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**	

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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.

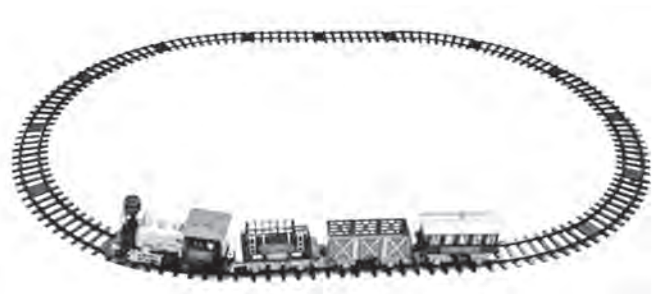
The number of marks is given in brackets at the end of each question or part question.

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

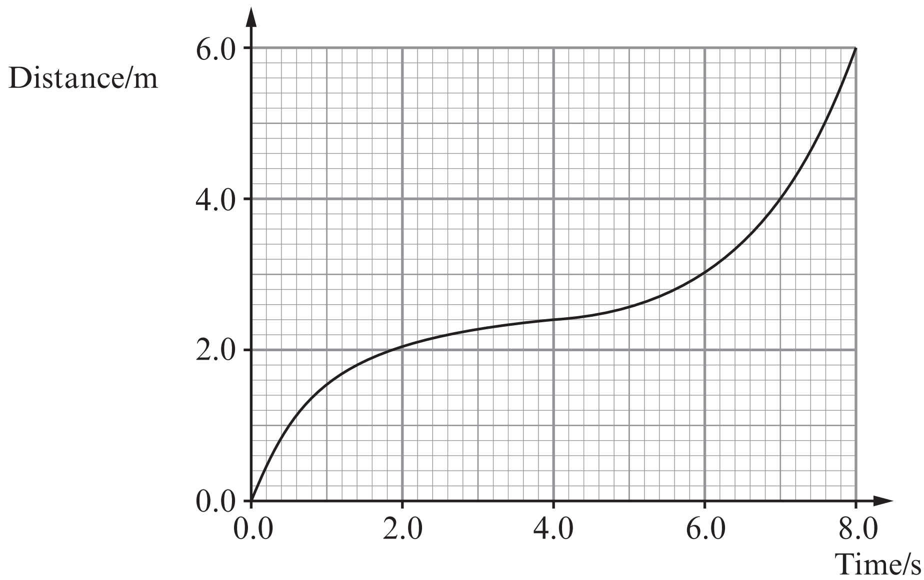
You are reminded to show all working. Credit is given for correct working even when the final answer given is incorrect.

Examiner only

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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Examiner only

(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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1321 010003

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]

$$\mathrm{J\,s\,C^{-2}}$$

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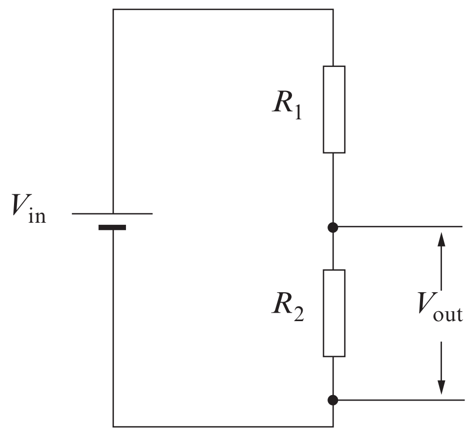
(b) The diagram shows a potential divider.



(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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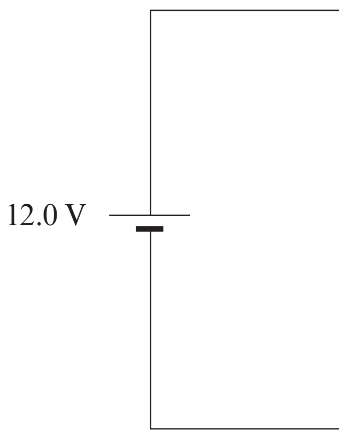
Examiner only

(c) Three resistors are available with values 40 Ω, 40 Ω and 80 Ω.

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

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



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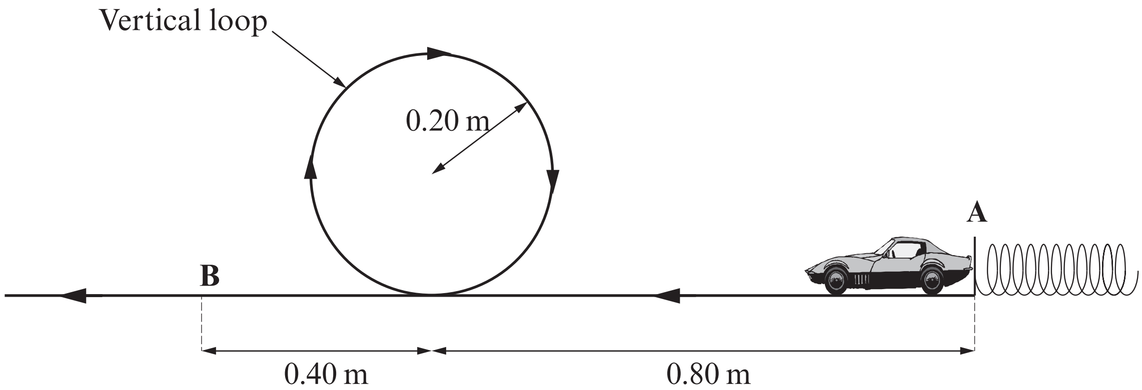
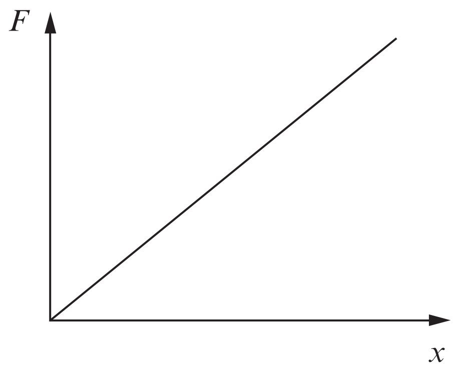
Examiner only

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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Examiner only

(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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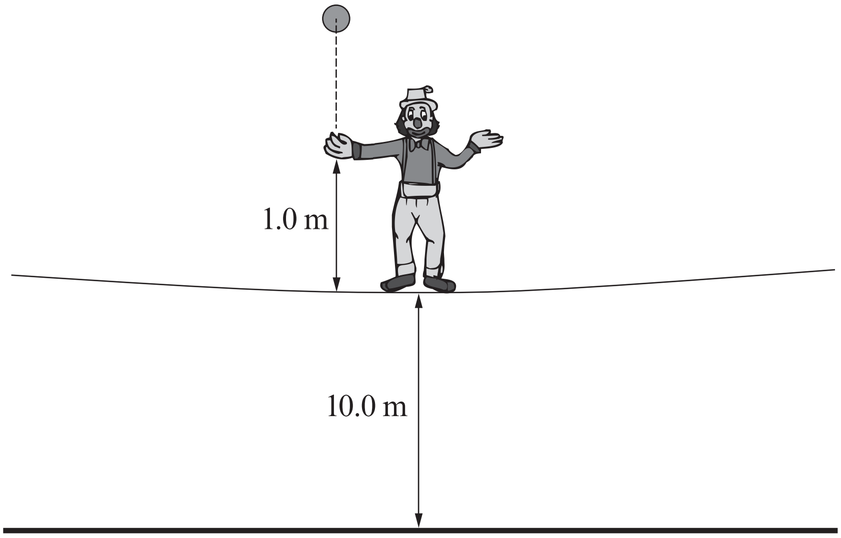
Examiner only

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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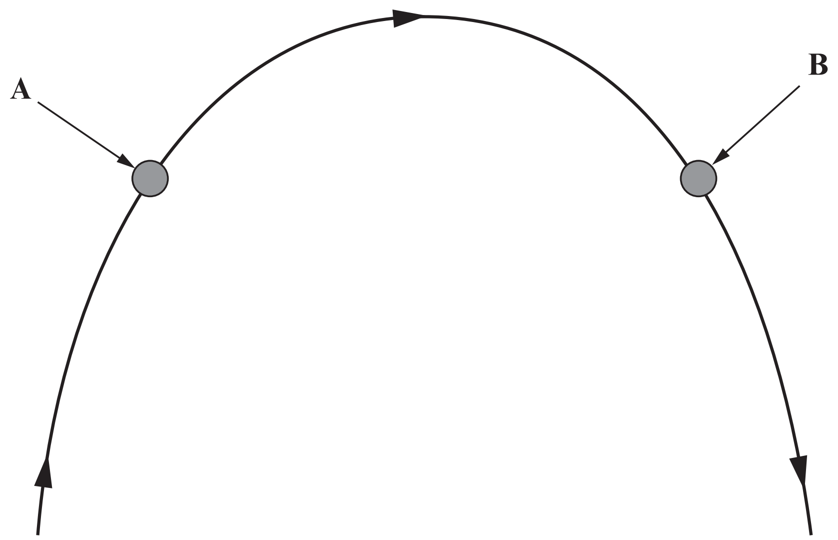
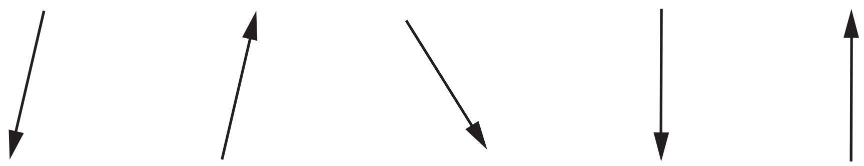
Examiner only

(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]



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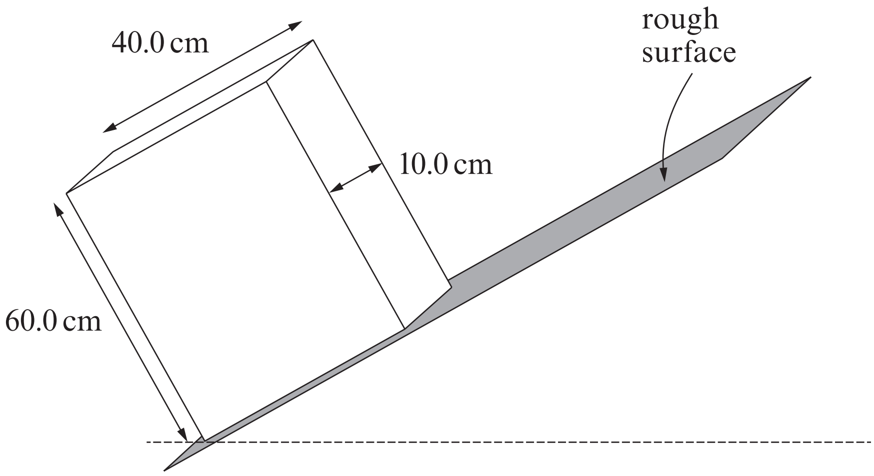
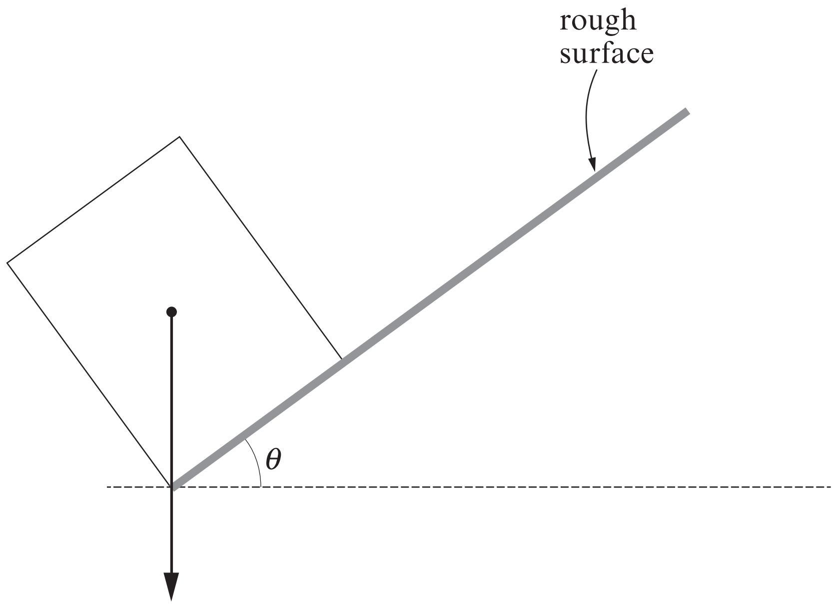
(ii) Assuming the force of air resistance **cannot** be neglected, sketch a diagram below to show the forces acting on the ball as it falls towards the ground in position **B** as shown in the above diagram. [2]

Examiner only

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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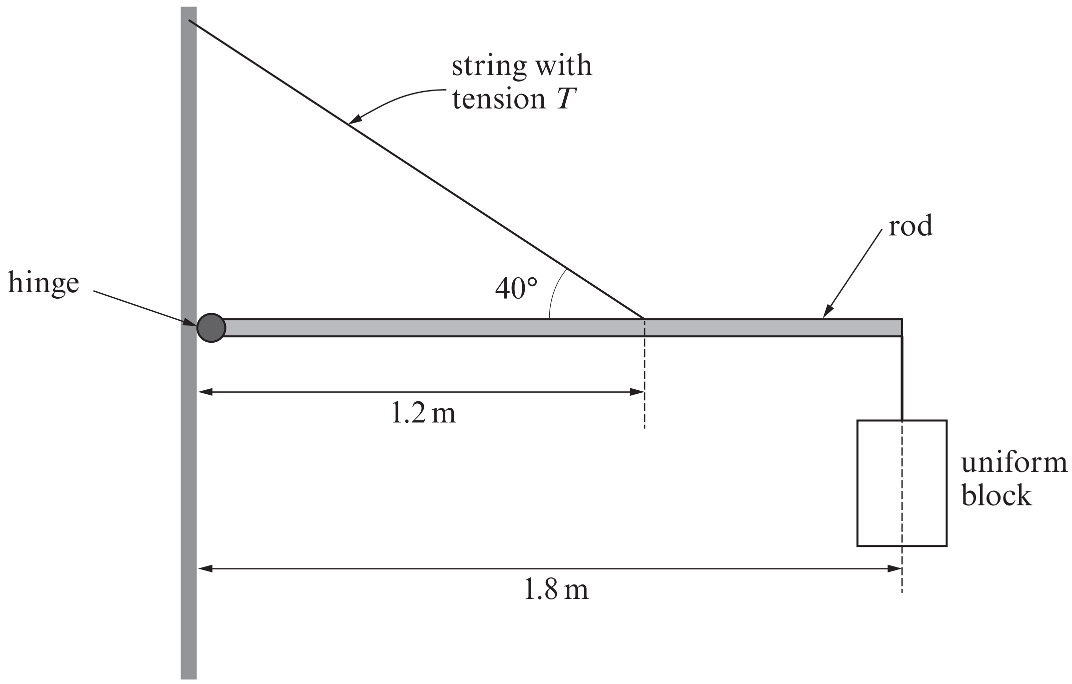
Examiner only

(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 $400\,\text{kg}\,\text{m}^{-3}$. 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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Examiner only

6. A power cable has a resistance of 11.2 Ω 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]

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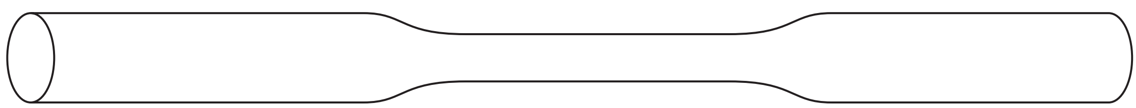
(b) A small portion of the cable is damaged. As a result its cross-sectional area is less than that of the rest of the cable, as shown in the diagram.



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

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

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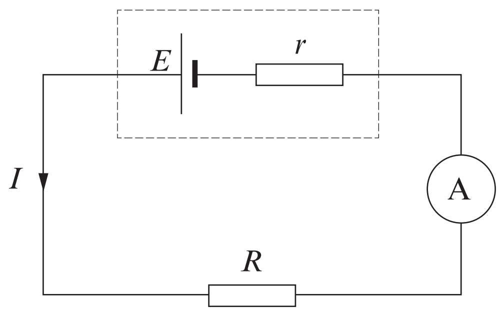
7. A student sets up the following circuit using a cell of emf E and internal resistance r.



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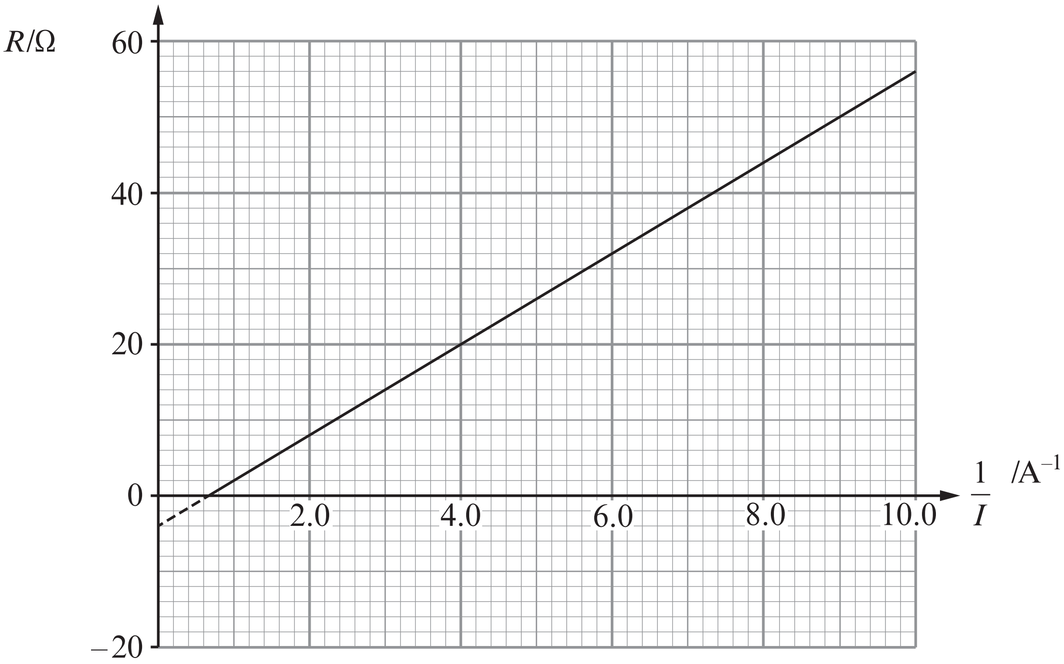
(b) The student measures the current I for different values of R. She then plots a graph of R against $\frac{1}{I}$.



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]

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(ii) Determine the emf of the cell. [2]

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(iii) Referring to the graph, calculate the power dissipated in the resistor R when there is a current of 0.25 A. [4]

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Examiner only

(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]

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

END OF PAPER

Examiner only

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	=	$6{\cdot}02 \times 10^{23}$ mol^{-1}
Fundamental electronic charge	e	=	$1{\cdot}60 \times 10^{-19}$ C
Mass of an electron	m_e	=	$9{\cdot}11 \times 10^{-31}$ kg
Molar gas constant	R	=	$8{\cdot}31$ J mol^{-1} K^{-1}
Acceleration due to gravity at sea level	g	=	$9{\cdot}81$ m s^{-2}
Gravitational field strength at sea level	g	=	$9{\cdot}81$ N kg^{-1}
Universal constant of gravitation	G	=	$6{\cdot}67 \times 10^{-11}$ N m^2 kg^{-2}
Planck constant	h	=	$6{\cdot}63 \times 10^{-34}$ J s
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}$ J K^{-1}
Speed of light *in vacuo*	c	=	$3{\cdot}00 \times 10^{8}$ m s^{-1}
Permittivity of free space	ε_0	=	$8{\cdot}85 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}$ H m^{-1}
Stefan constant	σ	=	$5{\cdot}67 \times 10^{-8}$ W m^{-2} K^{-4}
Wien constant	W	=	$2{\cdot}90 \times 10^{-3}$ m K

T/K = θ/°C + 273·15

1 u = $1{\cdot}66 \times 10^{-27}$ kg

AS

$$\rho = \frac{m}{V}$$
$$v = u + at$$
$$x = \tfrac{1}{2}(u+v)t$$
$$x = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2ax$$
$$\Sigma F = ma$$
$$W = Fx\cos\theta$$
$$\Delta E = mg\Delta h$$
$$E = \tfrac{1}{2}kx^2$$
$$E = \tfrac{1}{2}mv^2$$
$$Fx = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mu^2$$
$$\text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{total energy input}} \times 100\%$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$
$$I = \frac{\Delta Q}{\Delta t}$$
$$I = nAve$$
$$R = \frac{\rho l}{A}$$
$$R = \frac{V}{I}$$
$$P = IV$$

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

$$c = f\lambda$$
$$T = \frac{1}{f}$$
$$\lambda = \frac{ay}{D}$$
$$d\sin\theta = n\lambda$$
$$n_1 v_1 = n_2 v_2$$
$$n_1 \sin\theta_1 = n_2 \sin\theta_2$$
$$E_{k\,\text{max}} = hf - \phi$$
$$\lambda_{\text{max}} = W\,T^{-1}$$
$$P = A\sigma T^4$$

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

$$\omega = \frac{\theta}{t}$$
$$v = \omega r$$
$$a = \omega^2 r$$
$$a = -\omega^2 x$$
$$x = A\sin(\omega t + \varepsilon)$$
$$v = A\omega\cos(\omega t + \varepsilon)$$
$$T = 2\pi\sqrt{\frac{m}{k}}$$
$$p = mv$$
$$Q = mc\Delta\theta$$
$$p = \frac{h}{\lambda}$$
$$\frac{\Delta\lambda}{\lambda} = \frac{v}{c}$$

$$M/\text{kg} = \frac{M_r}{1000}$$
$$pV = nRT$$
$$p = \tfrac{1}{3}\rho\overline{c^2}$$
$$U = \tfrac{3}{2}nRT$$
$$k = \frac{R}{N_A}$$
$$W = p\Delta V$$
$$\Delta U = Q - W$$
$$C = \frac{Q}{V}$$
$$C = \frac{\varepsilon_o A}{d}$$
$$U = \tfrac{1}{2}QV$$
$$Q = Q_0 e^{-t/RC}$$

$$F = BIl\sin\theta \text{ and } F = Bqv\sin\theta$$
$$B = \frac{\mu_o I}{2\pi a}$$
$$B = \mu_o nI$$
$$\Phi = AB\cos\theta$$
$$V_{\text{r.m.s.}} = \frac{V_0}{\sqrt{2}}$$
$$A = \lambda N$$
$$N = N_o e^{-\lambda t} \text{ or } N = \frac{N_o}{2^x}$$
$$A = A_o e^{-\lambda t} \text{ or } A = \frac{A_o}{2^x}$$
$$\lambda = \frac{\log_e 2}{T_{½}}$$
$$E = mc^2$$

Fields

$$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1Q_2}{r^2} \qquad E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2} \qquad V_E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r} \qquad W = q\Delta V_E,$$

$$F = G\frac{M_1M_2}{r^2} \qquad g = \frac{GM}{r^2} \qquad V_g = \frac{-GM}{r} \qquad W = m\Delta V_g$$

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: $c = \frac{1}{\sqrt{\mu_0\varepsilon_0}}$; $\Delta t = \frac{\Delta\tau}{\sqrt{1 - \frac{v^2}{c^2}}}$

C: $\varepsilon = \frac{\Delta l}{l}$; $Y = \frac{\sigma}{\varepsilon}$; $\sigma = \frac{F}{A}$; $U = \tfrac{1}{2}\sigma\varepsilon V$

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

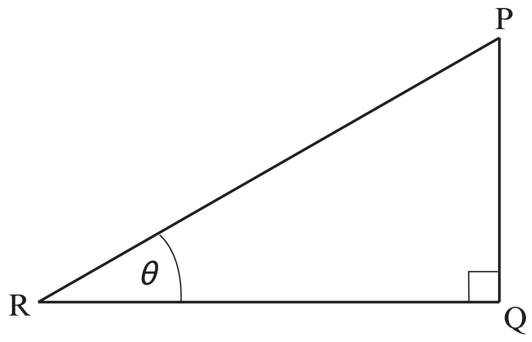
Areas and Volumes

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

Area of a triangle $= \frac{1}{2}$ base × 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 $\log_{10}$.]

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

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

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

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

$\log_e 2 = \ln 2 = 0{\cdot}693$