelled (1) Moving pointer or jockey or crocodile clip indicated (1) Either: Correctly positioned ohmmeter with no power supply; or correctly positioned voltmeter and ammeter with power supply (1) [No labelling required for either method].	[3]
		(ii)	Diagonal line through origin	[1]
		(iii)	CSA from <u>diameter of wire</u> (1) Gradient from graph = (R/l) or (ρ/A) Or stated take a pair of R and l values from the graph (1) $\rho = \text{gradient} \times \text{CSA}$ or use of $\rho = RA/l$ (1)	[3]
	(b)	(i)	$R = \frac{144}{32} = 4.5 [\Omega]$ (1) Correct substitution into $R = \rho l/A$ (1) $l = 0.375 [\text{m}]$ (1) (ecf on R)	[3]
		(ii)	$I = 2.7 [\text{A}]$ (from V/R or P/V etc) (1) (ecf on I) Correct substitution into $I = nAve$ (1) $v = 1.24 \times 10^{-2} [\text{m s}^{-1}]$ (1) accept 0.01 m s^{-1}	[3]
		Question 5 Total		[13]

Question			Marking details	Marks Available
6	(a)	(i)	Acceleration defined as rate of change of <u>velocity</u> [or equivalent] or $a = \frac{(v-u)}{t}$ (1) <u>Clear manipulation</u> to show that $v=u+at$ (1)	[2]
		(ii)	$v=u+at$ substituted into $x = (u+v)t/2$ (1) <u>Clear manipulation</u> shown (1)	[2]
	(b)	(i)	A (1) Horizontal velocity (= 65 ms^{-1}) constant or same speed as plane or sack lands directly underneath plane (1) Vertical velocity increases or there is a vertical acceleration (1)	[3]
		(ii) (I)	Substitution into $v^2=u^2+2ax$ and $u = 0$ shown (1) x calculated= 45.9 [m] (1)	[2]
		(II)	Correct substitution into $v = at$ or $x=1/2at^2$ or $x=\frac{(u+v)t}{2}$ (1) $t=3.1 \text{ [s]}$ (1)	[2]
		(iii)	$v_R^2= (65^2 + 30^2)$ (correct substitution into Pythagoras) (1) $v_R = 71.6 \text{ [ms}^{-1}\text{]}$ (1) Valid angle calculated <u>and shown</u> or described e.g. $\theta = 24.8^\circ$ below horizontal (1)	[3]
		Question 6 Total		
	7	(a)	Replace <i>mass</i> with <i>force</i> (1) Don't accept weight Introduce <u>perpendicular distance to pivot</u> (1)	[2]
		(b)	$(2 \times 700) - 1\,200$ (1) Weight of beam = 200 [N] (1) Alternative solution: Moment about A or B e.g. $(700 \times 5) = (1\,200 + W) \times 2.5$	[2]
		(c)	(i)	 Upward forces as shown and indicated (1) Downward forces as shown and indicated (1) N.B. $1\,200 \text{ [N]}$ force can be indicated anywhere between W and F_B
(ii)			Taking moments about A: $F_B \times 5.0$ (1) $(1\,200 \times 3.5) + (200 \times 2.5)$ (1) (ecf on 200) $F_B = 940 \text{ [N]}$ (1)	[3]
(iii)			$1\,400 - 940 = 460 \text{ [N]}$ (ecf from (b) and/or (c)(ii)) Accept answer based on moments calculated about B.	[1]
Question 7 Total			[10]	

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01

PHYSICS – PH1

Motion, Energy and Charge

A.M. WEDNESDAY, 15 January 2014

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	17	
4.	13	
5.	10	
6.	8	
7.	12	
Total	80	

1321
010001

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Answer all questions.

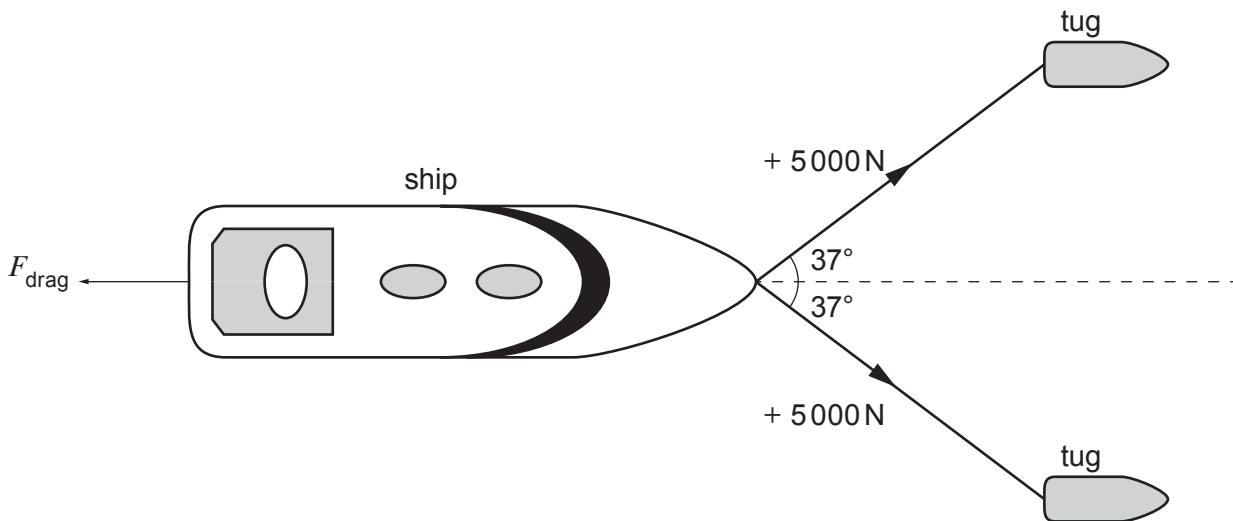
1. (a) State what is meant by a vector quantity. [1]

- (b) Newton's second law of motion can be expressed by the equation:

$$\Sigma F = ma$$

Name the vector quantities in this equation. [2]

- (c) A ship is being pulled along by cables attached to two tugs as shown. F_{drag} represents the total drag force that acts on the ship at the instant shown.



- (i) Show clearly that the magnitude of the resultant of the forces applied **by the tugs** is approximately 8000 N. [2]

- (ii) Given that $\Sigma F = + 2000 \text{ N}$ for the situation shown above, determine the value of F_{drag} . [1]

- (d) At a later stage the tension in the cables is changed so that the ship moves forward with a **constant speed** of 2.5 m s^{-1} . Calculate the work done on the ship by the tugs in one minute. [Assume F_{drag} is the same as that calculated in (c)(ii).] [3]

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2. The current I in a metal conductor of cross-sectional area A is given by:

$$I = nAve$$

- (a) State the meanings of n and v . [2]

n

v

- (b) Show that the equation is correct in terms of units. [3]

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- (c) (i) The current in a copper wire is 2.0 A. The wire has a cross-sectional area of 1.2 mm^2 and is 5.0 m long. Calculate the time it takes a free electron in the wire to travel from one end to the other. [Take $n_{\text{copper}} = 8 \times 10^{28} \text{ m}^{-3}$.] [3]

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- (ii) The **same current** (2.0 A) is now passed through a **thinner** wire of the **same length and material**. Use the above equation to explain the effect this change would have on the time for an electron to travel from one end to the other. [3]

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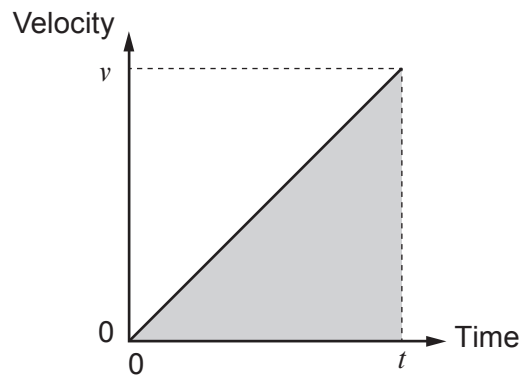
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3. (a) A velocity-time graph is given for a body which is accelerating from rest in a straight line.



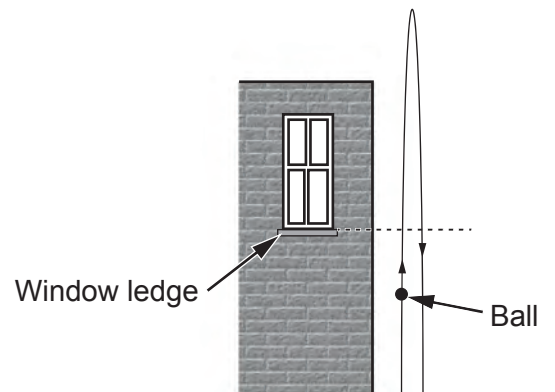
- (i) What does the shaded area under the graph represent? [1]

- (ii) Use the graph to show that, using the usual symbols:

$$x = \frac{1}{2} at^2$$

[3]

- (b) A ball is thrown vertically upwards and passes a window ledge 0.3 s after being released. It passes the window ledge on its way back down, 1.6 s **later**. Ignore air resistance.



- (i) Determine the time of flight of the ball.

[1]

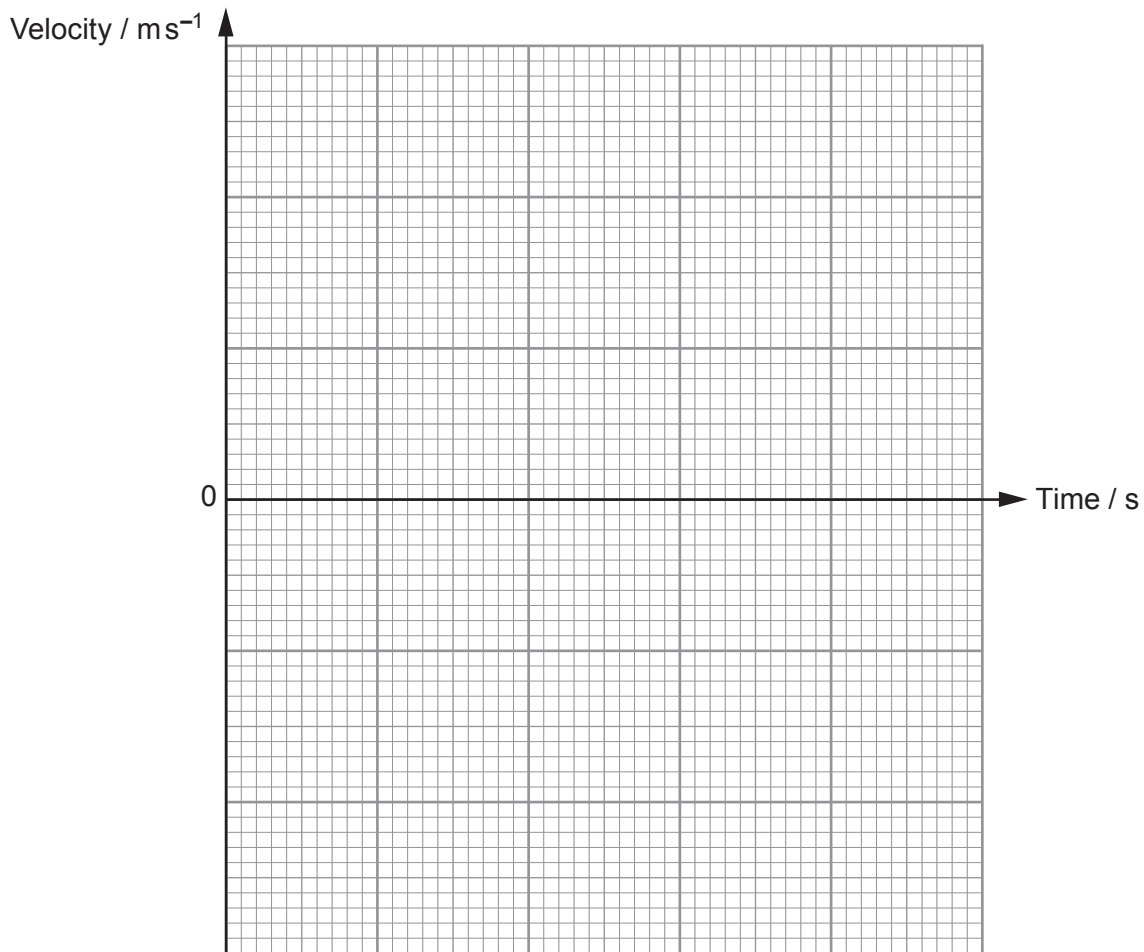
- (ii) Calculate the initial velocity of the ball when it is released.

[3]

- (iii) Calculate the height of the window ledge above the ground.

[2]

- (c) Draw, on the grid below, a velocity-time graph for the whole of the ball's flight. Include suitable scales on both axes. [3]



- (d) In reality, air resistance also acts on the ball. In the spaces provided draw **three** free body diagrams showing the forces acting on the ball at the positions indicated. **Label** these forces. [4]



As the ball passes the window ledge **travelling upwards**

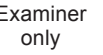


At maximum height above the ground



As the ball passes the window ledge **travelling downwards**

- Examiner
only



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Examiner
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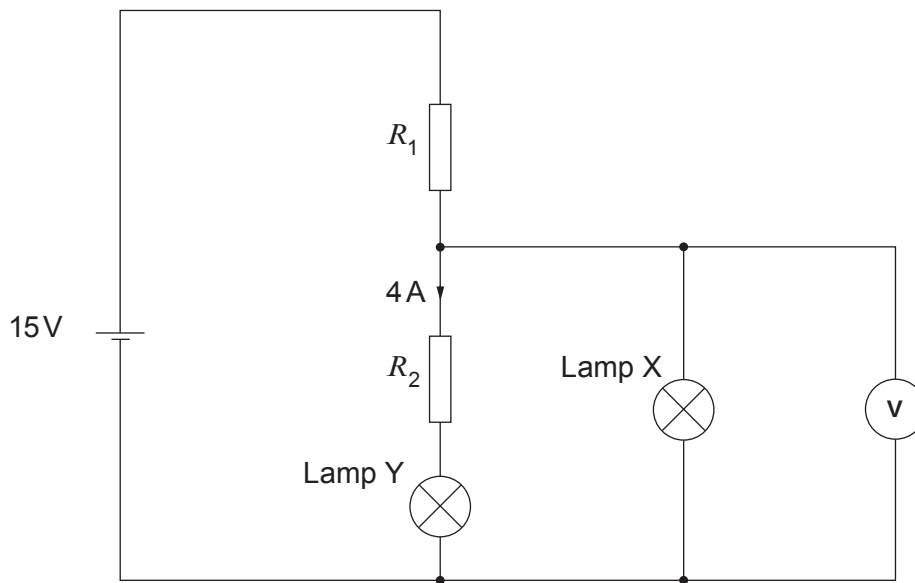
(b) X and Y are two lamps.

- (i) Lamp X is labelled at 12 V, 24 W. Calculate the current in the lamp when it operates at its rated voltage. [1]

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- (ii) Lamp Y is labelled at 6 V, 4 A. In the following circuit, the values of R_1 and R_2 are chosen so that **both lamps operate at their rated voltages**.



- (I) State the reading on the voltmeter. [1]

- (II) Calculate the pd across R_2 . [1]

- (III) Calculate R_2 . [1]

- (IV) Calculate R_1 . [3]

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5. A resistance strain gauge is a device used to detect very small changes in structures such as buildings and bridges. It consists of a very fine wire glued onto a thin plastic sheet. The gauge is attached to the structure under test, so that when the structure deforms the wire is either stretched or compressed.

- (a) If the wire is stretched it gets **longer** and **thinner**. Using an equation to justify your answer, explain the effect that stretching the wire has on its resistance. [3]

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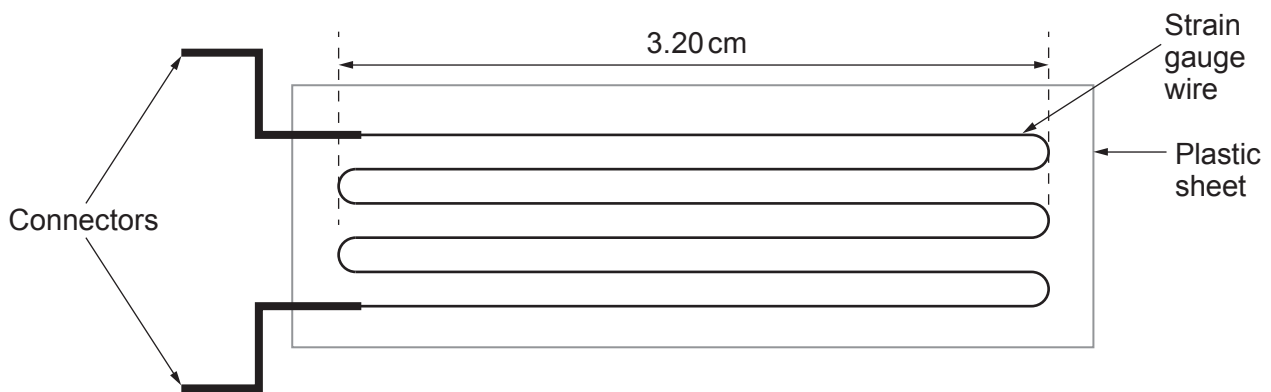
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- (b) The diagram shows a typical strain gauge. The wire is of circular cross-section and is arranged in a zig-zag pattern.



- (i) Show that the resistance of the wire in the strain gauge is $56\ \Omega$. Assume that its **diameter** is $1.75 \times 10^{-5}\text{ m}$ and its resistivity, $\rho = 7.0 \times 10^{-8}\ \Omega\text{ m}$. [3]

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- (ii) Calculate the change in length needed to produce a 0.1% variation in resistance in the strain gauge opposite. For this calculation, **ignore changes in cross-sectional area**. [2]

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- (iii) Suggest why it is beneficial for the wire to be arranged in a zig-zag pattern. [2]

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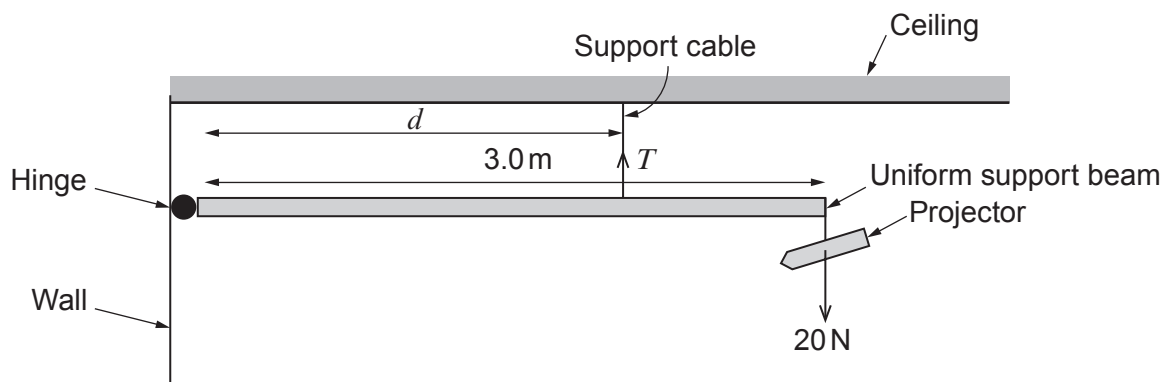
6. (a) State the **two** conditions necessary for a body to remain in equilibrium. [2]

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- (b) A school technician installs a projector of weight 20 N and uniform support beam of weight 10 N in a classroom as shown.



- (i) **Label** with an arrow on the diagram, the weight of the beam. [1]
- (ii) The manufacturer states that, for safety purposes, the tension, T , in the support cable must not exceed 40 N. Calculate the minimum distance, d , that the technician can place the cable so that the tension in it does not exceed the safe limit. [3]

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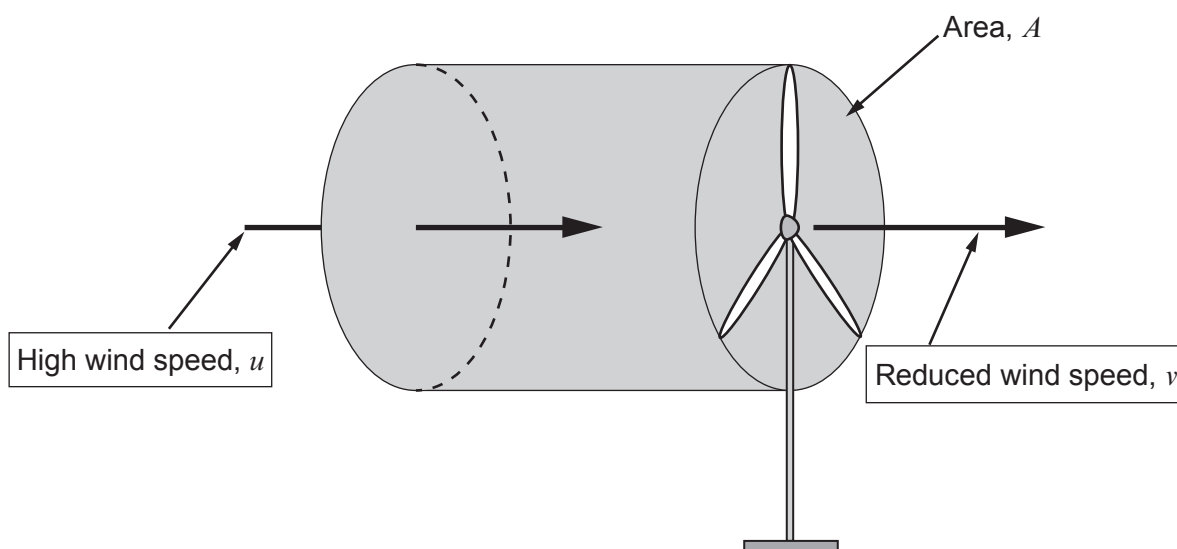
- (iii) Determine the size and direction of the force that the hinge exerts on the beam when the tension in the support cable is at its maximum safe limit. [2]

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7. Wind turbines are used to generate electrical energy. They work by converting as much as possible of the kinetic energy of the air that moves through the area swept out by the blades into electrical energy.



- (a) (i) The volume of air arriving on the blades per second is Au . Show that the kinetic energy per second (the power, P) arriving is given by:

$$P = \frac{1}{2} A \rho u^3$$

where ρ is the density of the air.

[2]

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- (ii) Use the above equation to complete the following sentences:

[2]

- (I) The power arriving is proportional to the *square of the radius*. So doubling the length of the turbine blades will increase the power arriving by a factor of

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- (II) Doubling the wind speed will increase the power arriving by a factor of

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- (iii) The blades cannot remove all the energy arriving from the wind. Having passed through the blades, the moving air has a reduced speed, v , as shown in the diagram. The following equation can be used to approximate the power possessed by this moving air:

$$P = \frac{1}{2} A \rho v^3$$

Use this equation and the one in (a)(i) to write an expression for the power **lost** by the air as it passes through the moving blades. [1]

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- (iv) Suggest why it is not a good idea to erect wind turbines short distances behind each other. [1]

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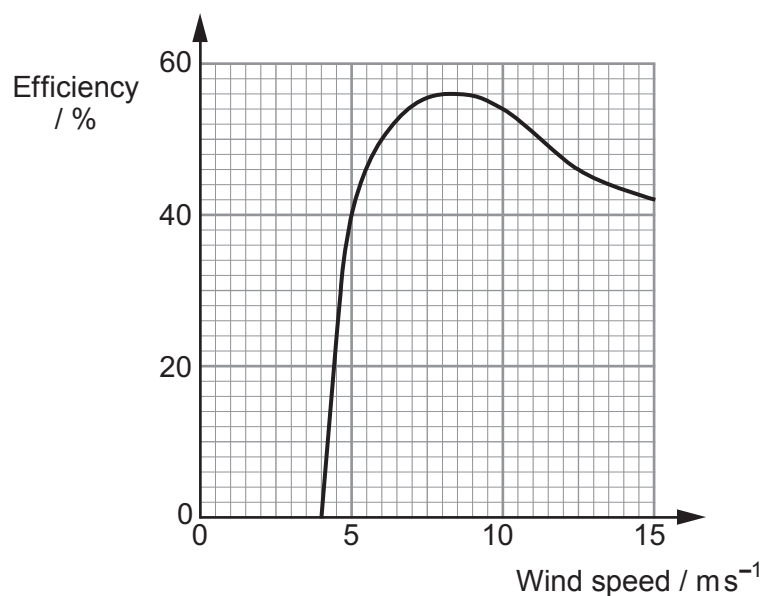
- (v) A wind turbine has blades of length 2.0 m. Wind of speed 7.0 m s^{-1} arrives on the blades, which is reduced to 5.0 m s^{-1} after passing through the blades. Calculate the net power input to the wind turbine. [Assume $\rho_{\text{air}} = 1.2 \text{ kg m}^{-3}$.] [2]

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- (b) The calculation in (a)(v) assumes that all the kinetic energy lost from the wind is converted into electrical energy. This is not the case as electrical generators in the wind turbines are not 100% efficient. A significant amount of energy is lost due to friction between the moving parts of the turbine for example. Below is a typical graph of efficiency against the speed of the wind arriving on the blades.



- (i) Suggest why no power is generated for wind speeds up to 4.0 ms^{-1} . [1]

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- (ii) Use the graph to determine the actual power generated by the turbine in (a)(v) in a wind of speed 7.0 ms^{-1} . [2]

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- (c) State why an undersea turbine of the same size as the wind turbine in (a)(v), when placed in a water current of speed 7.0 ms^{-1} , would provide significantly greater power output than the wind turbine. [1]

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END OF PAPER



GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ ms}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ Nm}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ Js}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ JK}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ ms}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ mK}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k\text{max}} = hf - \phi$$

$$\lambda_{\text{max}} = WT^{-1}$$

$$P = A\sigma T^4$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e ⁻)	electron neutrino (v _e)		up (u)	down (d)
charge (e)	- 1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A \omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3}\rho\overline{c^2}$$

$$U = \frac{3}{2}nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2}QV$$

$$Q = Q_0 e^{-t/\tau_c}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

A2**Fields**

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2} \quad E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \quad V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} \quad W = q\Delta V_E,$$

$$F = G \frac{M_1 M_2}{r^2} \quad g = \frac{GM}{r^2} \quad V_g = \frac{-GM}{r} \quad W = m\Delta V_g$$

Orbiting Bodies

Centre of mass: $r_1 = \frac{M_2}{M_1 + M_2} d;$

Period of Mutual Orbit: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$

Options

A: $\frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$

B: Electromagnetism and Space-Time

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

B: The Newtonian Revolution

$$\frac{1}{T_P} = \frac{1}{T_E} - \frac{1}{t_{\text{opp}}}$$

$$\frac{1}{T_P} = \frac{1}{T_E} + \frac{1}{t_{\text{inf conj}}}$$

$$r_P = a(1 - \epsilon)$$

$$r_A = a(1 + \epsilon)$$

$$r_P v_P = r_A v_A$$

C: $\epsilon = \frac{\Delta I}{I}; \quad Y = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \epsilon V$

D: $I = I_0 \exp(-\mu x); \quad Z = c\rho$

E: $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x} \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

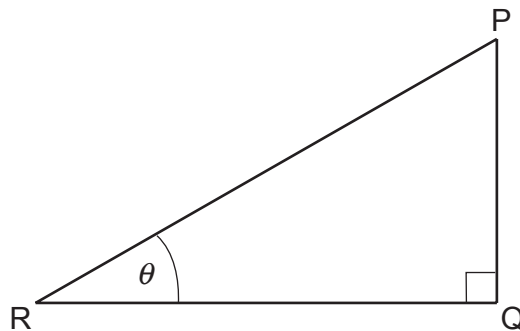
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS AS/Advanced

JANUARY 2014

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2014 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
PH1	1
PH2	6
PH3	10

PH1

Question				Marking details	Marks Available
1	(a)			A quantity which has magnitude [accept size] and direction.	[1]
	(b)			[Resultant] Force (1) Acceleration (1) (award 1 mark only if both symbols identified correctly)	[2]
	(c)	(i)		$2T (1) \times \cos 37^\circ (1) [= 8000 \text{ N}]$	[2]
		(ii)		$F_{\text{drag}} = 6000 \text{ [N]}$	[1]
	(d)			$F = 6000 \text{ N}$ (1) ecf from (c)(ii) $d = 2.5 \times 60 (1)$ $W = 6000 \times 2.5 \times 60$ $= 9 \times 10^5 \text{ J}$ (1) UNIT mark	[3]
Question 1 total					[9]
2	(a)			n - number of free/conducting electrons (charge carriers) per unit volume (1) accept free electron density v - drift velocity (1)	[2]
	(b)			LHS: $C s^{-1} (1)$ RHS: $m^{-3} \times m^2 \times m s^{-1} \times C (1)$ Clear manipulation to show/state LHS = RHS (1)	[3]
	(c)	(i)		$v = \frac{I}{nAe} (1) \text{ (or correct substitution)}$ $v = 1.30 \times 10^{-4} \text{ m s}^{-1} (1) \text{ (-1 for slips in powers of 10)}$ $t = \frac{5.0}{1.30 \times 10^{-4}} = 3.85 \times 10^4 \text{ [s]} (1) \text{ ecf for incorrect value of } v$	[3]
		(ii)		Reduced CSA (or diameter) and n, e constant..... (1) ...Increased v (1) Hence reduced t (1)	[3]
Question 2 total					[11]

Question				Marking details	Marks Available
3	(a)	(i)		Displacement (don't accept distance)	[1]
		(ii)		Shaded area = $\frac{1}{2} tv$ (1) $u = 0$ shown or implied (1) $v = at$ and clear substitution (1)	[3]
	(b)	(i)		2.2 [s]	[1]
		(ii)		Valid substitution into $v = u + at$ (e.g. $0 = u - g \times 1.1$ or $2u = 2.2g$ etc) Or any other valid kinematic equation (ecf on t from (i)) Correct algebra/manipulation (1) $u = 10.8[\text{ms}^{-1}]$ (1)	[3]
		(iii)		Correct substitution into $x = ut + \frac{1}{2} at^2$ (i.e. $x = 10.8 \times 0.3 - \frac{1}{2} \times 9.81 \times 0.3^2$) (ecf on 10.8ms^{-1}) (1) $x = 2.8[\text{m}]$ (1)	[2]
	(c)			Reasonable scales on both axes (1) Diagonal straight line from $(0, \pm 10.8)$ (ecf) to (1.1) (ecf), 0) (1) Diagonal line continued to $(2.2, \pm 10.8)$ (1)	[3]
	(d)			Two vertical downwards arrows shown during upward motion (1) Single vertical downwards arrow shown at max height (1) Vertical upwards and vertical downwards arrows shown during downward motion (1) All labels correct (weight or force due to gravity, air resistance or force due to air) (1)	[4]
				Question 3 Total	[17]

Question				Marking details	Marks Available	
4	(a)	(i)		Metal wire at constant temperature - straight diagonal line. Filament of lamp - curved line.	[1]	
		(ii)		Straight line: R constant throughout [or V/I constant] as... (1) T constant throughout (1) Curve: Initially R constant [or V/I constant] as....(1) Then T increases (1) so R increases - accept explanation in terms of particles (1)	[5]	
	(b)	(i)		$I = 2\text{ [A]}$	[1]	
		(ii)	(I)	Voltage across X = 12 [V]	[1]	
			(II)	12 V - 6 V = 6 [V] ecf from (I)	[1]	
		(III)	$R_2 = \frac{6}{4} = 1.5[\Omega]$ ecf from (II)	[1]		
		(IV)	V across $R_1 = 3\text{ [V]}$ (1) I through $R_1 = 6\text{ [A]}$ (1)	[3]		
			$R_1 = \frac{3}{6}$ (ecf on I and/or V) = 0.5[Ω] (1)			
			Question 4 Total			

Question				Marking details	Marks Available
5	(a)			$R = \frac{\rho \ell}{A}$ (1) ρ constant (1) Effect of change in l and A on R (1)	[3]
	(b)	(i)		$CSA = 2.4 \times 10^{-10} \text{ m}^2$ (1) $l = 6 \times 3.2 \times 10^{-2} \text{ m}$ (= 0.192 m) (1) Correct substitution into $R = \frac{\rho \ell}{A}$ to show $R = 56 [\Omega]$ (1)	[3]
		(ii)		$0.1\% \times 56 = 0.056 \Omega$ (1) $\Delta l = 1.9 \times 10^{-4} [\text{m}]$ (ecf) (1)	[2]
		(iii)		Zig-zag pattern ensures long length of wire (1) Therefore maximise Δl (or maximise ΔR - or equivalent) or measure strain in a small region (1)	[2]
				Question 5 Total	[10]
6	(a)			No net force (1) No net moment (1)	[2]
	(b)	(i)		Downward pointing arrow placed in (approximate) centre of beam	[1]
		(ii)		Clockwise: $(10 \times 1.5) + (20 \times 3)$ (1) Anti-clockwise: $40d$ (1) $d = 1.875 [\text{m}]$ (1)	[3]
		(iii)		$10 [\text{N}]$ (1) Downwards (1)	[2]
				Question 6 Total	[8]

Question				Marking details	Marks Available
7	(a)	(i)		Mass of air = ρAu (1) Convincing substitution into $\frac{1}{2} mu^2$ (1)	[2]
		(ii)	(I) (II)	4 (1) 8 (1)	[2]
		(iii)		$\frac{1}{2} A\rho(u^3 - v^3)$ (or equivalent)	[1]
		(iv)		Turbines in front will have removed energy from the wind - or equivalent	[1]
		(v)		Substitution into $\frac{1}{2} A\rho(u^3 - v^3)$ (or equivalent) (1) $P = 1\,644\text{ [W]}$ (1) (- 1 mark for error in A)	[2]
	(b)	(i)		Energy passing through blades insufficient to overcome friction of moving parts.	[1]
		(ii)		Efficiency = $54\% \pm 1\%$ (1) $P = 888\text{ W}$ (ecf from (a)(v)) UNIT mark (1)	[2]
	(c)			<u>Density of water</u> much greater than density of air	[1]
				Question 7 Total	[12]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01

PHYSICS – PH1

Motion Energy and Charge

P.M. MONDAY, 20 May 2013

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	11	
2.	16	
3.	12	
4.	10	
5.	12	
6.	9	
7.	10	
Total	80	

1321
010001

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

1. (a) Velocity and acceleration are both vector quantities.

(i) State what is meant by a vector quantity. [1]

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(ii) Name **one** other vector quantity. [1]

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(b) One of the equations of motion for constant acceleration is $x = ut + \frac{1}{2}at^2$.

(i) Show that this equation is correct in terms of units. [3]

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(ii) The displacement x , in metres, of a car travelling in a straight line with uniform acceleration at a time t , in seconds, from the start of the motion is given by

$$x = 8t + 3t^2$$

(I) State the initial velocity, u , of the car (at $t = 0$). [1]

(II) Determine the car's acceleration. [1]

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(III) Calculate the displacement when $t = 5.0$ s. [1]

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(IV) Calculate the velocity when $t = 5.0\text{ s}$.

[3]

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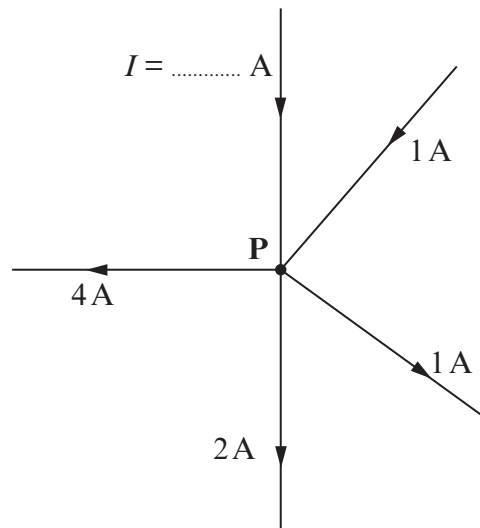
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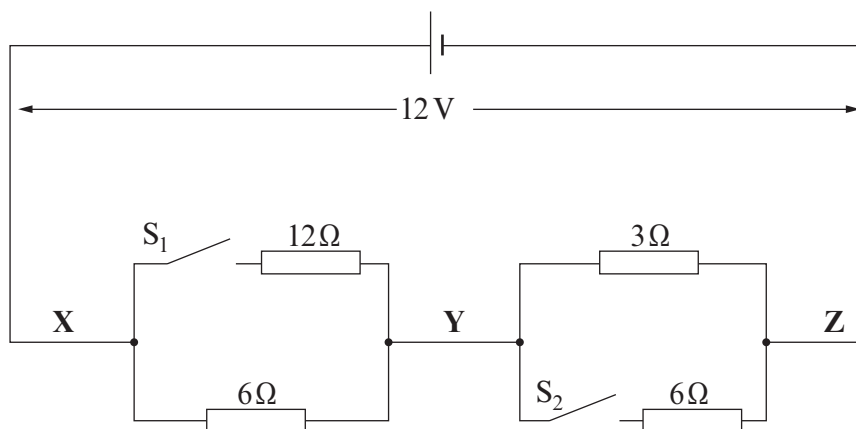
2. (a) When a quantity of charge flows into a junction in a circuit, an equal quantity must flow out again. In this way the flow of charge is conserved in any circuit.

(i) What name is given to the rate of flow of charge? [1]

(ii) Apply the above conservation law to the junction at **P** to determine the value of I . [1]



- (b) Resistors are connected as shown in the diagram, and a pd of 12 V is applied across them. S_1 and S_2 are switches.



(i) Calculate the resistance of the circuit when both S_1 and S_2 are closed. [3]

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- (ii) Hence determine the pd between **X** and **Y** and also the pd between **Y** and **Z** when both switches are closed. [2]

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- (iii) How would your answers to (b)(ii) differ (if at all) with both switches open? Explain your answer. [2]

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- (iv) Determine the switch settings that would allow a current of 1.5 A to flow through the cell. [2]

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- (v) Determine the power developed in the circuit when both switches are open. [2]

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- (vi) Determine the switch settings that allow the maximum power to be developed in the circuit. Justify your answer. [3]

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3. (a) Define the *emf* of a cell.

[2]

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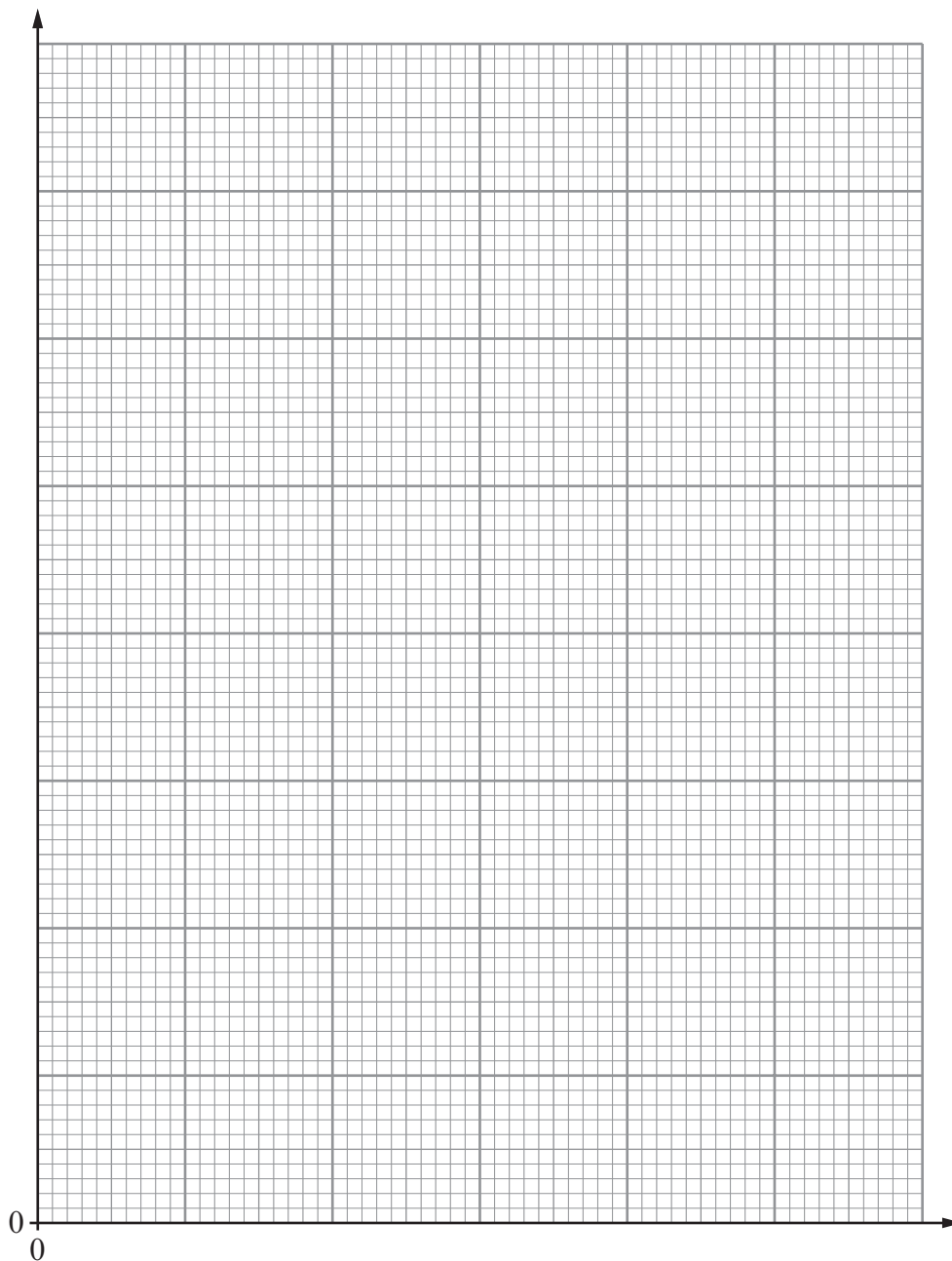
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- (b) A student carries out an experiment to determine the *emf* and internal resistance of a cell. The *pd* across the cell is measured when it is supplying various currents. The following readings are obtained. Plot these results on the grid (*pd* on the *y*-axis and current on the *x*-axis) and draw a line through your points.

[3]

Current / A	0.20	0.42	0.66	0.96	1.20
<i>pd</i> / V	1.31	1.13	0.93	0.68	0.48



(c) Use your graph to determine:

(i) the emf of the cell;

[1]

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(ii) the internal resistance of the cell.

[2]

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(d) The cell is then connected to a torch bulb of resistance 6.0Ω for 20 minutes. Calculate the charge that flows through the bulb in this time. Assume the emf remains constant.

[4]

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4. (a) (i) Draw a labelled diagram of the apparatus you could use to determine the relationship between the resistance and length of a metal wire. [3]

- (ii) Sketch a graph to show the relationship you would expect to find. [1]



- (iii) Describe how you would use your graph to find the resistivity of the metal. You should describe the **additional measurement** you need to make and how you would use it. [3]

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- (b) A metal wire has resistance R and is in the form of a cylinder of length l and uniform cross-sectional area A . The wire is now stretched to **three** times its original length in a process that keeps the volume constant. Show, in clear steps, that the resistance of the wire increases to $9R$. [3]

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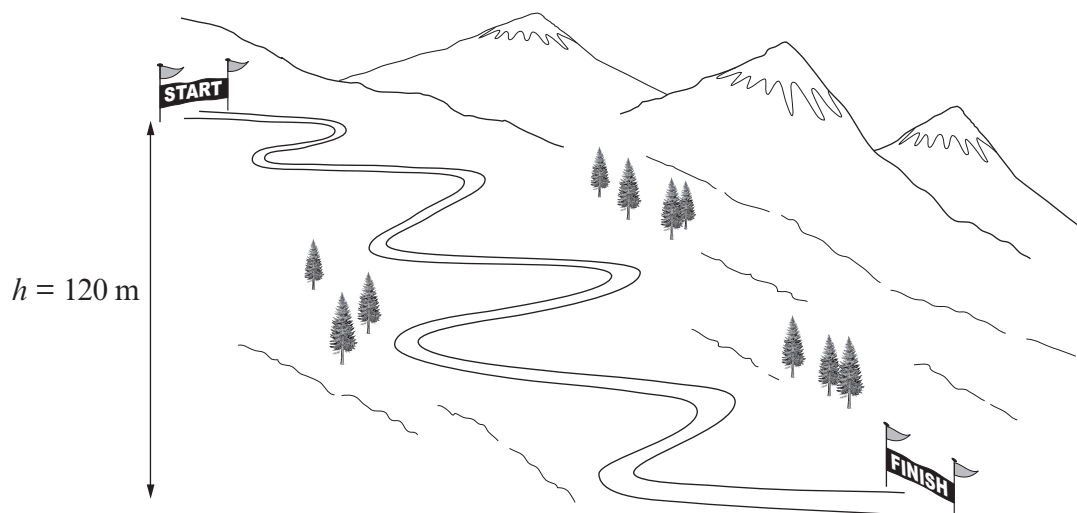
5. (a) State the principle of conservation of energy.

[1]

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- (b) A bobsleigh run in Norway has a curving track of overall length 1.4 km from start to finish. During a run, the bobsleigh starts from rest, and drops through a vertical height, h , of 120 m.



- (i) Assuming no resistive forces, show that the maximum possible speed, v , of a bobsleigh at the finish line is given by [2]

$$v = \sqrt{2gh}$$

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- (ii) Hence calculate the maximum possible speed of a bobsleigh at the finishing line. [1]

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- (c) (i) Due to resistive forces, the actual speed at the finishing line is **20% less** than the maximum possible speed. Give **two** examples of resistive forces acting on the bobsleigh. [2]

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- (ii) Taking the resistive forces into account, calculate the kinetic energy of the bobsleigh at the finish. The mass of the bobsleigh and riders = 280 kg. [2]

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- (iii) Hence, determine the mean resistive force experienced by the bobsleigh from start to finish. [4]

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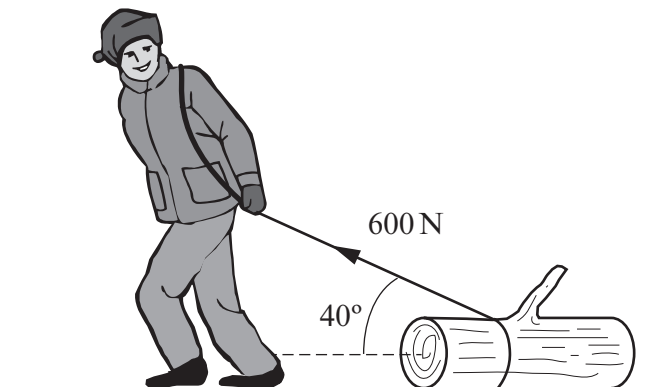
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6. A man pulls a tree trunk with a force of 600 N inclined at 40° to the horizontal.



- (a) (i) Calculate the horizontal component of the 600 N force pulling the tree trunk forwards. [2]

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- (ii) Calculate the vertical component of the 600 N force. [1]

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- (b) Using your answer to (a)(ii) and taking the mass of the tree trunk to be 90 kg, determine the vertical force between the tree trunk and the ground. [2]

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- (c) The **horizontal frictional force** acting on the tree trunk is $0.8 \times$ the vertical force between the tree trunk and the ground. Calculate the acceleration of the tree trunk. [3]

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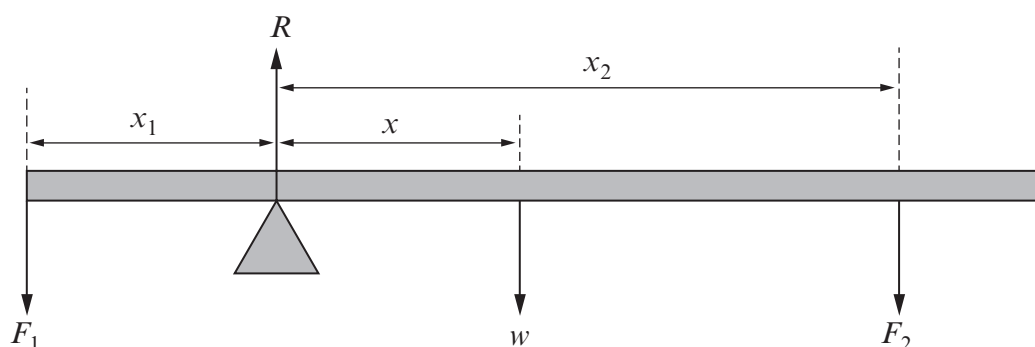
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- (d) The weight of the tree trunk is a measure of the Earth's gravitational pull on the tree trunk. Identify the Newton third law 'equal and opposite' force to the weight of the tree trunk. [1]

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7. (a) One condition for a body to remain in equilibrium is that there should be *no net moment* acting on it about any point. State the other condition necessary for a body to remain in equilibrium. [1]

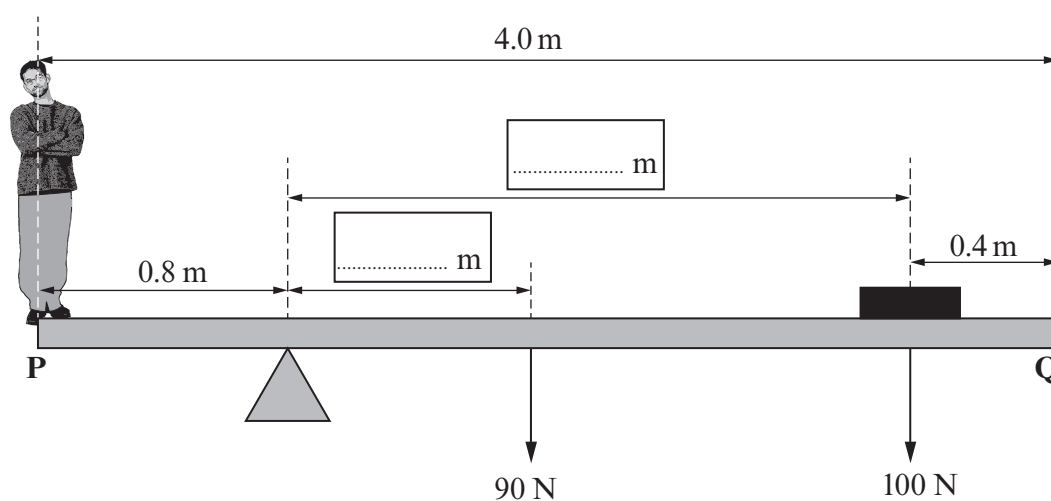
- (b) The diagram shows a uniform plank of weight w pivoted so that it remains in equilibrium when forces F_1 and F_2 are applied to it at distances x_1 and x_2 as shown. R represents the contact force at the pivot.



Applying the principle of moments about the pivot, complete the equation: [1]

$$F_1 x_1 = \dots\dots\dots$$

- (c) An experiment is carried out to find the weight of a Physics student. A uniform plank of wood **PQ**, 4.0 m long and weighing 90 N is pivoted about a point 0.8 m from **P**. A 100 N weight is placed 0.4 m from **Q** in order to balance the plank horizontally.



- (i) Use the information given to fill in the two blank boxes with relevant distances. [1]

- (ii) Hence calculate the weight of the student.

[2]

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- (iii) Determine the value of the force exerted by the pivot on the plank.

[1]

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- (iv) By taking moments about **Q**, and using your answers to (c)(ii) and (c)(iii), confirm that the plank is in equilibrium.

[2]

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- (v) The student now steps off the plank and is replaced by another, heavier student who stands at point **P**. Which way must the **pivot** be moved in order to balance the plank horizontally? Explain your answer.

[2]

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END OF PAPER



GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k \text{ max}} = hf - \phi$$

$$\lambda_{\text{max}} = W T^{-1}$$

$$P = A\sigma T^4$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e ⁻)	electron neutrino (ν _e)		up (u)	down (d)
charge (e)	-1	0		+ $\frac{2}{3}$	- $\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A \omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3}\rho\overline{c^2}$$

$$U = \frac{3}{2}nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2}QV$$

$$Q = Q_0 e^{-t/\tau_{RC}}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

A2**Fields**

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2} \quad E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} \quad V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} \quad W = q\Delta V_E,$$

$$F = G \frac{M_1 M_2}{r^2} \quad g = \frac{GM}{r^2} \quad V_g = \frac{-GM}{r} \quad W = m\Delta V_g$$

Orbiting Bodies

Centre of mass: $r_1 = \frac{M_2}{M_1 + M_2} d;$

Period of Mutual Orbit: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$

Options

A: $\frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$

B: Electromagnetism and Space-Time

$$c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

B: The Newtonian Revolution

$$\frac{1}{T_P} = \frac{1}{T_E} - \frac{1}{t_{\text{opp}}}$$

$$\frac{1}{T_P} = \frac{1}{T_E} + \frac{1}{t_{\text{inf conj}}}$$

$$r_P = a(1 - \epsilon)$$

$$r_A = a(1 + \epsilon)$$

$$r_P v_P = r_A v_A$$

C: $\epsilon = \frac{\Delta I}{I}; \quad Y = \frac{\sigma}{\epsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \epsilon V$

D: $I = I_0 \exp(-\mu x); \quad Z = c\rho$

E: $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x} \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

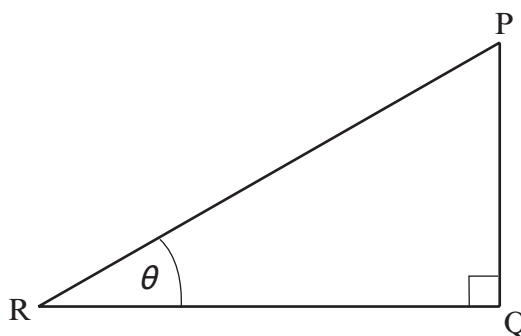
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the Summer 2013 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

	Page
PH1	1
PH2	5
PH4	10
PH5	17

GCE Physics - PH1

Question			Marking details	Marks Available
1.	(a)	(i)	[A quantity with] magnitude / size and direction.	[1]
		(ii)	Any suitable quantity (e.g force) other than velocity or acceleration.	[1]
	(b)	(i)	<i>ut shown</i> to have units: $\text{m s}^{-1} \times \text{s} \rightarrow [\text{m}]$ (1) $(\frac{1}{2})at^2$ shown to have units: $\text{m s}^{-2} \times \text{s}^2 \rightarrow [\text{m}]$ (1) Comment: all terms have same units or equivalent e.g. LHS=RHS (1)	[3]
		(ii)	(I) $u = 8 \text{ m s}^{-1}$ UNIT MARK	[1]
			(II) $\frac{1}{2} a = 3$ $a = 6 [\text{m s}^{-2}]$	[1]
			(III) Substitution and answer $x = 115 [\text{m}]$	[1]
			(IV) Equation (1) Substitution (1) ecf for u , a and x $v = 38 [\text{m s}^{-1}]$ (1)	[3]
		Question 1 total		[11]
	(a)	(i)	[electric] current	[1]
		(ii)	$I = 6 [\text{A}]$	[1]
		(b)	(i) Parallel combinations calculated: 4Ω (1); 2Ω (1) Series addition: $6 [\Omega]$ (1) ecf	[3]
			(ii) $XY \rightarrow \frac{2}{3} \times 12 = 8 [\text{V}]$ (1) or $I = 12/6 = [2 \text{ A}]$ (1) $YZ \rightarrow \frac{1}{3} \times 12 = 4 [\text{V}]$ (1) $V_{xy} = 8 [\text{V}]$ and $V_{yz} = 4 [\text{V}]$ (1)	[2]
		(iii)	ecf No Change (1) Correct explanation in terms of: Either: Ratio of <u>resistances</u> stays the same } (1) ecf Or: New current calculated ($\frac{1}{3}$ A) and used }	[2]
		(iv)	$R = 12/1.5 = 8 [\Omega]$ (1) S_1 open and S_2 closed (1)	[2]
		(v)	$P = (12)^2/9$ or $P = \frac{1}{3} \times 12$ or $P = (\frac{1}{3})^2 \times 9$ (1) $P = 16 [\text{W}]$ (1)	[2]
		(vi)	Strategy - various switch settings and corresponding powers calculated e.g. Close S_1 : $R = 7 \Omega$ or Close S_2 : $R = 8 \Omega$ } (1) $P = 20.6 \text{ W}$ $P = 18 \text{ W}$ }	[3]
		Question 2 total		[16]

Question			Marking details	Marks Available
3.	(a)		[Electrical] energy [or work done] transferred to whole of circuit [or through cell] (1) per coulomb [or unit charge] (1)	[2]
	(b)		Sensible scale and axes labelled with units (1) All points correct $\pm \frac{1}{2}$ small square division (1) Line of best fit (1) (no requirement $\rightarrow$ y axis)	[3]
	(c)	(i)	$E = 1.48$ [V] (± 0.01 V) ecf from graph	[1]
		(ii)	Gradient attempted or $r = \frac{E - V}{I}$ (by implication) (1) $r = 0.83$ [Ω] (1) ecf from graph	[2]
	(d)		$I = \frac{E}{R + r} \left\{ \frac{1.48}{6 + 0.83} \right\}$ (1) (ecf on E and r) $I = 0.22$ A (1) $t = 20 \times 60$ [1 200 s] (1) $Q = 0.22$ (ecf) $\times$ 1 200 (ecf) = 264 [C] (1) Question 3 Total	[4] [12]
4.	(a)	(i)	Ruler and wire (1) Moving pointer (or crocodile clip shown) (1) Ohmmeter connected correctly with no power supply or voltmeter and ammeter positioned correctly with power supply (1)	[3]
		(ii)	Straight line through origin	[1]
		(iii)	Gradient = R/l or pair of R and l values from graph (1) Measure diameter to calculate area (1) $\rho = \text{grad} \times \text{area}$ or substitution into $\rho = RA/l$ (1)	[3]
	(b)		$\text{Vol} = Al = \frac{1}{3}A \times 3l$ (CSA reduced to $\frac{1}{3}$ original) (1) $R = \frac{\rho 3l}{A/3}$ (1) $\rho = \text{constant}$ stated (or implied) (1) OR: $A = \text{vol}/l$ so $R = \rho l^2/\text{vol}$ (1) $R \propto l^2$ (1) New $R \propto (3l)^2$ so new $R = 9R$ (1) Question 4 Total	[3] [10]

Question			Marking details	Marks Available
5.	(a)		Energy cannot be created or destroyed, only converted to other forms.	[1]
	(b)	(i)	$\frac{1}{2}mv^2 = mgh$ shown or use of $v^2 = u^2 + 2ax$ (1) (no mark for $E_k = E_p$ only)	[2]
		(ii)	Clear manipulation (1) $v = 48.5 \text{ [ms}^{-1}\text{]}$	[1]
	(c)	(i)	Air resistance /drag (1) Friction between bobsleigh and ice or surface or track or on surface /ice/snow (1)	[2]
		(ii)	Actual $v = [48.5 - 20\% \times 48.5] = 38.8 \text{ ms}^{-1}$ (1) (ecf) Actual $E_k = 210\,762 \text{ [J]}$ (1)	[2]
		(iii)	Either $[\frac{1}{2} \times 280 \times (48.5)^2 - 210\,762]$ or $[280 \times 9.8 \times 120 - 210\,762]$ (ecf on 48.5 or 210 762) (1) Work done against resistive forces = 118 500 J (1) $= F \times 1\,400$ (1) ecf $F = 85 \text{ [N]}$ (1) ecf for use of 1.4 km	[4]
			Question 5 Total	[12]
6.	(a)	(i)	$\cos 40^\circ$ (1); $600 \cos 40^\circ = 460 \text{ [N]}$ (1)	[2]
		(ii)	386 [N] no ecf if sin or cos mixed up	[1]
	(b)		$(90 \times 9.8) - 386$ (1) (ecf) N.B. if 10 used -1 mark) $= 496 \text{ [N]}$ (1)	[2]
	(c)		$0.8 \times 496 = 397 \text{ N}$ (1) ecf $\Sigma F_{\text{horizontal}} = (460 - 397) = 63 \text{ N}$ (1) (ecf) $a = 0.7 \text{ ms}^{-2}$ (1) UNIT MARK	[3]
	(d)		gravitational pull of tree trunk on earth	[1]
			Question 6 Total	[9]

Question			Marking details	Marks Available
7.	(a)		No net force / all forces acting on the body are balanced / $\sum F=0$	[1]
	(b)		$w x + F_2 x_2$	[1]
	(c)	(i)	1.2 [m] and 2.8 [m] – correctly labelled	[1]
		(ii)	$w \times 0.8 = 90 \times 1.2 + 100 \times 2.8$ (1) (ecf on 1.2 and 2.8) $w = 485$ [N] (1)	[2]
		(iii)	$R = 675$ [N] (ecf on w)	[1]
		(iv)	Anticlockwise and clockwise moments calculated correctly (even as ecf) (1) Both = 2 160 [N m] or $\sum$ moments about Q shown=0 (1)	[2]
		(v)	To the left (or towards P) (1) Increased clockwise moment needed to counteract increased anti-clockwise moment or sensible statement related to weight and distance (1)	[2]
Question 7 Total			[10]	

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01

PHYSICS – PH1

Motion Energy and Charge

P.M. FRIDAY, 11 January 2013

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	12	
4.	12	
5.	11	
6.	10	
7.	15	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

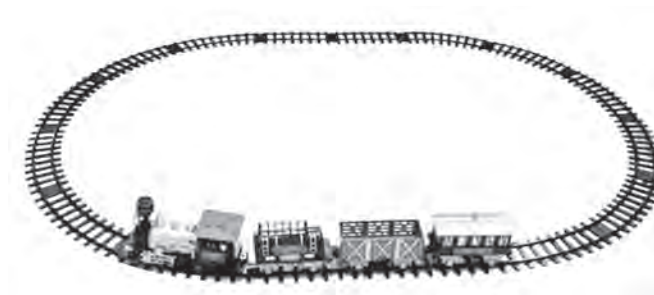
The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

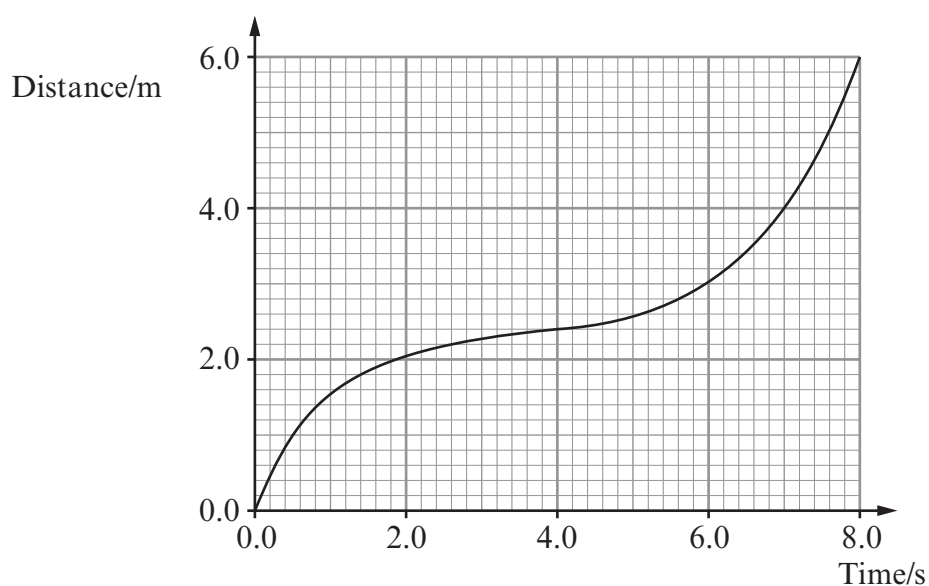
You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

1. The diagram shows a toy train track. One complete lap is 6.0 m.



- (a) A toy train takes 8.0 s to complete one lap. Its motion is described by the following distance-time graph.



- (i) Describe the motion of the train in the region 1.0 s to 3.0 s. Explain your answer. [2]

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- (ii) Determine the mean speed of the train over the lap. [1]

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- (iii) Determine the speed of the train at $t = 6.0$ s. [2]

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- (iv) The gradient of the graph is very large between 7.0 s and 8.0 s. Explain, making reference to the motion of the train, whether or not it would be possible for the graph to be

(I) vertical; [1]

.....

(II) horizontal. [1]

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- (b) Whilst playing with the train track a Physics student states:

“No matter how fast I make the train go, the mean velocity over one complete lap is always going to be zero.”

Explain whether the above statement is correct. [2]

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2. (a) (i) Define resistance.

[1]

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- (ii) The unit of resistance is the ohm (Ω). Show that it is possible to express the Ω as

[3]

$$\text{J s C}^{-2}$$

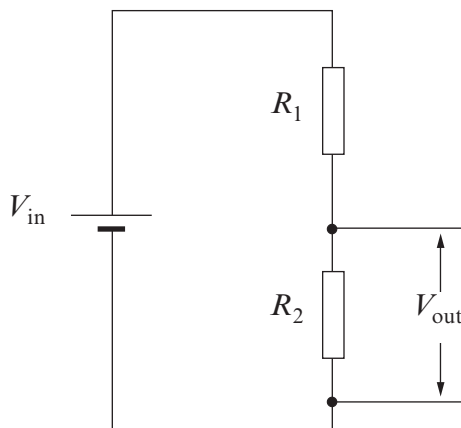
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- (b) The diagram shows a potential divider.



- (i) Write down an equation for the current through resistors R_1 and R_2 when the input pd V_{in} is applied as shown. [1]

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- (ii) Hence show that the output pd V_{out} is given by the equation [2]

$$V_{out} = \frac{R_2}{R_1 + R_2} V_{in}$$

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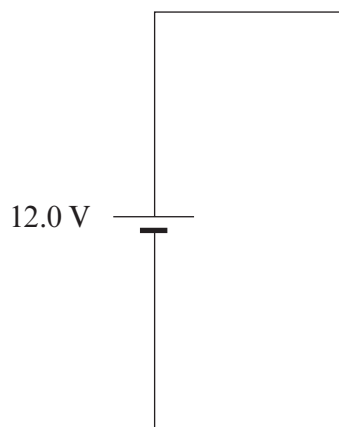
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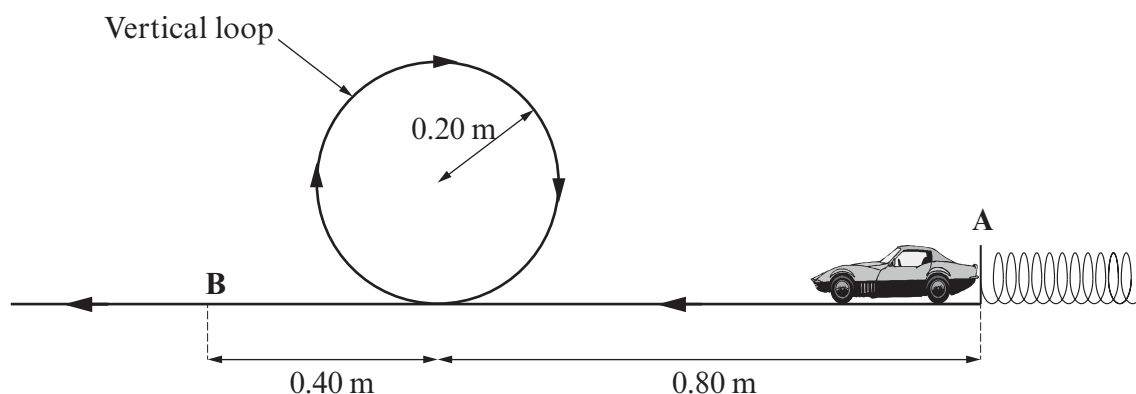
(c) Three resistors are available with values $40\ \Omega$, $40\ \Omega$ and $80\ \Omega$.

- (i) Draw a diagram showing how **two** of these resistors can be connected together to give a combined resistance of $20\ \Omega$. [2]

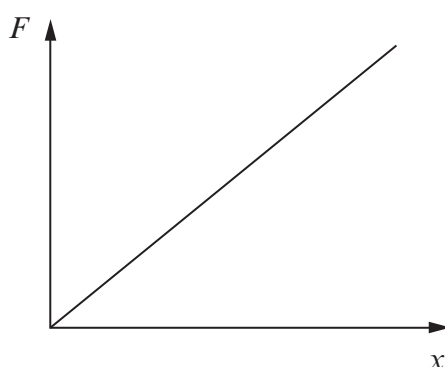
- (ii) Hence, using all three of the resistors, complete the following potential divider circuit for which $V_{\text{out}} = 2.4\ \text{V}$ when $V_{\text{in}} = 12.0\ \text{V}$. Clearly label the resistor values and V_{out} on your diagram. [2]



3. A compressed spring is used to shoot a small toy car along a track which contains a circular vertical loop of radius 0.20 m. The spring obeys Hooke's law. Points **A** and **B** are referred to later in the question.



- (a) The sketch graph shows how the extension, x , of the spring varies with the force, F , applied to it.



- (i) Explain how the graph shows that the spring obeys Hooke's law. [1]

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- (ii) Use the graph to show that the elastic potential energy stored in the spring $= \frac{1}{2} kx^2$, where k is the spring constant. [2]

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(b) The spring requires a force of 0.10 N to compress it 1.0 mm.

- (i) Calculate the elastic potential energy stored in it when it is compressed by 80 mm. [3]

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- (ii) A small car of mass 0.04 kg is placed at point A, against the end of the spring, which is then released. Using your answer to (b)(i), calculate the speed with which the car leaves the spring. [2]

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(c) The speed of the car at point B (after it has completed the loop) is 0.2 m s^{-1} less than its speed at A. Determine the mean frictional force on the car during its motion from A to B. [4]

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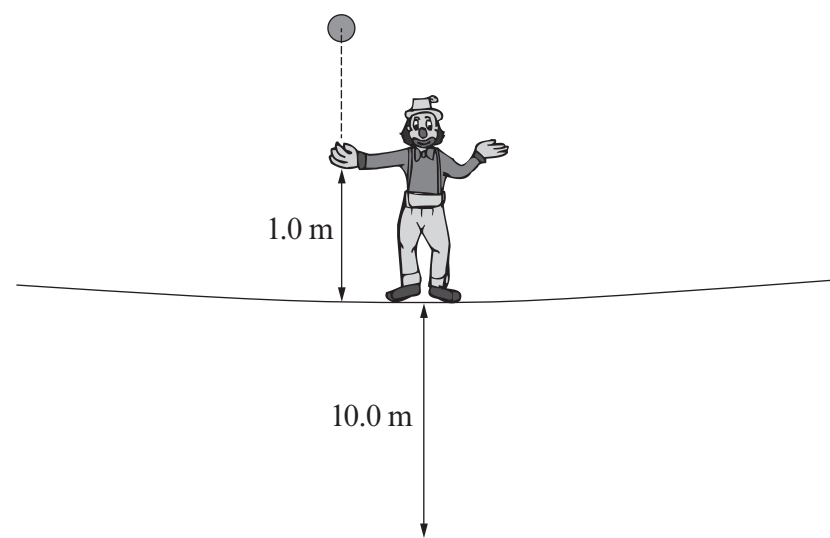
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4. (a) A circus performer standing on a tightrope 10.0 m above the ground throws a ball vertically upwards at a speed of 6.0 m s^{-1} . The ball leaves his hand 1.0 m above the tightrope as shown. *The diagram is not to scale.*



- (i) Calculate the maximum height **above the ground** that the ball reaches. [3]

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- (ii) The performer fails to catch the ball as it drops. Calculate:

- (I) the speed with which the ball hits the ground; [2]

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- (II) the **total** time the ball is in the air. [3]

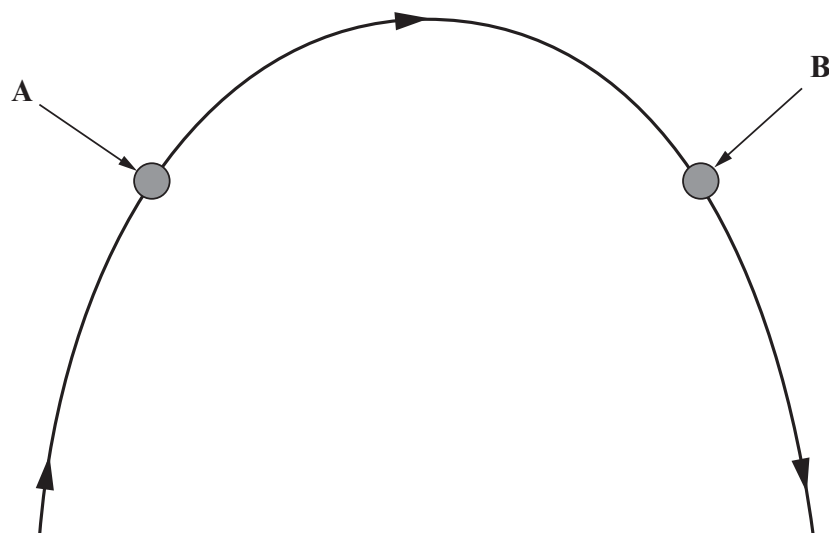
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- (b) Another ball is thrown into the air and follows the path shown. The ball is shown in two places, **A** and **B**.

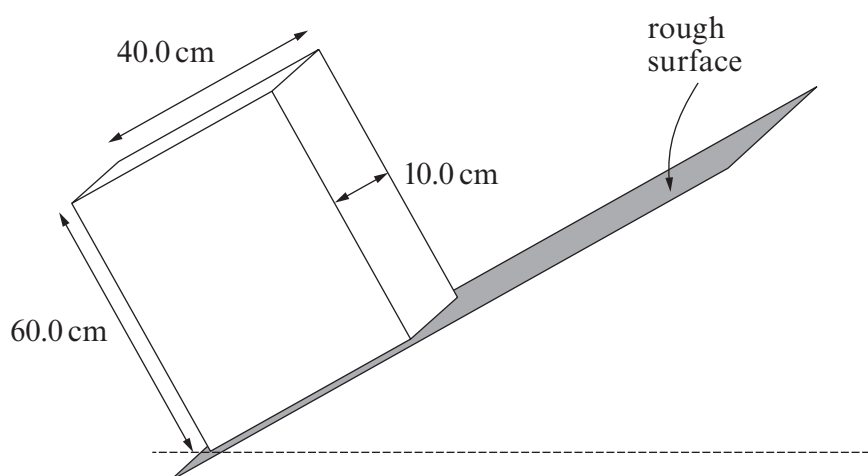


- (i) Assuming the force of air resistance is negligible, circle **one** of the following drawings that shows the direction of the resultant force on the ball when it is at **A**. Explain your answer. [2]

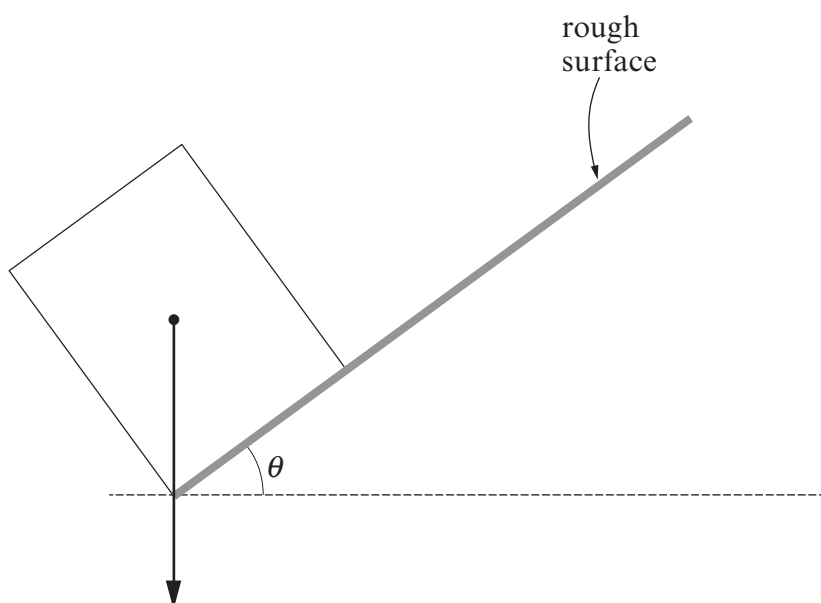


- (ii) Assuming the force of air resistance **cannot** be neglected, sketch a diagram below to show the forces acting on the ball as it falls towards the ground in position **B** as shown in the above diagram. [2]

5. (a) A solid block of uniform density with sides 60.0 cm, 40.0 cm and 10.0 cm rests on a sloping rough surface.



The following diagram shows the block viewed from the side **at the point of toppling**. An arrow is shown passing through the centre of gravity of the block.



- (i) Explain what is meant by 'centre of gravity'. [1]

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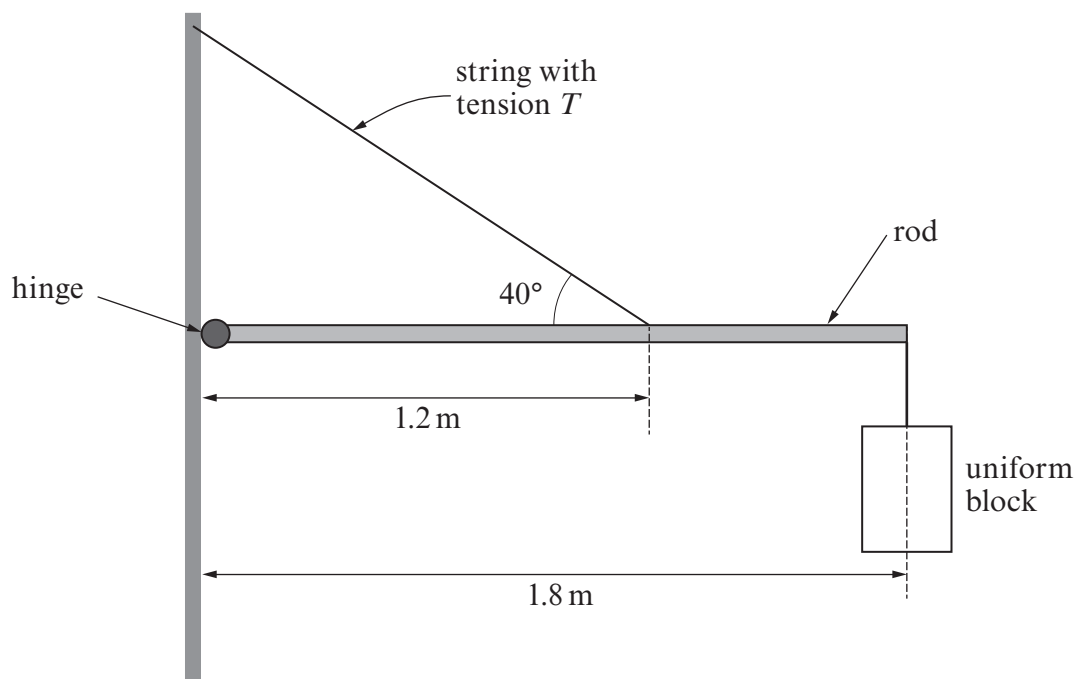
- (ii) Calculate the angle θ . Assume that no sliding occurs. [2]

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- (b) The block (in part (a)) is now attached to a rod of **negligible weight** which is supported by a string and a frictionless hinge as shown in the diagram below.



- (i) The density of the material of the block is 400 kg m^{-3} . Show that the mass of the block is 9.6 kg. [2]

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- (ii) By taking moments about the hinge, calculate the tension in the string. [4]

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- (iii) Hence calculate the horizontal component of the force that the rod exerts on the hinge. [2]

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6. A power cable has a resistance of 11.2Ω and is made of an alloy of aluminium of resistivity $2.8 \times 10^{-8}\Omega\text{m}$. It is used to link a power station to a town 160 km away.

(a) (i) Show that the cross-sectional area of the cable is $4.0 \times 10^{-4}\text{m}^2$. [1]

.....

.....

(ii) Calculate the current in the cable given that the pd across it is 2.0 kV. [1]

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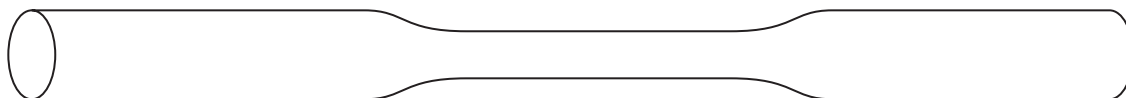
(iii) Calculate the mean drift velocity of the free electrons in the cable given that there are 6.0×10^{28} atoms per m^3 of aluminium and each atom contributes 3 free electrons. [3]

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- (b) A small portion of the cable is damaged. As a result its cross-sectional area is less than that of the rest of the cable, as shown in the diagram.



(i) State how the current in the thinner portion compares with the current in the rest of the cable. [1]

.....

(ii) State how the mean drift velocity of free electrons in the thinner portion compares with that in the rest of the cable. Justify your answer. [2]

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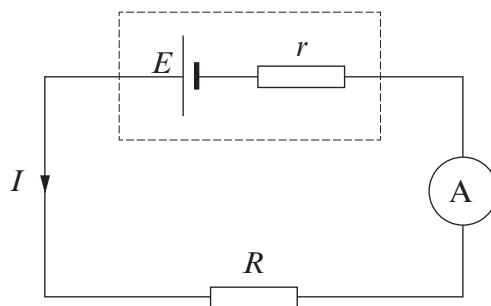
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(iii) Hence suggest, in terms of particles, why the damaged part of the cable will be prone to overheating. [2]

.....

.....

7. A student sets up the following circuit using a cell of emf E and internal resistance r .



- (a) An equation which can be applied to the above circuit is

$$V = E - Ir$$

Explain, **in terms of energy**, the meanings of V , E and Ir .

[4]

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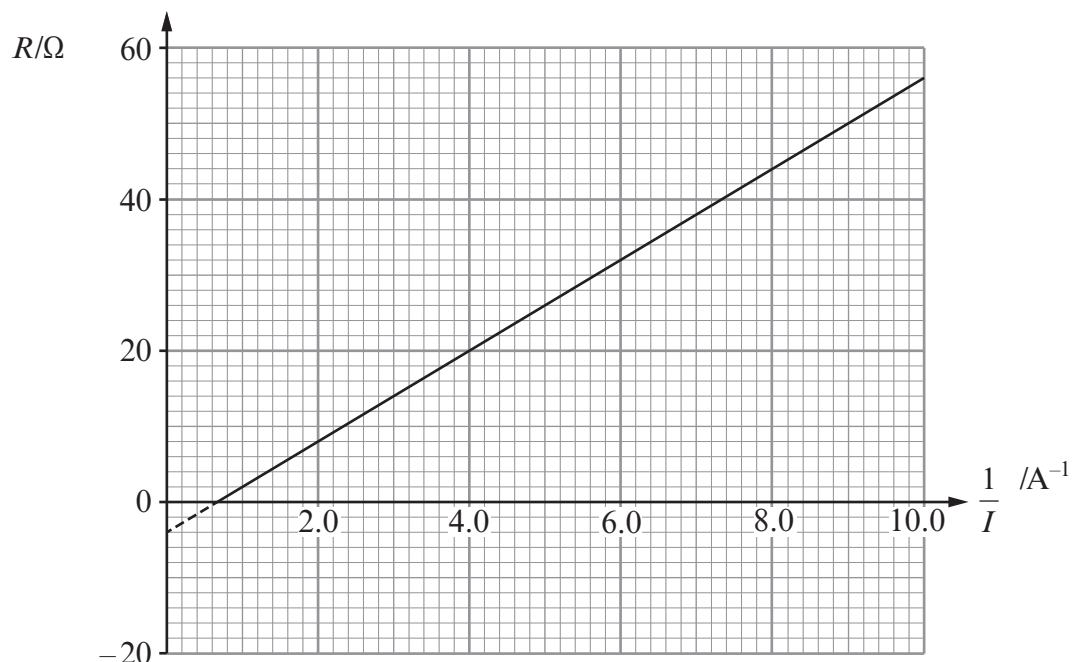
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- (b) The student measures the current I for different values of R . She then plots a graph of R against $\frac{1}{I}$.



The equation for this graph is

$$R = \frac{E}{I} - r$$

- (i) Use the graph to find the internal resistance, r , of the cell. [1]
-
- (ii) Determine the emf of the cell. [2]
-
-
-
- (iii) Referring to the graph, calculate the power dissipated in the resistor R when there is a current of 0.25 A. [4]
-
-
-
-
-

(c) A second identical cell is added in series with the original cell and the experiment is repeated.

- (i) Write down the emf and the internal resistance of the new combination of cells. [1]

emf = ... internal resistance = ...

- (ii) Hence, using the equation $R = \frac{E}{I} - r$, determine the value of R for this experiment when there is a current of 0.2 A. [1]

.....
.....

- (iii) **Draw on the graph** the result of this experiment. [2]

END OF PAPER

[illegible]



GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k \text{ max}} = hf - \phi$$

$$\lambda_{\text{max}} = WT^{-1}$$

$$P = A\sigma T^4$$

$$\text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{total energy input}} \times 100\%$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e ⁻)	electron neutrino (ν _e)		up (u)	down (d)
charge (e)	-1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
Lepton number	1	1		0	0

A2

$$\begin{array}{lll}
 \omega = \frac{\theta}{t} & M/\text{kg} = \frac{M_r}{1000} & F = BIl \sin \theta \text{ and } F = Bqv \sin \theta \\
 v = \omega r & pV = nRT & B = \frac{\mu_o I}{2\pi a} \\
 a = \omega^2 r & p = \frac{1}{3} \rho \overline{c^2} & B = \mu_o nI \\
 a = -\omega^2 x & U = \frac{3}{2} nRT & \Phi = AB \cos \theta \\
 x = A \sin(\omega t + \varepsilon) & k = \frac{R}{N_A} & V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}} \\
 v = A\omega \cos(\omega t + \varepsilon) & W = p\Delta V & A = \lambda N \\
 T = 2\pi \sqrt{\frac{m}{k}} & \Delta U = Q - W & N = N_o e^{-\lambda t} \text{ or } N = \frac{N_o}{2^x} \\
 p = mv & C = \frac{Q}{V} & A = A_o e^{-\lambda t} \text{ or } A = \frac{A_o}{2^x} \\
 Q = mc\Delta\theta & C = \frac{\varepsilon_o A}{d} & \lambda = \frac{\log_e 2}{T_{1/2}} \\
 p = \frac{h}{\lambda} & U = \frac{1}{2} QV & E = mc^2 \\
 \frac{\Delta\lambda}{\lambda} = \frac{v}{c} & Q = Q_o e^{-1/RC} &
 \end{array}$$

Fields

$$\begin{array}{llll}
 F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2} & E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2} & V_E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r} & W = q\Delta V_E, \\
 F = G \frac{M_1 M_2}{r^2} & g = \frac{GM}{r^2} & V_g = \frac{-GM}{r} & W = m\Delta V_g
 \end{array}$$

Orbiting Bodies

$$\text{Centre of mass: } r_1 = \frac{M_2}{M_1 + M_2} d;$$

$$\text{Period of Mutual Orbit: } T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$$

Options

$$\text{A: } \frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$$

$$\text{B: } c = \frac{1}{\sqrt{\mu_o \varepsilon_o}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\text{C: } \varepsilon = \frac{\Delta I}{l}; \quad Y = \frac{\sigma}{\varepsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \varepsilon V$$

$$\text{D: } I = I_o \exp(-\mu x); \quad Z = c\rho$$

$$\text{E: } \frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x} \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1} \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

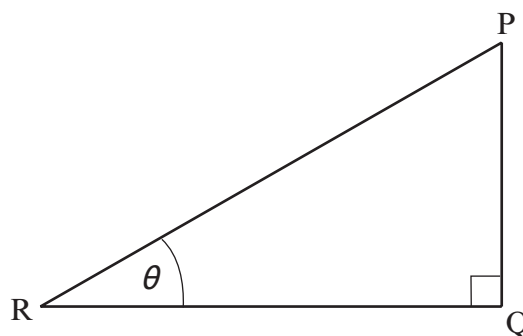
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS
AS/Advanced

JANUARY 2013

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2013 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

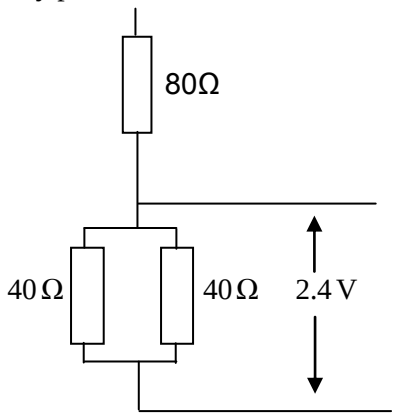
It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

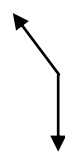
WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Unit	Page
PH1	1
PH2	5
PH4	12

GCE Physics - PH1

Mark Scheme - January 2013

Question			Marking details	Marks Available
1	(a)	(i)	Decelerating (1) Gradient changes/decreases or correct use of values from the graph (1)	[2]
		(ii)	0.75 m s^{-1} (unit mark)	[1]
		(iii)	Any tangent at 6 s (1) Speed: $0.55 - 0.75 \text{ [m s}^{-1}]$ (1)	[2]
		(iv)	(I) No- infinite speed (or equiv) don't accept very large speed (II) Yes- stopped	[1] [1]
	(b)		$Velocity = \frac{Displacement}{Time}$ (1); Displacement = 0 [over 1 complete lap] (1)	[2]
			Question 1 total	[9]
2	(a)	(i)	$Resistance = \frac{pd}{current}$ (accept: voltage / if V and I written must be qualified)	[1]
		(ii)	$V = JC^{-1}$ (1); $I = C s^{-1}$ (1); Convincing working (1) Don't accept use of t -award ecf for 3 rd mark. Alternative route using power formulae is acceptable.	[3]
	(b)	(i)	$I = \frac{V_{in}}{R_1 + R_2}$	[1]
		(ii)	$V_{out} = IR_2$ (1); I (from (i)) used correctly (1)	[2]
	(c)	(i)	Any parallel combination shown (1); $40 [\Omega]$ used correctly (1)	[2]
		(ii)	 Resistor combination shown (1) ecf from (c)(i) 2.4 [V] or V_{out} labelled correctly (1)	[2]
			Question 2 total	[11]

Question			Marking details	Marks Available
3	(a)	(i)	Straight line through origin. Accept $F \propto x$.	[1]
		(ii)	Area = $\frac{1}{2}Fx$ (1); $F = kx$ and clear substitution/manipulation (1)	[2]
	(b)	(i)	$F = 8.0 \text{ [N]}$ (1) or $k = 100 \text{ [N m}^{-1}\text{]}$ (1) Use of $\frac{1}{2}Fx$ (1) or Use of $\frac{1}{2}kx^2$ (1) (i.e. $\frac{1}{2} \times 8.0 \times 80 \times 10^{-3}$) (1) (i.e. $\frac{1}{2} \times 100 \times (80 \times 10^{-3})^2$) (1) $= 0.32 \text{ [J]}$ (1) (ecf for F) $= 0.32 \text{ [J]}$ (1) (ecf for derived value of k)	[3]
		(ii)	$0.32 = \frac{1}{2}mv^2$ (ecf) (1); $v = 4.0 \text{ [ms}^{-1}\text{]}$ (1)	[2]
	(c)		$\Delta E_k = Fd$ understood (1) $d = (0.8 + 0.4 + (2\pi(0.2)))$ or 2.46 [m] (1) $\Delta E_k = 0.03 \text{ [J]}$ or $(\frac{1}{2} \times 0.04 \times (4^2 - 3.8^2))$ (1) (ecf from (b) (ii)) $F = 0.013 \text{ [N]}$ (1) (ecf for d) Alternative method using equations of motion and $F = ma$ acceptable.	[4]
Question 3 Total			[12]	
4	(a)	(i)	Correct use of $v^2 = u^2 + 2ax$ (i.e. $0 = 6^2 - 2 \times 9.81 \times x$) (1) $x = 1.8 \text{ [m]}$ (1) Total height = 12.8 [m] (1) (ecf for x)	[3]
		(ii)		
		(I)	$v^2 = 2 \times 9.81 \times 12.8$ (ecf) (1) or suitable alternative $v = 15.9 \text{ [ms}^{-1}\text{]}$ (1)	[2]
		(II)	$t_{\text{up}} = \left(\frac{0 - 6}{-9.81} \right) = 0.6 \text{ [s]}$ (1)	
	(b)		$t_{\text{down}} = \left(\frac{15.9(\text{ecf}) - 0}{9.81} \right) = 1.6 \text{ [s]}$ (1) Total time = 2.2 [s] (1) (other solutions possible)	[3]
		(i)	 (1) Ball only acted upon by force due to gravity / weight is the only force acting (1) Only award 2 nd mark if 1 st mark correct.	[2]
	(ii)	 (1) Marks are independent. If additional arrows present deduct 1 mark for each extra arrow. (1)	[2]	
Question 4 Total			[12]	

Question			Marking details	Marks Available
5	(a)	(i)	Point where entire weight of object acts. Don't accept mass.	[1]
		(ii)	Tan $\theta = 40/60$ (1); $\theta = 33.7^\circ$ (1)	[2]
	(b)	(i)	$V = 0.6 \times 0.4 \times 0.1$ (1); $M = \rho \times V$ used correctly (1)	[2]
		(ii)	$T \sin \theta$ or equivalent (1) $\times 1.2$ (1) = $9.6 \times 9.81 \times 1.8$ (1) $T = 220$ [N] (1)	[4]
		(iii)	$F = 220$ (ecf) $\cos 40^\circ$ or equivalent (1) $F = 169$ [N] (1) Accept Pythagoras solution.	[2]
Question 5 Total			[11]	
6	(a)	(i)	Correct and convincing use of $\rho = \frac{RA}{l}$ (including unit conversion)	[1]
		(ii)	$\left(\frac{2000}{11.2} \right) = 179$ A unit mark	[1]
		(iii)	$v = \frac{I}{nAe}$ rearranged (or shown numerically) (1) $n = 6.0 \times 10^{28} \times 3$ (1) $v = 1.55 \times 10^{-5} \text{ [ms}^{-1}\text{]}$ (ecf on I and n) (1)	[3]
	(b)	(i)	Same (or equivalent)	[1]
		(ii)	v increased (1) because...; A decreased, I, n, e unchanged by implication (1)	[2]
		(iii)	Increased frequency / more collisions between electrons and lattice / atoms / ions or electrons carry greater kinetic energy (1) leading to increased vibrational / kinetic energy of lattice atoms (1)	[2]
		Question 6 Total		

Question			Marking details	Marks Available
7	(a)		V- energy (per coulomb) used in [external] resistor / circuit. (1) E- energy (per coulomb) transferred / supplied by source / in the whole circuit (1) Ir- energy (per coulomb) wasted / lost in source / cell / internal resistance (1) Use of 'per coulomb / unit charge' once. (1)	[4]
		(b) (i)	4 [Ω]	[1]
		(ii)	Gradient attempted e.g. 60/10 (1) (or use of equation ecf from (b) (i)) emf = 6 [V] (1)	[2]
		(iii)	1/I = 4 [A^{-1}] or by implication (1) R = 20 [Ω] (1) Use of I^2R i.e. $(0.25)^2 \times 20$ (ecf) (1) or correct substitution into both $V = IR$ and $P = IV$ or V^2/R $P = 1.25[W]$ (1)	[4]
	(c)	(i)	emf = 12.0 [V] (ecf) and $r = 8.0 [\Omega]$ (ecf)	[1]
		(ii)	R = 52.0 [Ω] (ecf)	[1]
		(iii)	y intercept ($r \rightarrow 8.0 \Omega$ (ecf)) (1) Precise gradient e.g. through (5,52) (ecf) (1)	[2]
			Question 7 Total	[15]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01

PHYSICS

PH1: MOTION ENERGY AND CHARGE

A.M. THURSDAY, 17 May 2012

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	14	
2.	7	
3.	9	
4.	12	
5.	11	
6.	10	
7.	17	
Total	80	

1321
010001

ADDITIONAL MATERIALS

In addition to this paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part-question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer is incorrect.

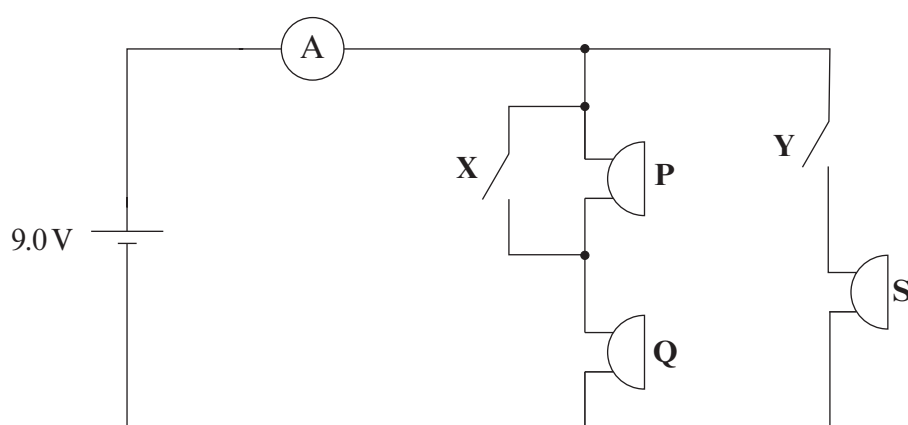
1. (a) (i) State Ohm's law.

[2]

- (ii) The unit of resistance is the ohm (Ω). One of the following is a correct alternative unit to the ohm. Circle the correct one. [1]

VA^{-1} AV^{-1} JC^{-1} Js^{-1}

(b)



In the above circuit, buzzers **P**, **Q** and **S** are controlled using switches **X** and **Y**. **The buzzers are identical and their resistances remain constant.**

- (i) The table shows the possible combinations of open and closed switches. When a switch is closed, charge can flow through it. Complete the table. The first row has been done for you. [3]

Switch combination	P	Q	S
X open, Y open	On	On	Off
X closed, Y open			
X open, Y closed			
X closed, Y closed			

- (ii) With **X** open and **Y** open, the ammeter reads 0.18 A. Calculate the resistance of **each** of the buzzers. [3]

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- (iii) Determine the reading on the ammeter when all three buzzers are on. [2]

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- (iv) When all three buzzers are on, show that

$$\text{power used by S} = 4 \times \text{power used by Q} \quad [3]$$

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2. (a) What is a *superconductor*?

[1]

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(b) A metal conductor is placed in liquid helium. It is noted that at a certain temperature, as the metal cools, its resistance changes suddenly, dropping rapidly to zero.

(i) What name is given to the temperature at which this sudden change occurs? [1]

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(ii) Sketch a graph of resistance against temperature for the above conductor, labelling any key features of your graph. [2]

(iii) What potential difference would be needed to maintain a current in the conductor when it has been immersed in the liquid helium for some time? [1]

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(c) Conducting electrons in a superconductor do not cause a heating effect. Explain why conducting electrons **do** produce a heating effect in wires at room temperature. [2]

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3. A car battery has an emf of 12.0 V. When the car is started the battery supplies a current of 120 A to the starter motor. The potential difference between the battery terminals [terminal pd] drops at this time to 8.4 V due to the internal resistance of the battery.

(a) Explain, **in terms of energy**,

- (i) what is meant by 'an emf of 12.0 V', [2]

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- (ii) why the terminal pd drops when the battery supplies a current. [1]

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- (b) Calculate the internal resistance of the battery. [2]

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- (c) The manufacturer warns against accidentally short-circuiting the battery. Calculate the current that would flow if the battery terminals were short-circuited with a spanner of negligible resistance. [1]

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- (d) The battery will become 'flat' (i.e run out of energy) if it is continually run for a long period of time. It can then be fully recharged by a current of 3.0 A supplied for 16 hours.

- (i) Calculate how much charge flows through the battery in this time. [2]

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- (ii) Estimate how long the starter motor could be operated on a fully-charged battery. [1]

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- [5]

(b) A bungee jumper of mass 70 kg jumps from a high bridge using a bungee cord of natural length 80 m. When he reaches the lowest point for the first time the length of the cord is 130 m. Calculate

- (i) the loss of gravitational potential energy from his position on the bridge to the lowest point for the first time, [2]

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- (ii) the stiffness constant (k) of the bungee cord assuming the cord obeys Hooke's law and that there are no losses due to air resistance, [3]

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- (iii) the extension of the cord when he finally comes to rest (after having 'bounced' a few times). [2]

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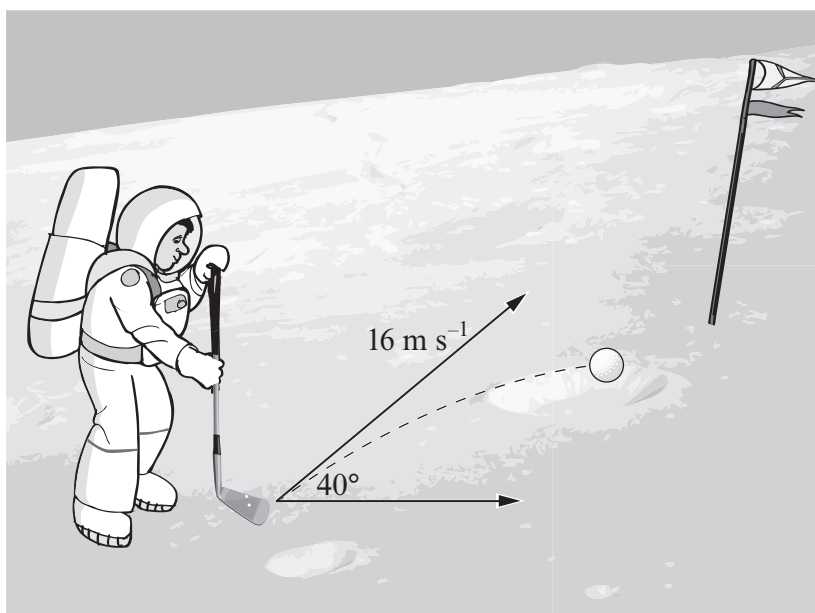
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5. The astronauts of Apollo 14 played golf on the Moon. They struck a number of shots such as the one shown below.



- (a) (i) Calculate the horizontal and vertical components of velocity of the golf ball at the instant it was struck. [2]

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- (ii) Describe the essential difference between the horizontal and vertical components of velocity during the flight of the ball. [1]

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(b) The acceleration due to gravity on the Moon is 1.6 m s^{-2} . Assuming the shot is played on horizontal ground, calculate

(i) the total time of flight, [3]

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(ii) the horizontal distance the ball travels, [1]

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(iii) the maximum height reached. [2]

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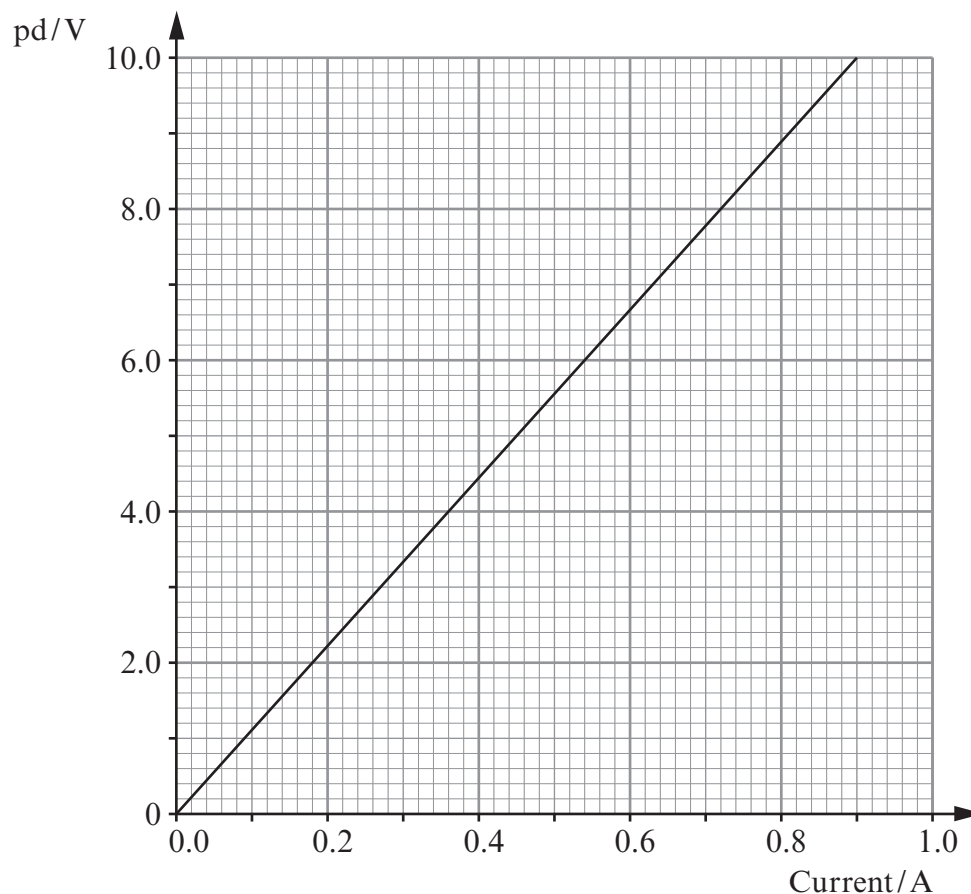
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(c) A similar golf shot is played on Earth. Give two reasons why your answer to (b)(iii) would be different. [2]

1.
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2.
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6. Experiments are carried out to determine the material from which a metal wire is made. Initially the resistivity of the metal is found. The wire's density is then determined and the results compared with known values of resistivity and density.

(a) As a first step to finding the resistivity, an experiment investigates the relationship between pd and current for the wire. The results are shown in the graph.



- (i) Draw a circuit diagram to show how the above results could be obtained. The apparatus available includes a battery, a switch, a variable resistor, an ammeter and a voltmeter. [2]

- (ii) The wire has length 3.2m and **diameter** 0.20mm. Use this information and the graph to calculate the resistivity of the material in the wire. [4]

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- (iii) Using the information in the table, write down **two** possible materials for the wire. [1]

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Material	Resistivity / $\Omega \text{ m}$	Density / kg m^{-3}
Iron	0.97×10^{-7}	7 850
Platinum	1.06×10^{-7}	21 400
Tin	1.12×10^{-7}	7 300
Nichrome	1.10×10^{-6}	8 400

- (b) The mass of the wire is found to be 0.74 grammes. Explaining how you obtain your answer, determine the material from which the wire is made. [3]

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7. The force due to air resistance F_{air} exerted on a skydiver due to her motion through the air is given by

$$F_{\text{air}} = \frac{\rho D v^2}{2}$$

where ρ is the density of air, v is the speed of the skydiver and D is a constant called the drag factor.

- (a) Show that the SI unit of D is **metre²**. [4]

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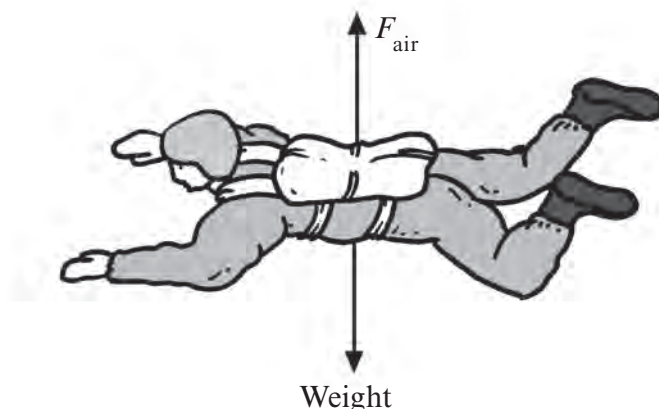
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- (b) The diagram shows two of the main forces acting on the skydiver during her descent.



- (i) Newton's third law concerns pairs of forces. State the law. [1]

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- (ii) Give **one** reason why the forces in the diagram are **not** a pair of Newton 3rd law forces. [1]

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(c) The table gives data for the first 16.0 seconds of the jump.

Time / s	0.0	2.0	4.0	6.0	8.0	10.0	12.0	14.0	16.0
Acceleration / m s^{-2}	9.8	8.8	6.6	4.3	2.5	1.4	0.8	0.4	0.2

(i) The mass of the skydiver is 60 kg. Calculate her weight. [1]

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(ii) Using your answer to (c)(i) and the information in the table, calculate the force due to air resistance acting on the skydiver at $t = 10.0$ s. [3]

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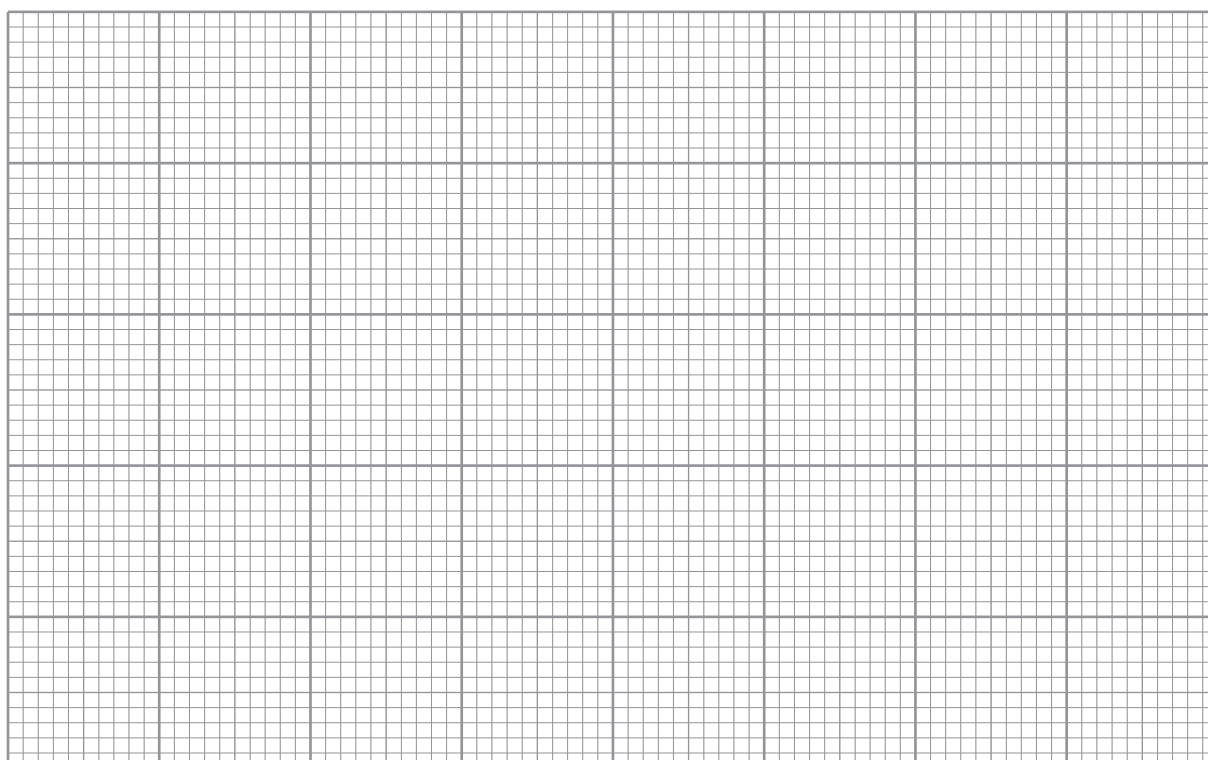
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(d) (i) Draw a graph of acceleration (y -axis) against time (x -axis) for the skydiver. [3]



- (ii) Use your graph to estimate the velocity of the skydiver at $t = 10.0$ s. [2]

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- (iii) Using your answers to (c)(ii), (d)(ii) and the equation given at the start of the question, calculate a value for the drag factor, D . Assume $\rho = 1.2 \text{ kg m}^{-3}$ [2]

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THERE ARE NO MORE QUESTIONS IN THE EXAMINATION.



GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k \text{ max}} = hf - \phi$$

$$\lambda_{\text{max}} = W T^{-1}$$

$$P = A\sigma T^4$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)		up (u)	down (d)
charge (e)	-1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A\omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3} \rho \overline{c^2}$$

$$U = \frac{3}{2} nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2} QV$$

$$Q = Q_0 e^{-t/\tau}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

Fields

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

$$V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$$

$$W = q\Delta V_E$$

$$F = G \frac{M_1 M_2}{r^2}$$

$$g = \frac{GM}{r^2}$$

$$V_g = \frac{-GM}{r}$$

$$W = m\Delta V_g$$

Orbiting Bodies

$$\text{Centre of mass: } r_1 = \frac{M_2}{M_1 + M_2} d;$$

$$\text{Period of Mutual Orbit: } T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$$

Options

$$\text{A: } \frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$$

$$\text{B: } c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\text{C: } \varepsilon = \frac{\Delta l}{l}; \quad Y = \frac{\sigma}{\varepsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \varepsilon V$$

$$\text{D: } I = I_0 \exp(-\mu x); \quad Z = c\rho$$

$$\text{E: } \frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x}; \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1}; \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

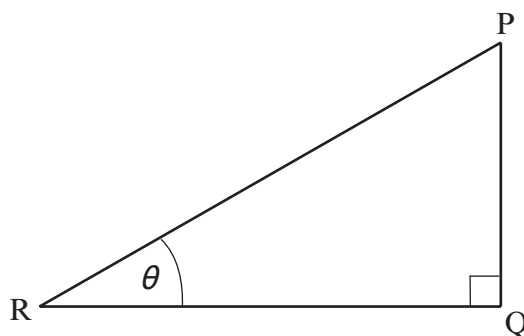
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless other wise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS
AS/Advanced

SUMMER 2012

INTRODUCTION

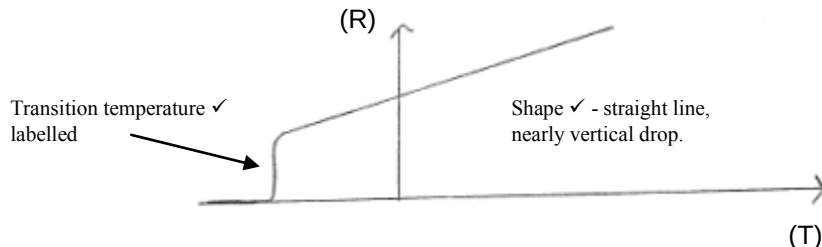
The marking schemes which follow were those used by WJEC for the Summer 2012 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

PH1

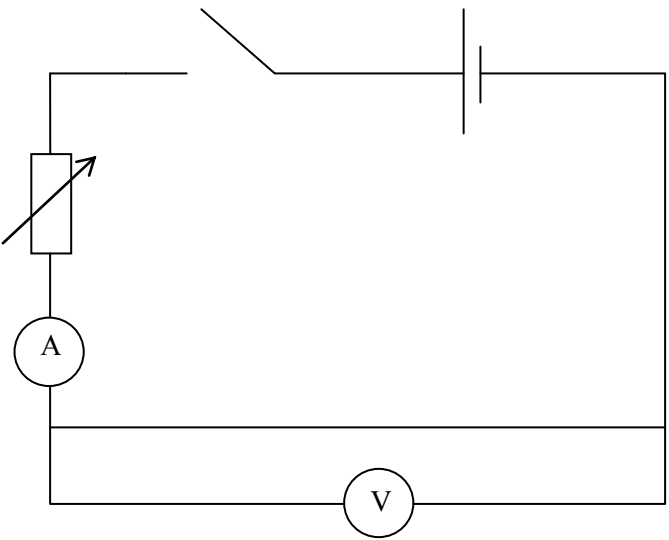
Question			Marking details	Marks Available																				
1	(a)	(i)	$I \propto V$ (1) Providing the temperature / physical conditions remain constant (1)	2																				
		(ii)	V A ⁻¹ circled	1																				
	(b)	(i)	<table border="1"><thead><tr><th>Switch combination</th><th>P</th><th>Q</th><th>S</th></tr></thead><tbody><tr><td>X open, Y open</td><td>On</td><td>On</td><td>Off</td></tr><tr><td>X closed, Y open</td><td>Off</td><td>On</td><td>Off</td></tr><tr><td>X open, Y closed</td><td>On</td><td>On</td><td>On</td></tr><tr><td>X closed, Y closed</td><td>Off</td><td>On</td><td>On</td></tr></tbody></table> (1) (1) (1)	Switch combination	P	Q	S	X open, Y open	On	On	Off	X closed, Y open	Off	On	Off	X open, Y closed	On	On	On	X closed, Y closed	Off	On	On	3
		Switch combination	P	Q	S																			
		X open, Y open	On	On	Off																			
		X closed, Y open	Off	On	Off																			
		X open, Y closed	On	On	On																			
		X closed, Y closed	Off	On	On																			
		(ii)	Either $R = \frac{9}{0.18}$ (1) (= 50 Ω) $\rightarrow$ $R_P + R_Q = 50$ (1) $R_{\text{each buzzer}} = 25[\Omega]$ (1) ecf between 2 nd and 3 rd marks Or $R = \frac{4.5 (1)}{0.18}$ (1) = 25[Ω] (1)	3																				
		(iii)	$R_{\text{Total}} = 16\frac{2}{3} [\Omega]$ (1) $I = \frac{9}{16\frac{2}{3}} = 0.54 [\text{A}]$ (1) ecf from (b)(ii) / no ecf for R_{Total}	2																				
(iv)	Either ecf from (b)(ii) or (b)(iii) or both $P_S = \left(\frac{2}{3} \times 0.54\right)^2 \times 25$ (1) $P_S = 3.24 [\text{W}]$ $P_Q = \left(\frac{1}{3} \times 0.54\right)^2 \times 25$ (1) $P_Q = 0.81 [\text{W}]$ Or $P_S = \frac{9^2}{25}$ (1) = 3.24 [W] $P_Q = \frac{4.5^2}{25}$ (1) = 0.81 [W] Or $P_S = \frac{2}{3} \times 0.54 \times 9$ (1) = 3.24 [W] $P_Q = \frac{1}{3} \times 0.54 \times 4.5$ (1) = 0.81 [W] $\rightarrow \frac{3.24}{0.81} = 4$ (1) or any correct algebraic solution = 3 marks	3																						
Question 1 total			[14]																					

Question			Marking details	Marks Available
2	(a)		A <u>material</u> with <u>zero/negligible</u> resistance	1
	(b)	(i)	Transition temperature (accept critical temperature)	1
		(ii)		2
	(c)	(iii)	If axes labelled, must be correct. 0 / negligible / almost zero	1
			Collisions between <u>free/delocalised/flowing/conducting</u> electrons and ions/atoms in lattice/atoms/particles (1) increase vibrations of ions /atoms / particles or electrons transfer <u>KE</u> to ions (1)	2
Question 2 Total			[7]	

Question			Marking details	Marks Available
3	(a)	(i)	<u>12</u> Joules per coulomb (1)	
			Supplied from cell / source / battery / chemical to electrical (1)	2
	(b)	(ii)	Energy lost in the resistance of cell	1
			$\left\{ \frac{3.6(1)}{120} \right\} = 0.03 \text{ } [\Omega] \text{ (1)}$	2
	(c)		$I = \frac{12}{0.03} = 400 \text{ [A]}$ ecf from (b)	1
	(d)	(i)	$Q = 3 \times [(16 \times 60^2) \text{ or } 57\,600 \text{ (1)}]$ $= 172800 \text{ [C]} \text{ (1)}$	2
		(ii)	$t = \frac{172,800}{120} = 1440 \text{ seconds / 24 mins UNIT mark}$	1
	Allow ecf from (d) (i)			
			Question 3 Total	[9]

Question		Marking details	Marks Available
4	(a)	<u>All 4 positions considered, 2 relevant statements per position</u> <u>At start (A)</u> $E_{Grav} - \text{max}$ $E_k - \text{zero}$ (1) $E_{Elastic} - \text{zero}$ <u>Free fall, Cord slack(B)</u> $E_{Grav} - \text{decreasing}$ $E_k - \text{increasing}$ (1) $E_{Elastic} - \text{zero}$ <u>Cord stretching (C)</u> $E_{Grav} - \text{decreasing}$ $E_k - \text{increasing or decreasing}$ (1) $E_{Elastic} - \text{increasing}$ <u>At lowest point (D)</u> $E_{Grav} - \text{minimum (accept zero if explained)}$ $E_k - \text{zero}$ (1) $E_{Elastic} - \text{maximum}$ 5th mark available for other general comment e.g. Some of initial energy lost due to air resistance / rope gets hot (1) Don't accept statement of the conservation of energy on its own.	5
	(b)	(i) $E_{p \text{ loss}} = 70 \times 9.8[1] \times 130$ (1) substitution (not $g = 10 \text{ m s}^{-2}$) $= 89\,271 \text{ [J]}$ (1) (accept 89 300 or 89 000)	2
		(ii) $89271 = \frac{1}{2} k (50)^2$ (2) [1 mark for $E_{p \text{ loss}} = \frac{1}{2} kx^2$; 1 mark for 50 [m]] $k = 71.4 \text{ [N m}^{-1}\text{]}$ (1) ecf from (b)(i)	3
		(iii) $mg = kx$ (1) $= \frac{70 \times 9.81}{71.4} = 9.6 \text{ [m]}$ (1) ecf on k from (b)(ii) N.B. Only penalise once for use of $g = 10 \text{ m s}^{-2}$	2
		Question 4 total	[12]

Question			Marking details	Marks Available
5	(a)	(i)	$v_H = 16 \cos 40^\circ$ (1) = 12.3 [m s ⁻¹] $v_V = 16 \sin 40^\circ$ (1) = 10.3 [m s ⁻¹]	2
		(ii)	Horizontal: constant velocity Vertical: acceleration / changing (both statements required)	1
	(b)	(i)	$0 = 10.3 - 1.6 t$ (1) ecf from (a)(i) penalise only once for use of 9.8 m s ⁻² $t = 6.4$ [s] (1) $t_{\text{flight}} = 12.8$ [s] (1) ecf between 2 nd and 3 rd marks Or any other alternative method used to gain correct answer = 3 marks	3
		(ii)	$D_H = 12.3 \times 12.8 = 157$ [m] ecf from (b)(i)	1
		(iii)	$0 = (10.3)^2 - 2 \times 1.6 s$ (1) ecf from (a)(i) $S = 33.2$ [m] (1)	2
		(c)	Air resistance on Earth (1) g on Earth different (accept greater) than on the Moon (1)	2
	Question 5 Total			[11]

Question			Marking details	Marks Available
6	(a)	(i)	 Circuit (without voltmeter and ammeter) (1) Voltmeter and Ammeter correctly positioned (1)	2
		(ii)	$R = \frac{10}{0.9} = 11.11 \text{ } [\Omega] \text{ (1)}$ $A = 3.14 \times 10^{-8} \text{ } [\text{m}^2] \text{ (1)}$ $\rho = \frac{11.11 \times 3.14 \times 10^{-8}}{3.2} \text{ (1) substitution } \rho = 1.09 \times 10^{-7} \text{ } [\Omega \text{ m}] \text{ (1)}$ ecf for R and A	
		(iii)	Platinum and Tin	
		(b)	$\rho = \frac{0.74 \times 10^{-3}}{(3.14 \times 10^{-8} \times 3.2)(1)} = 7365 \text{ } [\text{kg m}^{-3}] \text{ (1) ecf for A}$ Tin (1) ecf from density value	
			Question 6 Total	[10]

Question			Marking details	Marks Available
7	(a)		$F \rightarrow \text{kg m s}^{-2}$ (1) $\rho \rightarrow \text{kg m}^{-3}$ (1), $v^2 \rightarrow \text{m}^2 \text{s}^{-2}$ (1) Correct manipulation / cancelling seen $\rightarrow \text{m}^2$ (1)	4
		(b)	(i) Correct statement of Newton's 3 rd Law	1
		(ii)	• <u>May</u> not have same magnitude • Forces act on same object • Forces not of same type (e.g. not two 'g' forces or contact forces) Don't accept : They are not equal unless qualified Only one statement required.	1
	(c)	(i)	$60 \times 9.8 = 588 \text{ N}$ unit mark	1
		(ii)	$F_{\text{res}} = W - F_{\text{drag}}$ implied in any correct form (1) $F_{\text{drag}} = 588 - [(60 \times 1.4) (1)]$ ecf from (c)(i) $F_{\text{drag}} = 504 \text{ [N]}$ (1)	3

Question			Marking details	Marks Available
	(d)	(i)	Axes labelled with units (1); Points plotted correctly to within $\pm\frac{1}{2}$ square division (1); Line (1)	3
		(ii)	Area attempted (1) $(1.4 \times 10) + (\frac{1}{2} \times 10 \times [9.8-14])$ $14 + 42 = 56 \text{ [m s}^{-1}\text{]} (1) \text{ (accept range } 52 - 60)$	2
		(iii)	$504 = \frac{1.2 \times D \times 56^2}{2}$ substitution (1) allow ecf on F_{drag} and v $D = 0.27 \text{ [m}^2\text{]} (1) \text{ (accept range } 0.23 - 0.31)$	2
			Question 7 total	[17]

Surname	Centre Number	Candidate Number
Other Names		2



GCE AS/A level

1321/01

PHYSICS

PH1: MOTION ENERGY AND CHARGE

P.M. THURSDAY, 12 January 2012

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	13	
2.	10	
3.	7	
4.	11	
5.	9	
6.	14	
7.	16	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

1. (a) (i) State Ohm's law.

[2]

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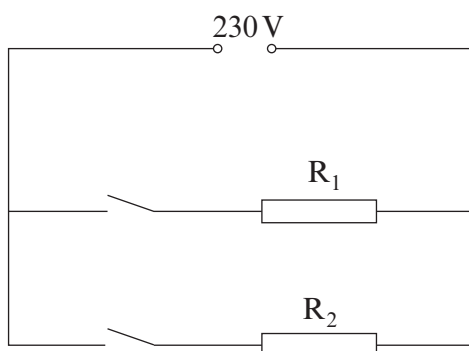
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- (ii) What can be said about the resistance of a conductor that obeys Ohm's law? [1]

.....

- (b) The heating circuit of a hairdryer consists of two heating elements R_1 and R_2 connected in parallel as shown. The elements are made from wire of the same material of resistivity $95 \times 10^{-8} \Omega \text{m}$ and diameter $1.4 \times 10^{-4} \text{m}$.



- (i) The length of wire used to make R_1 is 3.2m. Show that the resistance of R_1 is approximately 200Ω . [3]

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- (ii) Calculate the power output from the heating circuit with only R_1 switched on. [1]

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.....

- (iii) With both elements switched on the **total resistance** is only a third of the resistance of R_1 on its own. Calculate the resistance of R_2 . [3]

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- (iv) Explain which element, R_1 or R_2 , would provide the greater power output from the heating circuit. [2]

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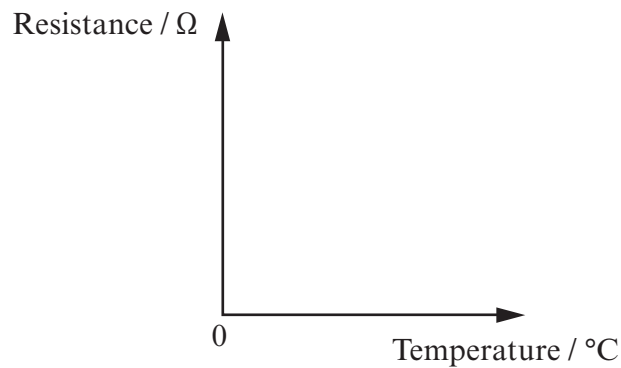
- (v) Calculate the total current with both elements switched on. [1]

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2. (a) (i) Draw a labelled diagram of the apparatus you would use to determine the relationship between the resistance and temperature of a metal wire. [3]

- (ii) Sketch, on the axis below, a graph of the results you would expect from the experiment. [2]



- (b) (i) Explain in terms of particles how electrical resistance arises in metal conductors. [3]

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- (ii) Hence suggest an explanation for your results to the experiment in part (a). [2]

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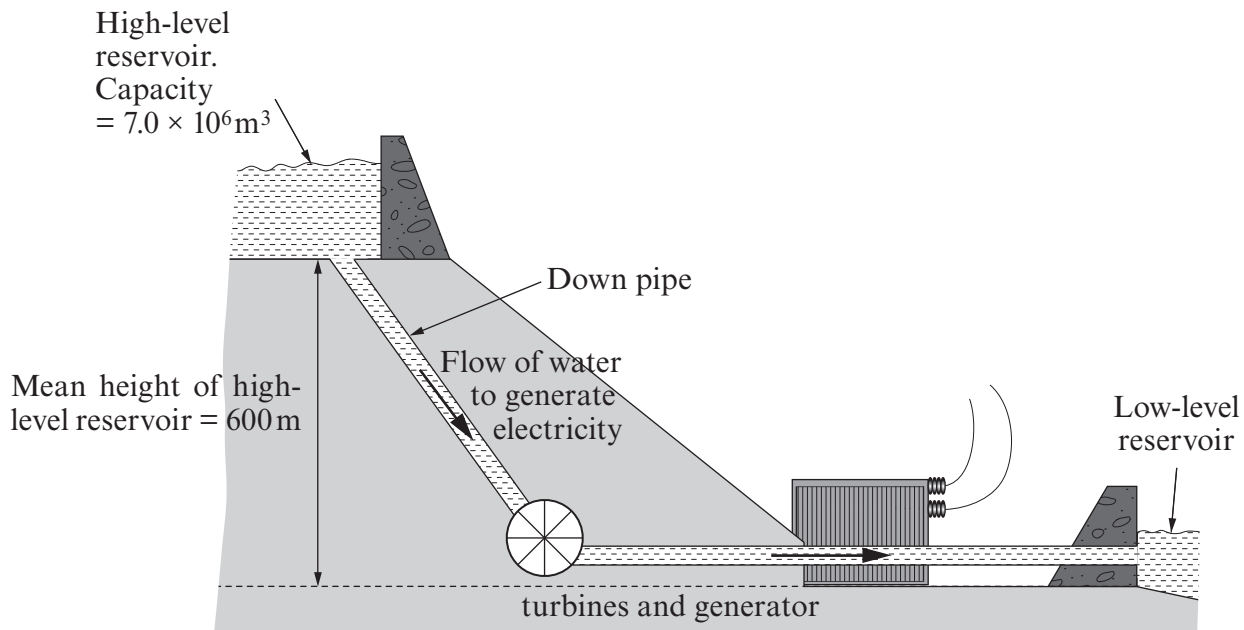
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4. The hydroelectric power station at Dinorwig in North Wales is the largest of its kind in Europe. A simplified diagram showing the main features of the plant is shown.



- (a) Use the information in the diagram to show that the gravitational potential energy stored in the high-level reservoir is approximately $4 \times 10^{13} \text{ J}$.
[Density of water = 1000 kg m^{-3}]. [2]

- (b) The power plant has six 300 MW generators. Calculate the longest time for which the stored energy could provide power at maximum output given that the generation process is 90% efficient [i.e. 10% of the gravitational potential energy stored in the high level reservoir is wasted]. [3]

- (c) (i) Calculate the mean rate of flow of water (in kg s^{-1}) through the turbines of the power station when it is operating at full power. [1]

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- (ii) After passing through the turbines the water enters the lower lake at a speed of 20 ms^{-1} . Use your answer to (c)(i) to calculate the kinetic energy per second [power] of this water. [1]

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- (iii) Calculate the **wasted energy per second** (power lost) during the generation process. [2]

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- (iv) Hence show that your answer to (c)(ii) represents between 30% and 40% of the wasted power. [1]

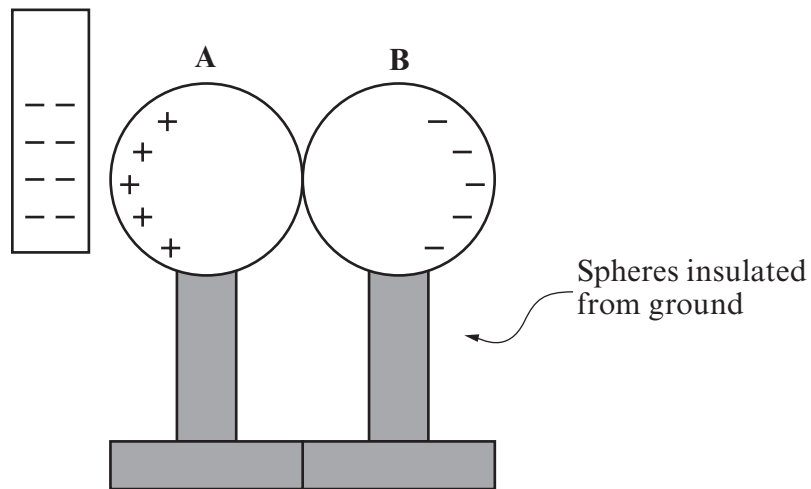
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- (v) Where else would energy be wasted during the generating process? [1]

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5. Two insulated metal spheres, **A** and **B** are placed in contact with each other. When a negatively charged rod is brought near, the charges become distributed on the metal spheres as shown.



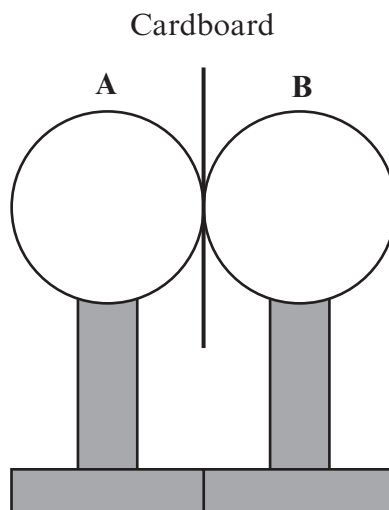
- (a) (i) State the particle which carries the negative charge. [1]

- (ii) Explain why the charges become distributed as shown. [3]

- (iii) The following procedure is carried out:

- A thin insulating piece of cardboard is placed in between the spheres.
- The negatively charged rod is then removed.

Sketch the distribution of charges now on both spheres. [2]



- (b) (i) In another process, a negatively charged rod is rubbed against one of the spheres and in doing so places approximately 300×10^9 free negative charges onto the sphere. Calculate the charge on the sphere. [1]

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- (ii) The sphere is discharged in a time of $20 \mu\text{s}$ by connecting a wire from it to the ground. Calculate the mean current. [2]

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6. (a) Define:

(i) mean speed;

[1]

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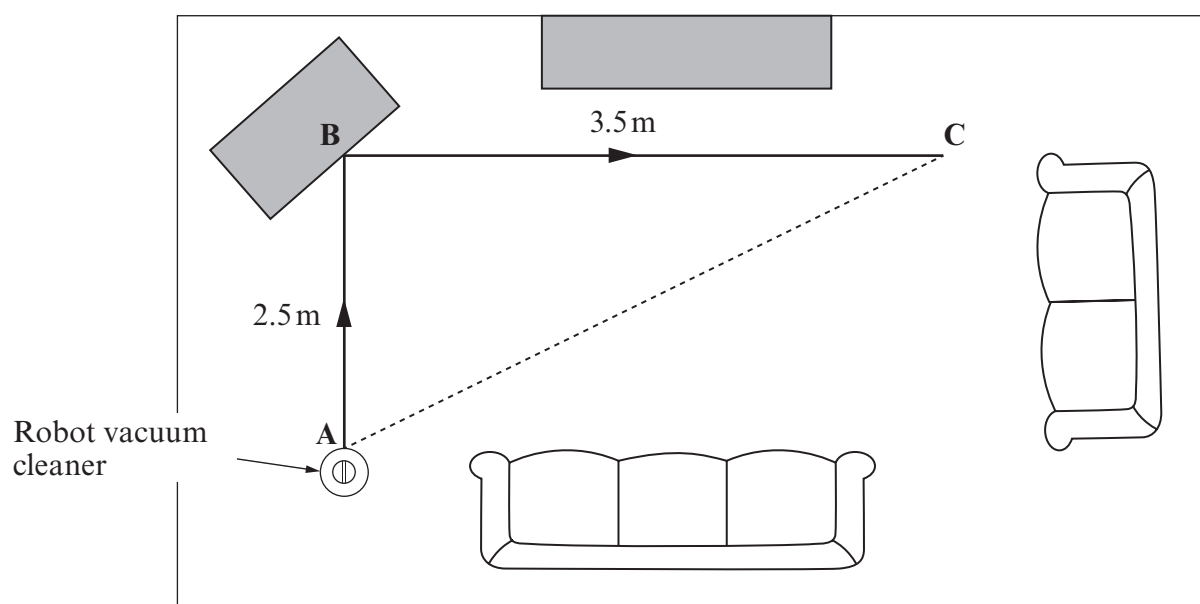
(ii) mean velocity.

[1]

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(b) Robot vacuum cleaners can clean carpets automatically. When sensors on the cleaner detect the presence of nearby objects the cleaner changes direction, thus avoiding collision. The diagram shows the path of such a cleaner inside a living room.



The vacuum cleaner follows the path AB and then BC. The whole journey ABC takes 25 s. Calculate

(i) the cleaner's average speed,

[1]

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(ii) the magnitude of the cleaner's average velocity.

[2]

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- (c) The manufacturer of a robot vacuum cleaner provides the following technical information:

Battery type: 15.0 V Ni-MH (Nickel-Metal Hydride) re-chargeable.

Battery capacity: 2.5 Amp-hours (this means the battery is able to supply 2.5 A for 1 hour, or 1.25 A for 2 hours and so on).

Power when in use: 30 watts.

- (i) Calculate the total energy stored in the battery. [3]

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- (ii) Hence calculate the time, in hours, that the battery can be used before recharging. [2]

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- (d) (i) A resistive force, F , acts on the cleaner in the opposite direction to the direction of motion of the cleaner. Starting from the definition of *power*, show that for the cleaner to move at a steady speed v , the mechanical power needed is Fv . [2]

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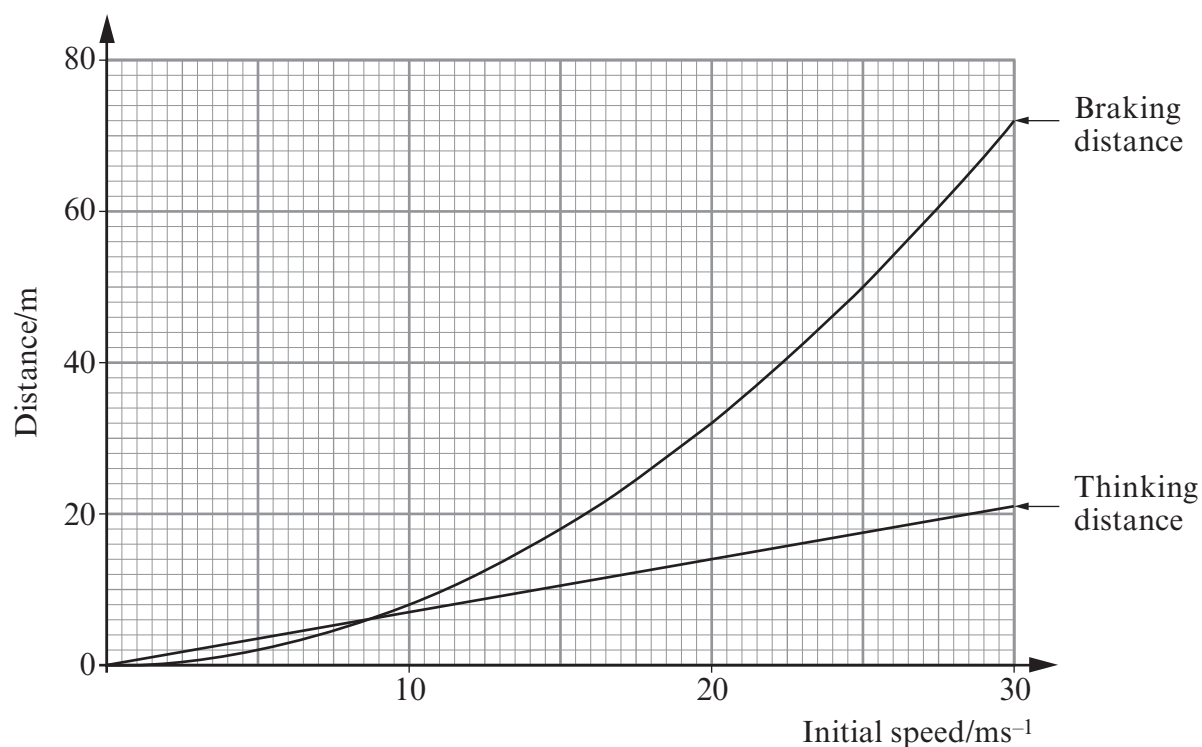
- (ii) Calculate F , given that the mechanical power is 9 W. [2]

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7. The following graph gives data taken from the 'Highway Code' for 'Thinking' and 'Braking' distances for a car when stopping. Thinking distance is the distance a car travels between the driver seeing an incident and beginning to apply the brakes. Braking distance is the distance a car travels while it is decelerating.



- (a) The graph of braking distance against speed is curved. Use information from the graph to test whether braking distance is proportional to (initial speed)². [3]

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- (b) (i) Calculate the mean deceleration of a car as it slows down from 15 ms⁻¹ to rest. [3]

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GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\text{efficiency} = \frac{\text{useful energy transfer}}{\text{total energy input}} \times 100\%$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k \text{ max}} = hf - \phi$$

$$\lambda_{\text{max}} = W T^{-1}$$

$$P = A\sigma T^4$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)		up (u)	down (d)
charge (e)	-1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
lepton number	1	1		0	0

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

$$a = -\omega^2 x$$

$$x = A \sin(\omega t + \varepsilon)$$

$$v = A\omega \cos(\omega t + \varepsilon)$$

$$T = 2\pi \sqrt{\frac{m}{k}}$$

$$p = mv$$

$$Q = mc\Delta\theta$$

$$p = \frac{h}{\lambda}$$

$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$

$$pV = nRT$$

$$p = \frac{1}{3} \rho \overline{c^2}$$

$$U = \frac{3}{2} nRT$$

$$k = \frac{R}{N_A}$$

$$W = p\Delta V$$

$$\Delta U = Q - W$$

$$C = \frac{Q}{V}$$

$$C = \frac{\varepsilon_0 A}{d}$$

$$U = \frac{1}{2} QV$$

$$Q = Q_0 e^{-t/\tau}$$

$$F = BIl \sin \theta \text{ and } F = Bqv \sin \theta$$

$$B = \frac{\mu_0 I}{2\pi a}$$

$$B = \mu_0 nI$$

$$\Phi = AB \cos \theta$$

$$V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}}$$

$$A = \lambda N$$

$$N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x}$$

$$A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x}$$

$$\lambda = \frac{\log_e 2}{T_{1/2}}$$

$$E = mc^2$$

Fields

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

$$V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$$

$$W = q\Delta V_E$$

$$F = G \frac{M_1 M_2}{r^2}$$

$$g = \frac{GM}{r^2}$$

$$V_g = \frac{-GM}{r}$$

$$W = m\Delta V_g$$

Orbiting Bodies

$$\text{Centre of mass: } r_1 = \frac{M_2}{M_1 + M_2} d;$$

$$\text{Period of Mutual Orbit: } T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$$

Options

$$\text{A: } \frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$$

$$\text{B: } c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\text{C: } \varepsilon = \frac{\Delta l}{l}; \quad Y = \frac{\sigma}{\varepsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \varepsilon V$$

$$\text{D: } I = I_0 \exp(-\mu x); \quad Z = c\rho$$

$$\text{E: } \frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x}; \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1}; \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

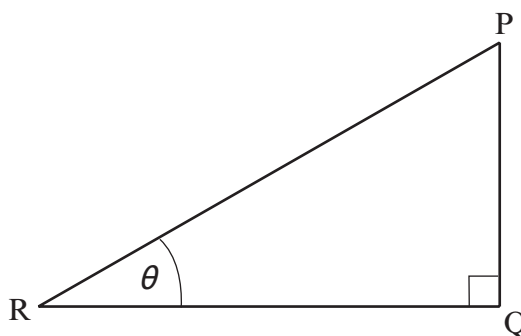
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2(lh + hb + lb)$	lbh
cylinder	$2\pi r(r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless other wise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$



GCE MARKING SCHEME

PHYSICS
AS/Advanced

JANUARY 2012

INTRODUCTION

The marking schemes which follow were those used by WJEC for the January 2012 examination in GCE PHYSICS. They were finalised after detailed discussion at examiners' conferences by all the examiners involved in the assessment. The conferences were held shortly after the papers were taken so that reference could be made to the full range of candidates' responses, with photocopied scripts forming the basis of discussion. The aim of the conferences was to ensure that the marking schemes were interpreted and applied in the same way by all examiners.

It is hoped that this information will be of assistance to centres but it is recognised at the same time that, without the benefit of participation in the examiners' conferences, teachers may have different views on certain matters of detail or interpretation.

WJEC regrets that it cannot enter into any discussion or correspondence about these marking schemes.

Unit	Page
PH1	1
PH2	5
PH4	10

PH1

Question			Marking details	Marks Available
1	(a)	(i)	[For a metallic conductor] the potential difference and current are [directly] proportional/ $I \propto V$ (1), provided the temperature remains constant / all physical factors remain constant (1) $V = IR$ only no marks	2
		(ii)	It is constant / stays the same / increases as the temperature increases	1
	(b)	(i)	$A = 1.5(3) \times 10^{-8} [\text{m}^2](1)$ $R = \frac{\rho l}{A} = \frac{95 \times 10^{-8} \times 3.2}{1.5(3) \times 10^{-8}} (1) = 199 [\Omega] (1)$	3
		(ii)	$\frac{230^2}{200} = 265 [\text{W}]$ allow e.c.f. from (b)(i)	1
		(iii)	$\frac{1}{66.7(1)} = \frac{1}{200} + \frac{1}{R_2} (1)$ $R_2 = 100 [\Omega] (1)$	3
		(iv)	$R_2 (1)$ either reference to $\frac{V^2}{R}$ so lower R / same V across lower R or reference to $I^2 R$ so greater I or reference to IV so I increased [for constant V] or correct calculation of $R_2 (1)$	2
		(v)	$\frac{230}{66.7} = 3.5 [\text{A}]$ allow e.c.f. from (b)(iii)	1
			Question 1 total	[13]
2	(a)	(i)	Diagram to include - Correct electric circuit with ohmmeter or power supply with ammeter + voltmeter with correct symbols and positioning (1) - Method of heating shown (1) - Method of recording temperature shown (1)	3
		(ii)	Linear [or approximately linear] graph with positive gradient (1) and positive intercept on R axis (1).	2
	(b)	(i)	Conducting / delocalised / free electrons (1) collide (1) with metal lattice / atoms / ions (1) [not with other free electrons]	3
		(ii)	The greater the temperature the greater the vibrational energy of the lattice / metal ions (1) producing a greater chance [or rate] of collisions/ collisions more often / greater frequency of collisions (1) [not harder] .	2
			Question 2 total	[10]

Question			Marking details	Marks Available
3	(a)	(i)	Rate of change of velocity or $\frac{v-u}{t}$ or change in velocity / time taken	1
		(ii)	$(u = 0)$ (1) [or by impl.] Acceleration = $\frac{6.0}{0.8} = 7.5 \text{ m s}^{-2}$ (1) UNIT mark	2
	(b)		After release there are no [horizontal] forces acting [on the trolley] (1) so it travels with constant speed [to the left] (1). When Nigel catches it there is a force on the trolley to the right / towards Nigel (1) which causes the trolley to decelerate/ slow down/ stop moving [to rest] (1)	4
			Question 3 total	[7]
4	(a)		$E_p = (7.0 \times 10^6 \times 1000)(1) \times 9.81 \times 600$ (1) [= 4.1×10^{13}] 1 st mark – use of density equation to get $7.0 \times 10^9 \text{ kg}$ 2 nd mark – use of mgh	2
	(b)		Energy available per second = $0.9 \times 4.1 \times 10^{13}$ [= 3.6×10^{13}] J (1) allow e.c.f. from (a) Time = $\frac{3.6 \times 10^{13}}{6 \times 300 \times 10^6 (1)}$ [= 2×10^4 [s] / 5.6 [hour]] (1)	3
	(c)	(i)	$\frac{7.0 \times 10^9}{2 \times 10^4 \text{ e.c.f.}} = 3.5 \times 10^5 \text{ [kg s}^{-1}\text{]}$ allow e.c.f from (a) and (b)	1
		(ii)	E_k per second [= $\frac{1}{2} \times 3.5 \times 10^5 \times 20^2$] = $7 \times 10^7 \text{ [J s}^{-1}\text{]}$ allow e.c.f from (c)(i)	1
		(iii)	Energy wasted per second = $\frac{10\% \times 4 \times 10^{13} \text{ J}}{2 \times 10^4 \text{ s}}$ (1) allow e.c.f. from (a) and (b) [or equiv, or by impl.] = $2 \times 10^8 \text{ [W]}$ (1)	2
		(iv)	% lost in $E_k = \frac{7 \times 10^7}{2 \times 10^8}$ [e.c.f. on (ii) and (iii)] = 35%	1
		(v)	Any sensible answer, e.g. [k.e. in] water turbulence, [work against] friction in turbines, drag/friction between water and pipes not just heat or sound or refilling the high level reservoir.	1
			Question 4 Total	[11]

Question			Marking details	Marks Available
5	(a)	(i)	Electron	1
		(ii)	Negative charges repelled [by rod] (1) and move from A to B/ to the right (1) leaving A with a net positive charge (1)	3
		(iii)	Diagram with A shown as positive and B as negative (1) and the charges shown on the sides of the sphere which are nearly touching.(1)	2
	(b)	(i)	$[1.6 \times 10^{-19} \times 300 \times 10^9 =] 4.8 \times 10^{-8} \text{ C}$ UNIT mark	1
		(ii)	$I = \frac{4.8 \times 10^{-8}}{20 \times 10^{-12}} (1) = 2.4 \times 10^3 \text{ [A]} (1)$ allow e.c.f from (b)(i)	2
Question 5 Total			[9]	
6	(a)	(i)	$\frac{[\text{Total}] \text{ distance}}{\text{time}}$ not rate of change of distance	1
		(ii)	$\frac{\text{displacement}}{\text{time}}$ not rate of change of displacement	1
	(b)	(i)	$\frac{6.0}{25} = 0.24 [\text{ m s}^{-1}]$	1
		(ii)	$\frac{\sqrt{3.5^2 + 2.5^2} (1)}{25} = 0.17 [\text{ m s}^{-1}] (1)$	2
	(c)	(i)	$E = IVt$ <u>used</u> [i.e. relevant numbers substituted] (1) Energy stored = $2.5 \times (60 \times 60)$ or $1.25 \times 2 \times (60 \times 60) (1) \times 15.0$ i.e. conversion to seconds $E = 1.35 \times 10^5 \text{ [J]}$ or 37.5 Watt hours (1) Watt hours unit needed	3
		(ii)	$\frac{1.35 \times 10^5}{30} (1) = 4.5 \times 10^3 \text{ s } [= 1\frac{1}{4} \text{ hour}] (1)$ allow e.c.f. from (c)(i)	2
	(d)	(i)	Power = $\frac{\text{Work [or energy]}}{\text{time}} = \frac{F \times d}{t}$ Identification of work as $F \times d$ in context of power equation (1) Identification of velocity as d/t (1)	2
		(ii)	$9 = F \times 0.24 (1)$ [or by impl. – use of 0.24 m s^{-1} , i.e. identification of relevant v] allow e.c.f. from (b)(i) $F = 37.5 \text{ [N]} (1)$	2
		Question 6 Total		

Question			Marking details	Marks Available
7	(a)		Relevant pairs of values chosen (1) [e.g. $10 \text{ m s}^{-1} \rightarrow 8 \text{ m}$ and $20 \text{ m s}^{-1} \rightarrow 32 \text{ m}$] Method / strategy, e.g compare $\frac{\text{distance}}{\text{speed}^2}$ for the pairs of values. (1) Conclusion clearly linked to calculation (1) Allow e.c.f for values of pairs if marking points 2 and 3 completed correctly.	3
	(b)	(i)	Identification of relevant equation: e.g. $v^2 = u^2 + 2ax$ (1) Identification of $x = 18 \text{ m}$ (1) deceleration = $6.3 \text{ [m s}^{-2}]$ or $a = -6.3 \text{ [m s}^{-2}]$ (1)	3
		(ii)	$F = 800 \times 6.3 = 5000 \text{ [N]}$ allow e.c.f. from (b)(i)	1
	(c)		Reaction time is independent of speed / doesn't change (1) Then $v \propto d$ [from $d = vt$] (1)	2
	(d)	(i)	$21 + 72 = 93 \text{ [m]}$	1
		(ii)	No change to thinking distance (1) [Reduced acc/deceleration would] increase braking distance (1)	2
	(e)		Time required = $\frac{\text{total distance}}{\text{speed}} = \frac{10}{50} [= 0.2 \text{ hour}]$ (1) Time for first 6.0 km = $\frac{6.0}{80} [= 0.075 \text{ hour}]$ (1) remaining time = $0.2 - 0.075 = 0.125 \text{ hour}$ (1) Speed for remaining 4 km = $\frac{4}{0.125} = 32 \text{ [km / h]}$ or $8.9 \text{ [m s}^{-1}]$ (1)	4
Question 7 Total				[16]

Candidate Name	Centre Number	Candidate Number
		2



GCE AS/A level

1321/01

PHYSICS

PH1: MOTION ENERGY AND CHARGE

A.M. TUESDAY, 24 May 2011

1½ hours

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	12	
2.	10	
3.	9	
4.	21	
5.	17	
6.	11	
Total	80	

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

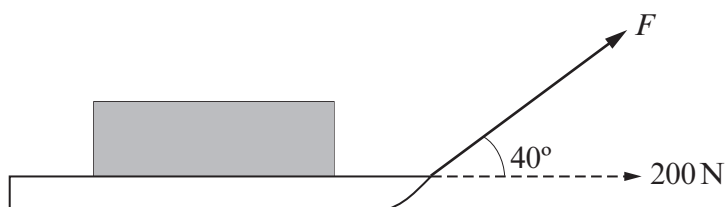
The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

1. A heavy sledge is pulled across a level snowfield by a force F as shown. To keep the sledge moving at constant velocity a **horizontal** force component of 200 N is required.



- (a) Calculate the force F needed to produce a horizontal component of 200 N on the sledge. [2]

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- (b) (i) Define *work done* and use this definition to explain why no work is done in the vertical direction. [3]

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- (ii) It takes 30 minutes to pull the sledge a distance of 2.0 km across level ground. Calculate

- (I) the work done; [2]

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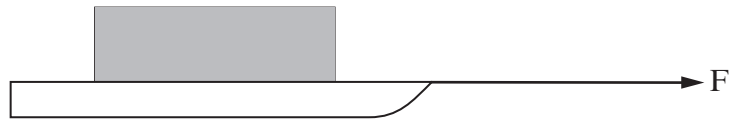
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- (II) the mean power needed. [2]

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- (c) Assume the force F calculated in (a) is now applied horizontally as shown. Calculate the initial acceleration of the sledge given that its mass is 40.0 kg and assuming that the frictional force stays the same. [3]



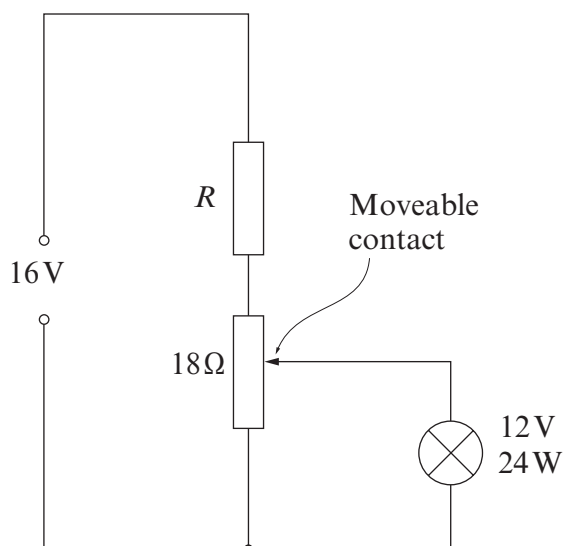
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2. A student uses the circuit below to produce a current-voltage graph for a 12 V, 24 W filament lamp.



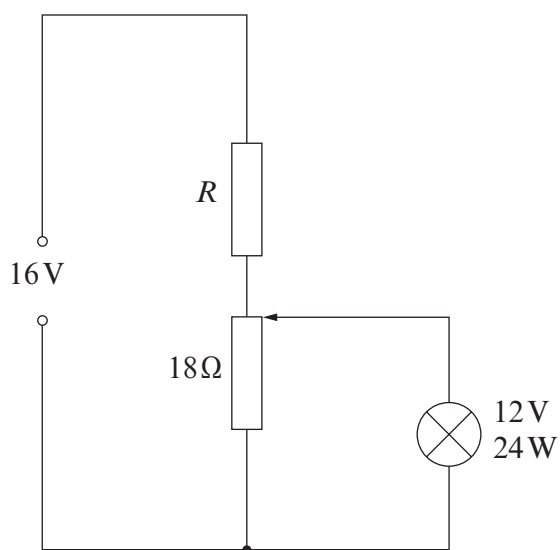
- (a) Show clearly on the diagram the correct positions for the voltmeter and ammeter. [2]

- (b) When the lamp is working normally, calculate

- (i) the current flowing through it; [1]

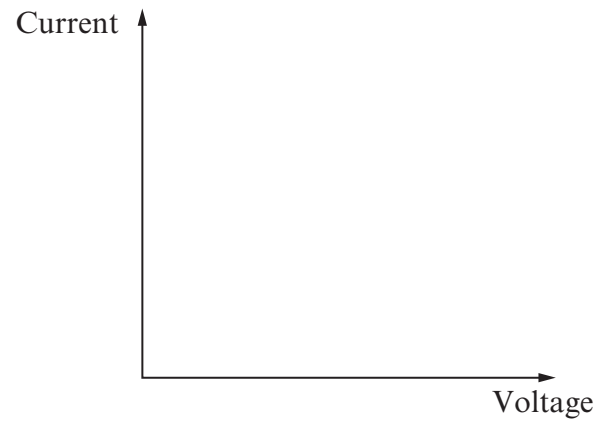
- (ii) its resistance. [1]

- (c) The value of R is chosen so that the voltage across the lamp can be varied between 0 V and 12 V. The circuit below shows the position of the moveable contact when the lamp is operating normally (i.e. at 12 V).



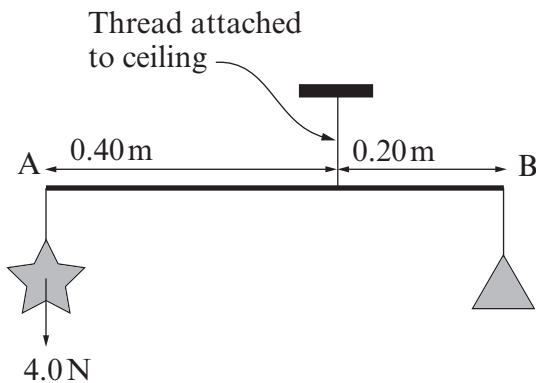
- Calculate the required value of R . [4]

- (d) Sketch on the axes below the current-voltage graph expected for the filament lamp. [2]



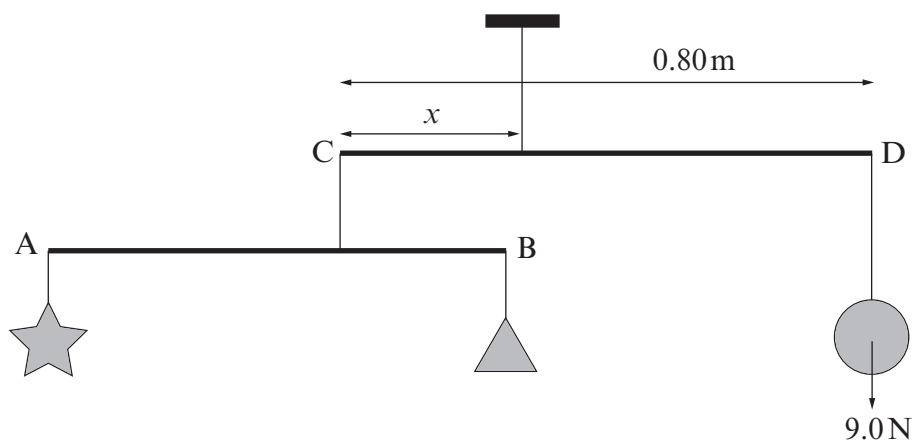
3. (a) What name is given to the turning effect of a force? [1]

- (b) (i) A simple toy mobile, consisting of a star and a triangle is shown hanging freely. Assume the rod AB is weightless. Calculate the weight of the triangle. [2]



- (ii) Hence calculate the tension in the thread attached to the ceiling. [1]

- (c) The mobile is now attached to another weightless rod CD of length 0.80 m, making a more complex mobile as shown. A sphere of weight 9.0 N is attached to D and the mobile is hung freely from the ceiling.



- (i) The distance x can be adjusted to allow the rod CD to hang horizontally. Calculate x . [3]

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- (ii) The original star and triangle mobile is now replaced with a single 'crescent moon' of weight 12.0 N as shown. Explain whether x will now have to increase, decrease or stay the same to keep CD horizontal. [2]

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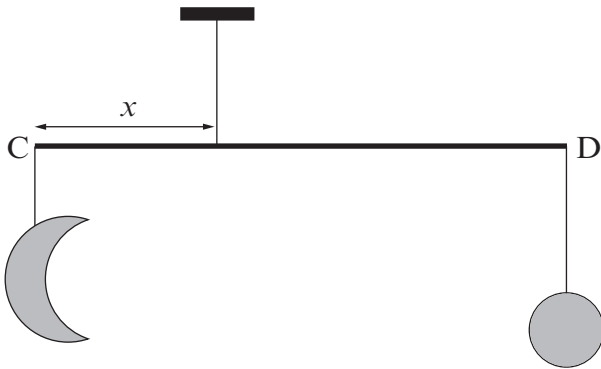
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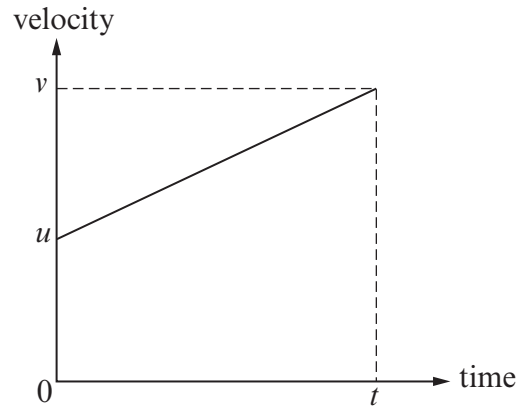
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4. (a) A velocity-time graph is given for a body which is accelerating in a straight line.



- (i) Using the symbols given on the graph, write down an expression for the gradient and state what it represents. [2]

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- (ii) Using the symbols given on the graph, write down an expression for the area under the graph and state what it represents. [2]

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- (iii) Hence or otherwise show clearly that, using the usual symbols,

$$x = ut + \frac{1}{2}at^2 \quad [2]$$

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(b) A cyclist accelerates **from rest** with a constant acceleration of 0.50 m s^{-2} for 12.0 s. Calculate

(i) the distance travelled in this time; [2]

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(ii) the maximum velocity attained. [2]

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(c) After 12.0 s, the cyclist stops pedalling and ‘freewheels’ to a standstill with constant deceleration over a distance of 120 m.

(i) Calculate the time taken for the cyclist to decelerate to a stand-still. [2]

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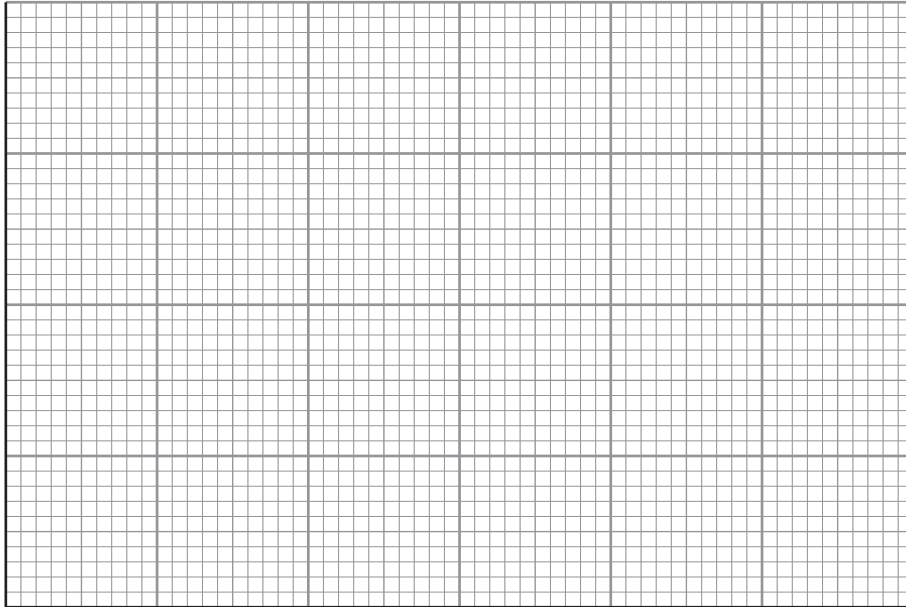
(ii) Calculate the magnitude of the cyclist’s deceleration. [2]

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- (d) Draw an acceleration-time graph on the grid below for the **whole of the cyclist's journey**. [4]



- (e) In reality the cyclist would not slow down with constant deceleration. This is because the total resistive force acting on the cyclist consists of a constant frictional force of 8.0 N **and** an air resistance force which is proportional to the square of the cyclist's velocity.

- (i) When the cyclist was travelling with maximum velocity, the total resistive force acting was 165 N . Calculate the force of air resistance at this velocity. [1]

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- (ii) Hence calculate the total resistive force acting when the cyclist is moving at half the maximum velocity. [2]

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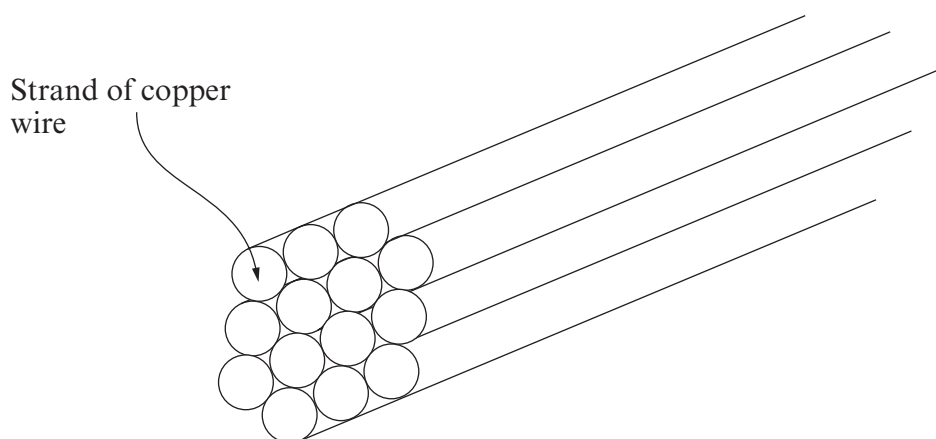
5. (a) Starting from a relevant equation, show that the unit of resistivity is $\Omega \text{ m}$. [2]

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- (b) A cable consists of 14 strands of copper wire, each of **diameter** 1.3 mm.



- (i) Show that the cross-sectional area of **one** strand of the copper wire is approximately $1.3 \times 10^{-6} \text{ m}^2$. [1]

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- (ii) Hence calculate the resistance of one strand of length 20.0m. [1]
[Resistivity of copper = $1.7 \times 10^{-8} \Omega \text{ m}$].

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- (iii) Determine the combined resistance of the 14 strand cable. [2]

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(iv) Showing your working clearly, calculate the ratio:

$$\frac{\text{Energy dissipated in one second in a **single strand** carrying a current of 3.0 A}}{\text{Energy dissipated in one second in the **whole cable** carrying a current of 3.0 A}}$$

[3]

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(v) Give an advantage of the 14 strand copper cable over

(I) a single strand copper cable of 1.3 mm diameter,

[1]

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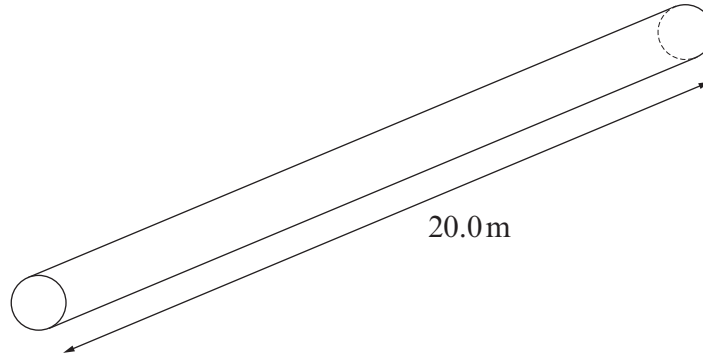
(II) a solid core cable of the same total cross-sectional area.

[1]

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- (c) Consider **one** strand of length 20.0 m as shown. The strand contains 2.0×10^{24} free electrons.



- (i) Calculate the number of free electrons per unit volume in this wire. [1]

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- (ii) Hence calculate the mean drift velocity of electrons in the strand when there is a current of 3.0 A in it. [2]

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- (iii) Determine the mean drift velocity in the whole (14 strand) cable when there is a current of 3.0 A in it. [3]

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6. (a) An equation which can be applied to a cell of emf E and internal resistance r is

$$V = E - Ir$$

- (i) What does V represent? [1]

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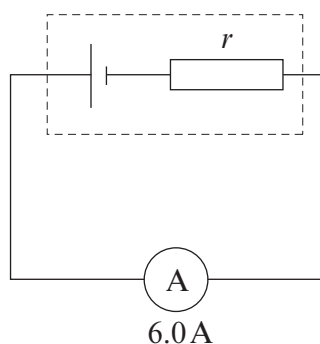
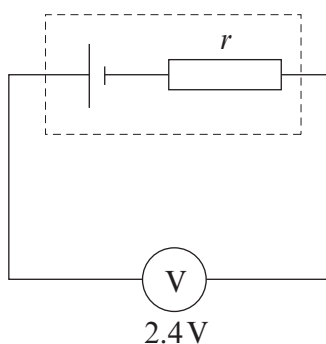
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- (ii) What does Ir represent? [1]

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- (b) A voltmeter connected across the terminals of a cell reads 2.4 V. An ammeter (whose resistance is zero) reads 6.0 A when connected briefly across the cell.



- (i) Write down the emf of the cell. [1]

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- (ii) Calculate the internal resistance of the cell. [1]

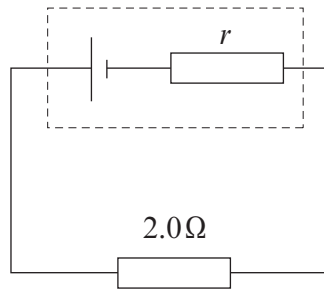
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- (iii) Give one reason for not leaving the ammeter connected to the cell. [1]

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- (c) Calculate the current through a 2.0Ω resistor when it is connected across the cell. [2]



- (d) Determine the number of cells of this type which, when connected in series with the 2.0Ω resistor, will produce a current of 3.0 A . [4]

This image shows a full page of white paper with horizontal dotted lines. The lines are evenly spaced and run across the width of the page, providing a guide for handwriting practice. There are no margins, text, or other markings on the page.



GCE PHYSICS
TAG FFISEG
Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{total energy input}} \times 100\%$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k \max} = hf - \phi$$

$$\lambda_{\max} = W T^{-1}$$

$$P = A\sigma T^4$$

Particle Physics

	Leptons			Quarks	
particle (symbol)	electron (e^-)	electron neutrino (ν_e)		up (u)	down (d)
charge (e)	-1	0		$+\frac{2}{3}$	$-\frac{1}{3}$
Lepton number	1	1		0	0

A2

$$\begin{array}{lll}
 \omega = \frac{\theta}{t} & M/\text{kg} = \frac{M_r}{1000} & F = BIl \sin \theta \text{ and } F = Bqv \sin \theta \\
 v = \omega r & pV = nRT & B = \frac{\mu_o I}{2\pi a} \\
 a = \omega^2 r & p = \frac{1}{3} \rho c^2 & B = \mu_o nI \\
 a = -\omega^2 x & U = \frac{1}{2} nRT & \Phi = AB \cos \theta \\
 x = A \sin(\omega t + \varepsilon) & k = \frac{R}{N_A} & V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}} \\
 v = A \omega \cos(\omega t + \varepsilon) & W = p \Delta V & A = \lambda N \\
 T = 2\pi \sqrt{\frac{m}{k}} & \Delta U = Q - W & N = N_0 e^{-\lambda t} \text{ or } N = \frac{N_0}{2^x} \\
 p = mv & C = \frac{Q}{V} & A = A_0 e^{-\lambda t} \text{ or } A = \frac{A_0}{2^x} \\
 Q = mc \Delta \theta & C = \frac{\varepsilon_o A}{d} & \lambda = \frac{\log_e 2}{T_{1/2}} \\
 p = \frac{h}{\lambda} & U = \frac{1}{2} QV & E = mc^2 \\
 \frac{\Delta \lambda}{\lambda} = \frac{v}{c} & Q = Q_0 e^{-\gamma_{hc}} &
 \end{array}$$

Fields

$$\begin{array}{llll}
 F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2} & E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2} & V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r} & W = q \Delta V_E, \\
 F = G \frac{M_1 M_2}{r^2} & g = \frac{GM}{r^2} & V_g = \frac{-GM}{r} & W = m \Delta V_g
 \end{array}$$

Orbiting Bodies

$$\text{Centre of mass: } r_1 = \frac{M_2}{M_1 + M_2} d;$$

$$\text{Period of Mutual Orbit: } T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$$

Options

$$\text{A: } \frac{V_1}{N_1} = \frac{V_2}{N_2}; \quad E = -L \frac{\Delta I}{\Delta t}; \quad X_L = \omega L; \quad X_C = \frac{1}{\omega C}; \quad Z = \sqrt{X^2 + R^2}; \quad Q = \frac{\omega_0 L}{R}$$

$$\text{B: } c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}; \quad \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$$

$$\text{C: } \varepsilon = \frac{\Delta I}{l}; \quad Y = \frac{\sigma}{\varepsilon}; \quad \sigma = \frac{F}{A}; \quad U = \frac{1}{2} \sigma \varepsilon V$$

$$\text{D: } I = I_0 \exp(-\mu x); \quad Z = c \rho$$

$$\text{E: } \frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; \quad U = \frac{K}{\Delta x}; \quad \frac{Q_2}{Q_1} = \frac{T_2}{T_1}; \quad \text{Carnot efficiency} = \frac{(Q_1 - Q_2)}{Q_1}$$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

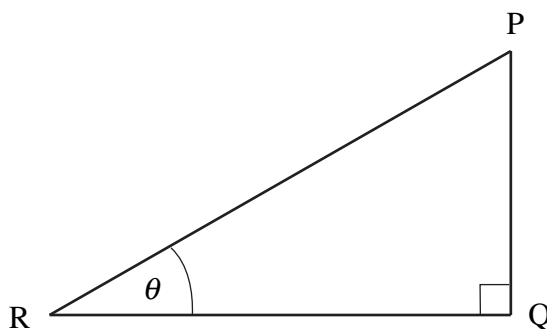
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2 (lh + hb + lb)$	lbh
cylinder	$2\pi r (r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$

Candidate Name	Centre Number	Candidate Number
		2



GCE AS/A level

1321/01

PHYSICS

PH1: MOTION ENERGY AND CHARGE

A.M. WEDNESDAY, 12 January 2011

1½ hours

ADDITIONAL MATERIALS

In addition to this examination paper, you will require a calculator and a **Data Booklet**.

INSTRUCTIONS TO CANDIDATES

Use black ink or black ball-point pen.

Write your name, centre number and candidate number in the spaces at the top of this page.

Answer **all** questions.

Write your answers in the spaces provided in this booklet.

INFORMATION FOR CANDIDATES

The total number of marks available for this paper is 80.

The number of marks is given in brackets at the end of each question or part question.

You are reminded of the necessity for good English and orderly presentation in your answers.

You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	12	
2.	8	
3.	15	
4.	8	
5.	8	
6.	8	
7.	21	
Total	80	

1. (a) (i) Using the idea of electric charge explain what is meant by *the electric current* in a conductor. [1]

- (ii) The unit of electric current is the ampère (A). One of the following is a correct alternative unit to the ampère. Circle the correct one. [1]

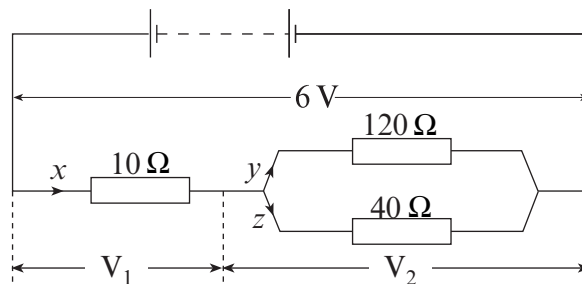
$$\text{JC}^{-1}$$

$$\text{Cs}^{-1}$$

$$\text{Js}^{-1}$$

$$\text{VA}^{-1}$$

(b)



- (i) Write down the relationship between the currents x , y and z in the circuit. [1]

- (ii) The relationship you wrote down in (b)(i) is a consequence of which conservation law? [1]

(c) Calculate

- (i) the resistance of the combination of the three resistors, [3]

- (ii) the current x , [1]

(iii) the potential differences, V_1 and V_2 ,

[2]

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(iv) the currents y and z .

[2]

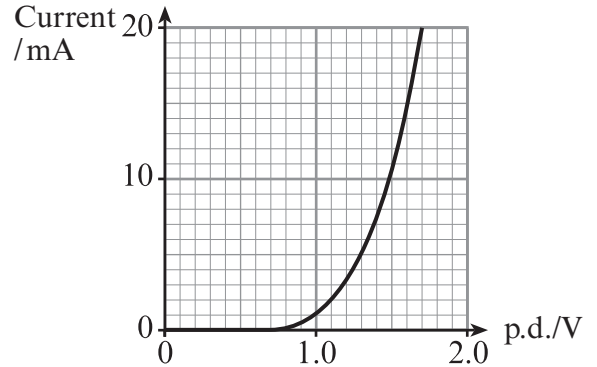
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2. The current-voltage characteristics of a diode also apply to a light emitting diode (LED). A graph of current against potential difference for an LED is shown.

- (a) (i) Calculate the resistance of the LED when the p.d. is 1.6 V. [2]

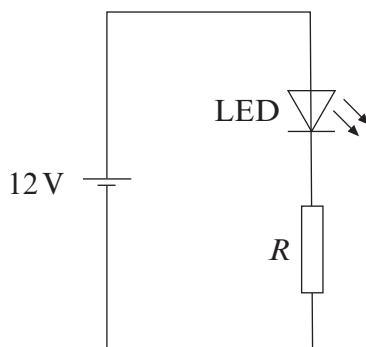


- (ii) Comment on the resistance of the LED at voltages below 1.0 V. Calculations are not required. [1]

- (b) (i) Explain how the graph shows that the LED does not obey Ohm's law. [1]

- (ii) Name one other device, other than a diode, to which Ohm's law does not apply. [1]

- (c) If the LED is connected across a supply of e.m.f. greater than 1.6 V, then the large current produced will destroy it. For this reason, LEDs usually have protective resistors in series with them to limit the current. The circuit shows this LED used as an indicator for a car alarm. The car battery supplies 12 V and the LED has an operating current of 15 mA. Determine the value, R , of the protective resistor needed. [3]



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3. (a) Derive, giving a labelled diagram, the relationship between the current I through a metal wire of cross sectional area A , the drift velocity, v , of the free electrons, each of charge e , and the number, n , of free electrons per unit volume of the metal. [4]
($I = nAve$).

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- (b) Calculate the drift velocity of free electrons in a copper wire of cross sectional area $1.7 \times 10^{-6} \text{ m}^2$ when a current of 2.0 A flows. [$n_{\text{copper}} = 1.0 \times 10^{29} \text{ m}^{-3}$]. [2]

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- (c) A potential difference is required across the copper wire in order for the current to flow. The size of the current depends on the wire's *resistance*. Explain in terms of free electrons, how this resistance arises. [2]

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- (d) The copper wire in (b) is of length 2.5 m. When it carries a current of 2.0 A, it dissipates energy at the rate of 0.1 W. Calculate its resistivity. [4]

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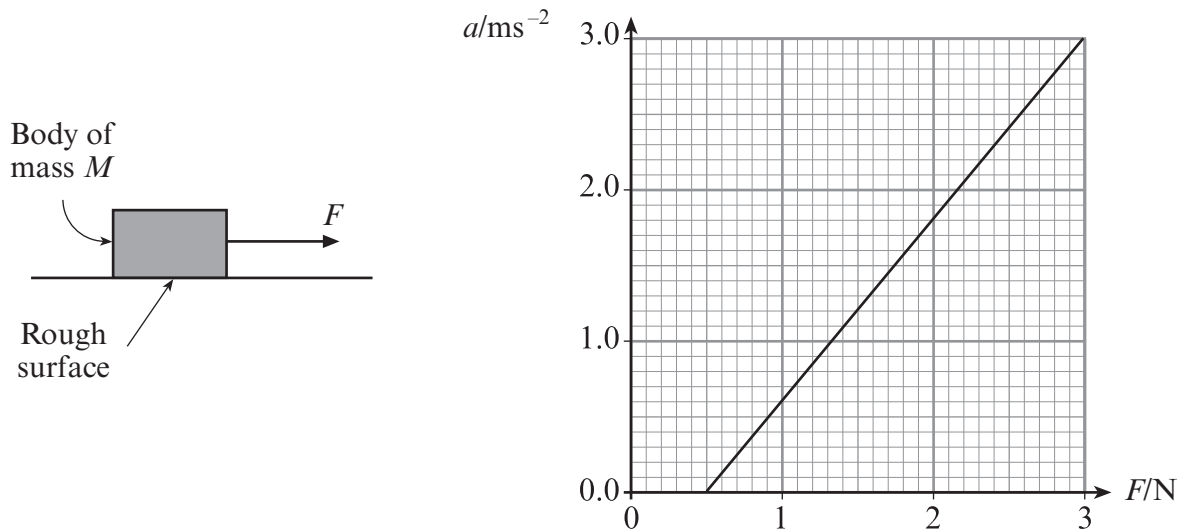
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- (e) A second copper wire has the same volume as the wire in (d), but is longer. Complete the table below indicating whether the quantity given is **bigger**, **smaller** or **the same** for this longer wire. [3]

Quantity	For the longer wire this quantity is ...
Cross-sectional Area	
n , number of free electrons/unit volume	
Resistivity	

4. A body of mass M is placed on a rough surface and a horizontal force, F , is applied to it as shown. Data-logging apparatus is used to determine the acceleration of the body for different values of F . The results are shown in the graph.



- (a) (i) Explain why the acceleration of the body is 0 when the applied force F is less than 0.5 N. [1]

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- (ii) Use your graph to determine the value of M . [3]

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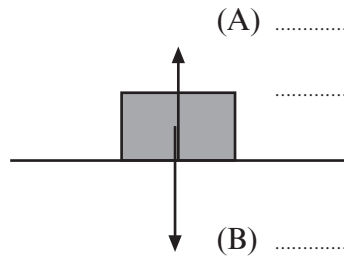
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- (b) (i) Label forces (A) and (B) also acting on the body.

[2]



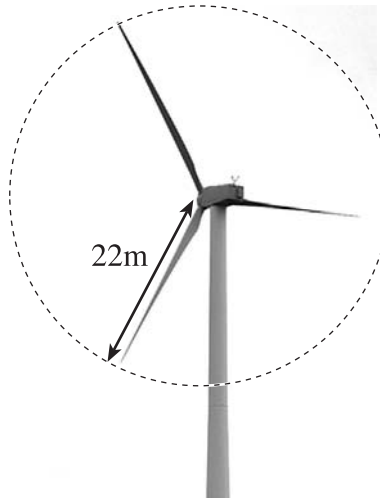
- (ii) State the Newton third law reaction to force (B) and the body upon which it acts.

[2]

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5. A wind turbine, designed to generate electricity, has blades which sweep out an area of radius 22 m. The turbine turns “into the wind” so that the area swept out by the blades is always at right angles to the wind direction.



- (i) The volume of air passing through the blades every second can be calculated by considering a cylinder of air incident on the blades. Show that the volume of air passing through the blades in one second is approximately $21000 \text{ m}^3 \text{ s}^{-1}$, when the wind speed is 14 m s^{-1} . [2]

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- (ii) Hence calculate the mass of air passing through the blades every second. [1]
[density of air = 1.2 kg m^{-3}].

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- (iii) The mean speed of the air after it has passed through the blades is 11 m s^{-1} . Calculate the kinetic energy lost by the air per second as it passes through the blades. [3]

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- (iv) Assuming that 65% of this 'lost' energy is used to generate electricity, determine the number of turbines that would be needed to produce the same power output as a single 1000 MW coal fired power station. [2]

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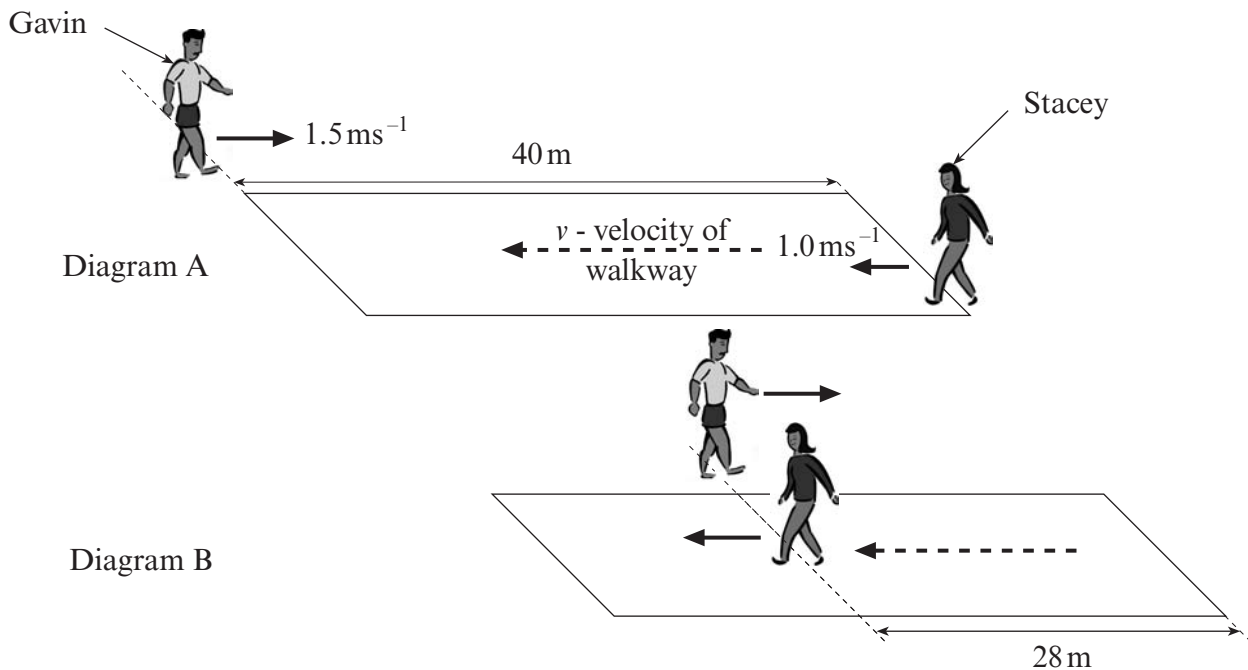
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6. (a) Define *velocity*.

[1]

- (b) (i) Stacey walks with a velocity of 1.0 ms^{-1} onto a moving walkway at an airport and continues to walk at the same pace. The walkway is itself moving with a velocity v , and in the same direction as Stacey. Write down an expression for Stacey's resultant velocity. [1]

- (ii) Gavin walks with a velocity of 1.5 ms^{-1} in the opposite direction to Stacey. He **does not** get on the walkway but instead walks in a straight line beside the walkway as shown in diagram A. At the instant Stacey steps onto the walkway, Gavin is positioned at the far end, 40 m away.



At some time ' t ' later (diagram B), Stacey has travelled 28 m from her start point when she passes Gavin who continues to walk in the opposite direction. Show that ' t ' is 8.0 seconds. [2]

- (iii) Hence or otherwise calculate the velocity, v , of the walkway. [3]

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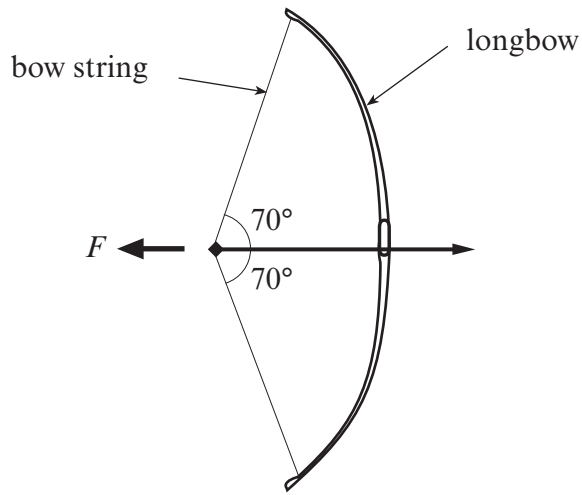
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- (iv) Calculate the velocity with which Gavin and Stacey approach each other. [1]

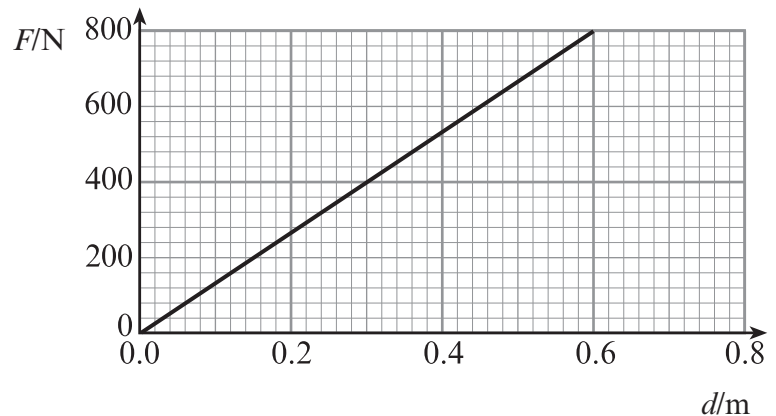
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7. (a) The medieval longbow was a devastatingly effective weapon. Assuming that a horizontal force F of 800 N is needed to draw back the bow string, show that the tension T in the string is approximately 1170 N. [2]



- (b) (i) The graph shows the variation of F with d for the longbow, where d is the distance the centre of the string is pulled back. Calculate the energy stored in the bow when the tension in the string is 1170 N. [2]



- (ii) Hence, **stating any assumptions you make**, show that the speed of the arrow as it leaves the bow is about 100 ms^{-1} . Take the mass of the arrow to be $50 \times 10^{-3} \text{ kg}$. [3]

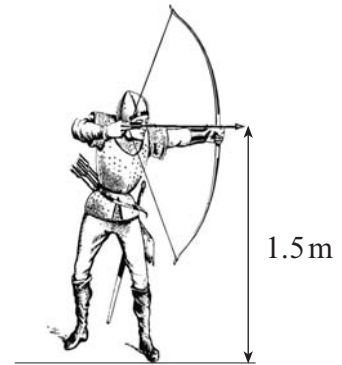
- (c) The arrow is released horizontally at this speed from 1.5 m above the ground as shown. The arrow continues its path until it embeds itself into the ground a horizontal distance D from the point of release. **Ignoring the effects of air on the arrow**, calculate

- (i) the time taken for the arrow to reach the ground, [3]

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- (ii) the horizontal distance D ,

[2]

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- (iii) the **resultant velocity** of the arrow when it hits the ground.

[5]

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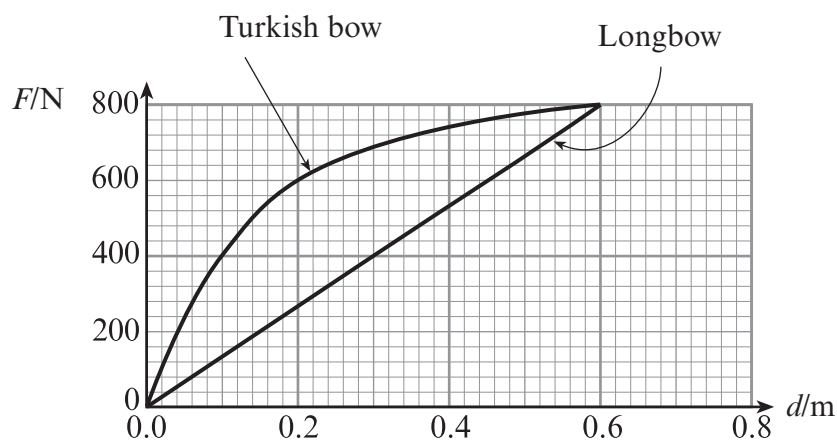
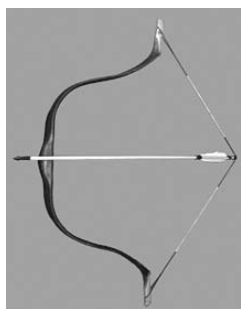
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QUESTION 7 CONTINUES ON PAGE 16

- (d) The Turkish war-bow of the 15th and 16th centuries (pictured) was also a fearsome weapon, able to shoot lightweight arrows great distances. A copy of the graph on page 14 is shown below which has included on it a curve to represent the draw force versus 'pull back distance' for a typical Turkish bow.



Use the graphs to compare the effectiveness of the Turkish bow in relation to the longbow. Your answer could refer to the ease of use of each bow, the energy stored and the effect this has on motion of an arrow.

Calculations are not required.

[4]

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[illegible]



GCE PHYSICS TAG FFISEG

Advanced Level / Safon Uwch

Data Booklet

A clean copy of this booklet should be issued to candidates for their use during each GCE Physics examination.

Centres are asked to issue this booklet to candidates at the start of the GCE Physics course to enable them to become familiar with its contents and layout.

Values and Conversions

Avogadro constant	$N_A = 6.02 \times 10^{23} \text{ mol}^{-1}$
Fundamental electronic charge	$e = 1.60 \times 10^{-19} \text{ C}$
Mass of an electron	$m_e = 9.11 \times 10^{-31} \text{ kg}$
Molar gas constant	$R = 8.31 \text{ J mol}^{-1} \text{ K}^{-1}$
Acceleration due to gravity at sea level	$g = 9.81 \text{ m s}^{-2}$
Gravitational field strength at sea level	$g = 9.81 \text{ N kg}^{-1}$
Universal constant of gravitation	$G = 6.67 \times 10^{-11} \text{ N m}^2 \text{ kg}^{-2}$
Planck constant	$h = 6.63 \times 10^{-34} \text{ J s}$
Boltzmann constant	$k = 1.38 \times 10^{-23} \text{ J K}^{-1}$
Speed of light <i>in vacuo</i>	$c = 3.00 \times 10^8 \text{ m s}^{-1}$
Permittivity of free space	$\epsilon_0 = 8.85 \times 10^{-12} \text{ F m}^{-1}$
Permeability of free space	$\mu_0 = 4\pi \times 10^{-7} \text{ H m}^{-1}$
Stefan constant	$\sigma = 5.67 \times 10^{-8} \text{ W m}^{-2} \text{ K}^{-4}$
Wien constant	$W = 2.90 \times 10^{-3} \text{ m K}$

$$T/\text{K} = \theta/^{\circ}\text{C} + 273.15$$

$$1 \text{ u} = 1.66 \times 10^{-27} \text{ kg}$$

AS

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

$$v = u + at$$

$$x = \frac{1}{2}(u + v)t$$

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

$$v^2 = u^2 + 2ax$$

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

$$\Delta E = mg\Delta h$$

$$E = \frac{1}{2}kx^2$$

$$E = \frac{1}{2}mv^2$$

$$Fx = \frac{1}{2}mv^2 - \frac{1}{2}mu^2$$

$$\text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{total energy input}} \times 100\%$$

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

$$I = \frac{\Delta Q}{\Delta t}$$

$$I = nAve$$

$$R = \frac{\rho l}{A}$$

$$R = \frac{V}{I}$$

$$P = IV$$

$$V = E - Ir$$

$$\frac{V}{V_{\text{total}}} \left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}} \right) = \frac{R}{R_{\text{total}}}$$

$$c = f\lambda$$

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

$$\lambda = \frac{ay}{D}$$

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

$$n_1 v_1 = n_2 v_2$$

$$n_1 \sin \theta_1 = n_2 \sin \theta_2$$

$$E_{k \text{ max}} = hf - \phi$$

$$\lambda_{\text{max}} = W T^{-1}$$

$$P = A\sigma T^4$$

Particle Physics

particle (symbol)	Leptons		Quarks	
	electron (e ⁻)	electron neutrino (ν _e)	up (u)	down (d)
charge (e)	-1	0	+ $\frac{2}{3}$	- $\frac{1}{3}$
Lepton number	1	1	0	0

A2

$\omega = \frac{\theta}{t}$	$M/\text{kg} = \frac{M_r}{1000}$	$F = BIl \sin \theta$ and $F = Bqv \sin \theta$
$v = \omega r$	$pV = nRT$	$B = \frac{\mu_o I}{2\pi a}$
$a = \omega^2 r$	$p = \frac{1}{3} \rho c^2$	$B = \mu_o nI$
$a = -\omega^2 x$	$U = \frac{3}{2} nRT$	$\Phi = AB \cos \theta$
$x = A \sin(\omega t + \varepsilon)$	$k = \frac{R}{N_A}$	$V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}}$
$v = A\omega \cos(\omega t + \varepsilon)$	$W = p\Delta V$	$A = \lambda N$
$T = 2\pi \sqrt{\frac{m}{k}}$	$\Delta U = Q - W$	$N = N_o e^{-\lambda t}$ or $N = \frac{N_o}{2^x}$
$p = mv$	$C = \frac{Q}{V}$	$A = A_o e^{-\lambda t}$ or $A = \frac{A_o}{2^x}$
$Q = mc\Delta\theta$	$C = \frac{\varepsilon_o A}{d}$	$\lambda = \frac{\log_e 2}{T_{1/2}}$
$p = \frac{h}{\lambda}$	$U = \frac{1}{2} QV$	$E = mc^2$
$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$	$Q = Q_o e^{-t/\tau}$	

Fields

$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$	$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$	$V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$	$W = q\Delta V_E,$
$F = G \frac{M_1 M_2}{r^2}$	$g = \frac{GM}{r^2}$	$V_g = \frac{-GM}{r}$	$W = m\Delta V_g$

Orbiting Bodies

Centre of mass: $r_1 = \frac{M_2}{M_1 + M_2} d;$

Period of Mutual Orbit: $T = 2\pi \sqrt{\frac{d^3}{G(M_1 + M_2)}}$

Options

A: $\frac{V_1}{N_1} = \frac{V_2}{N_2}; E = -L \frac{\Delta I}{\Delta t}; X_L = \omega L; X_C = \frac{1}{\omega C}; Z = \sqrt{X^2 + R^2}; Q = \frac{\omega_o L}{R}$

B: $c = \frac{1}{\sqrt{\mu_o \epsilon_o}}; \Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$

C: $\varepsilon = \frac{\Delta I}{l}; Y = \frac{\sigma}{\varepsilon}; \sigma = \frac{F}{A}; U = \frac{1}{2} \sigma \varepsilon V$

D: $I = I_o \exp(-\mu x); Z = c\rho$

E: $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}; U = \frac{K}{\Delta x}; \frac{Q_2}{Q_1} = \frac{T_2}{T_1}$ Carnot efficiency = $\frac{(Q_1 - Q_2)}{Q_1}$

Mathematical Information

SI multipliers

Multiple	Prefix	Symbol
10^{-18}	atto	a
10^{-15}	femto	f
10^{-12}	pico	p
10^{-9}	nano	n
10^{-6}	micro	μ
10^{-3}	milli	m
10^{-2}	centi	c

Multiple	Prefix	Symbol
10^3	kilo	k
10^6	mega	M
10^9	giga	G
10^{12}	tera	T
10^{15}	peta	P
10^{18}	exa	E
10^{21}	zetta	Z

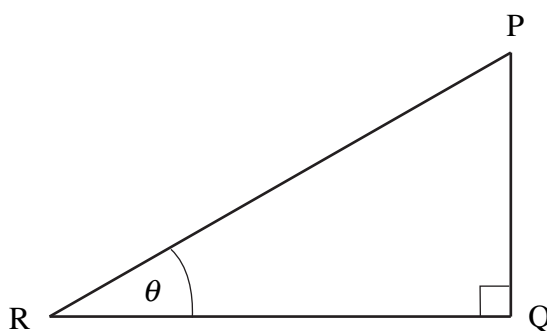
Areas and Volumes

$$\text{Area of a circle} = \pi r^2 = \frac{\pi d^2}{4}$$

$$\text{Area of a triangle} = \frac{1}{2} \text{ base} \times \text{height}$$

Solid	Surface area	Volume
rectangular block	$2 (lh + hb + lb)$	lbh
cylinder	$2\pi r (r + h)$	$\pi r^2 h$
sphere	$4\pi r^2$	$\frac{4}{3}\pi r^3$

Trigonometry



$$\sin \theta = \frac{PQ}{PR}, \quad \cos \theta = \frac{QR}{PR}, \quad \tan \theta = \frac{PQ}{QR}, \quad \frac{\sin \theta}{\cos \theta} = \tan \theta$$

$$PR^2 = PQ^2 + QR^2$$

Logarithms (A2 only)

[Unless otherwise specified 'log' can be $\log_e$ (i.e. $\ln$) or $\log_{10}$.]

$$\log(ab) = \log a + \log b$$

$$\log\left(\frac{a}{b}\right) = \log a - \log b$$

$$\log x^n = n \log x$$

$$\log_e e^{kx} = \ln e^{kx} = kx$$

$$\log_e 2 = \ln 2 = 0.693$$