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	

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.

2

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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**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]

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

$I = $ .... A

1 A

P

4 A

1 A

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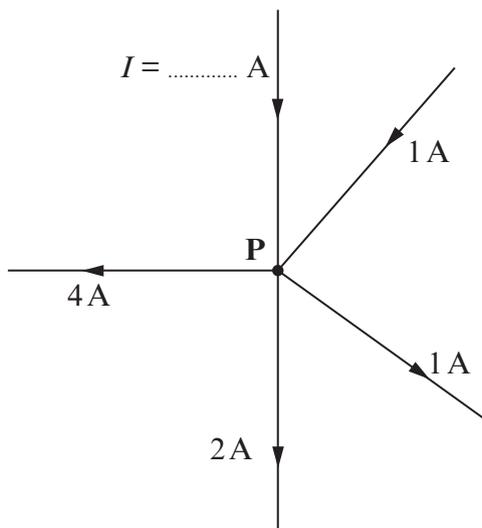
(b) Resistors are connected as shown in the diagram, and a pd of 12 V is applied across them. S_1 and S_2 are switches.

12 V

S_1 12 Ω   3 Ω

X   **Y**   **Z**

6 Ω S_2 6 Ω
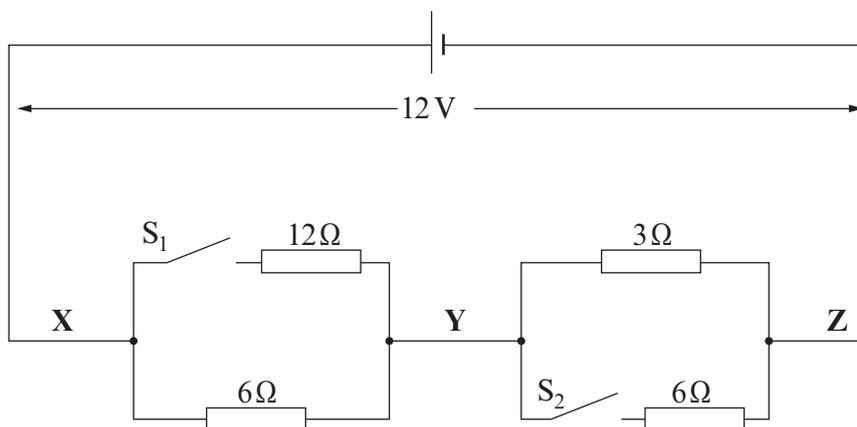
(i) Calculate the resistance of the circuit when both S_1 and S_2 are closed. [3]

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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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6

3. *(a)* Define the *emf* of a cell. [2]

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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
pd / V	1.31	1.13	0.93	0.68	0.48
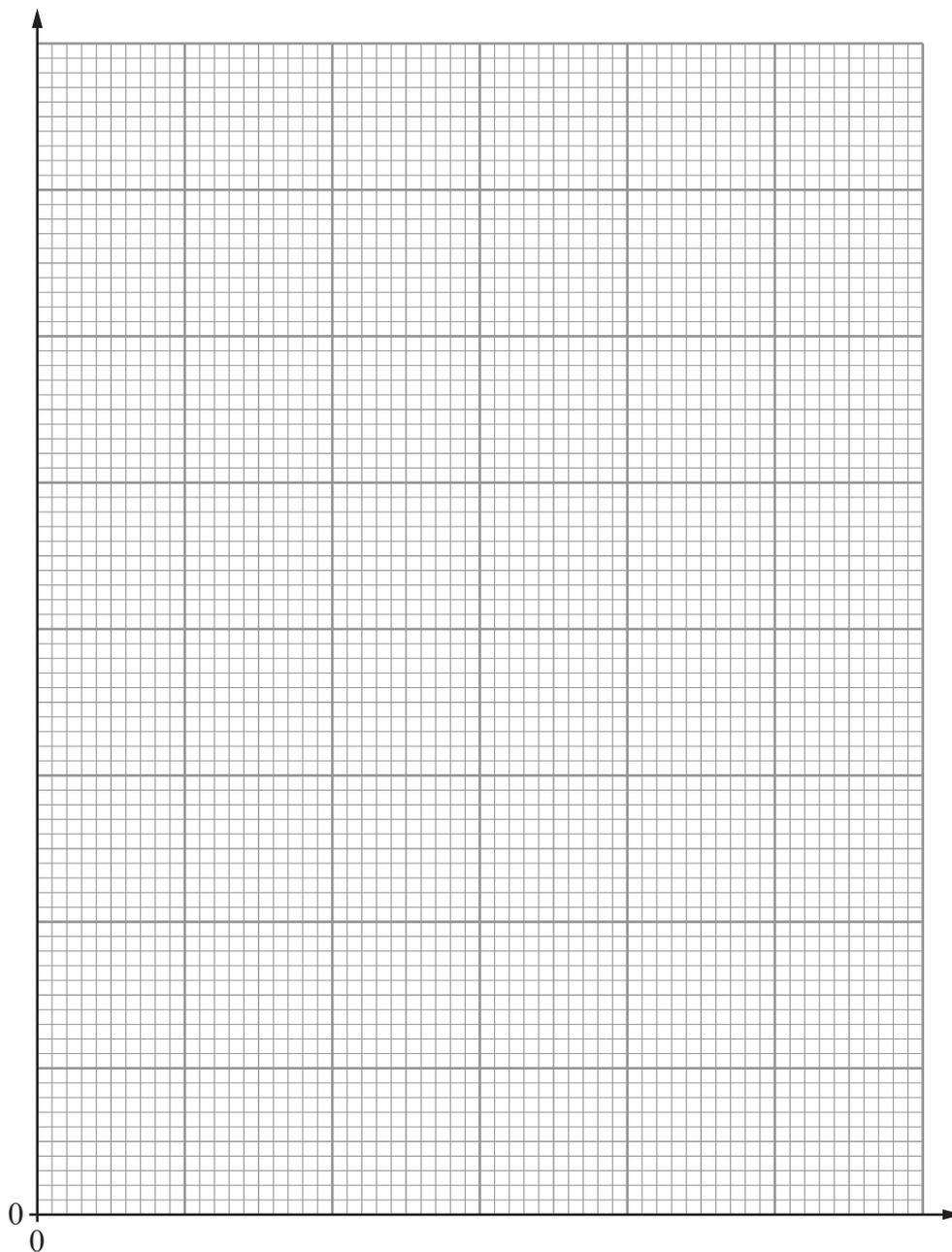
(c) Use your graph to determine:

(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 $6.0\,\Omega$ 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]

Resistance ↑

0
 0   Length

9

(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.

h = 120 m
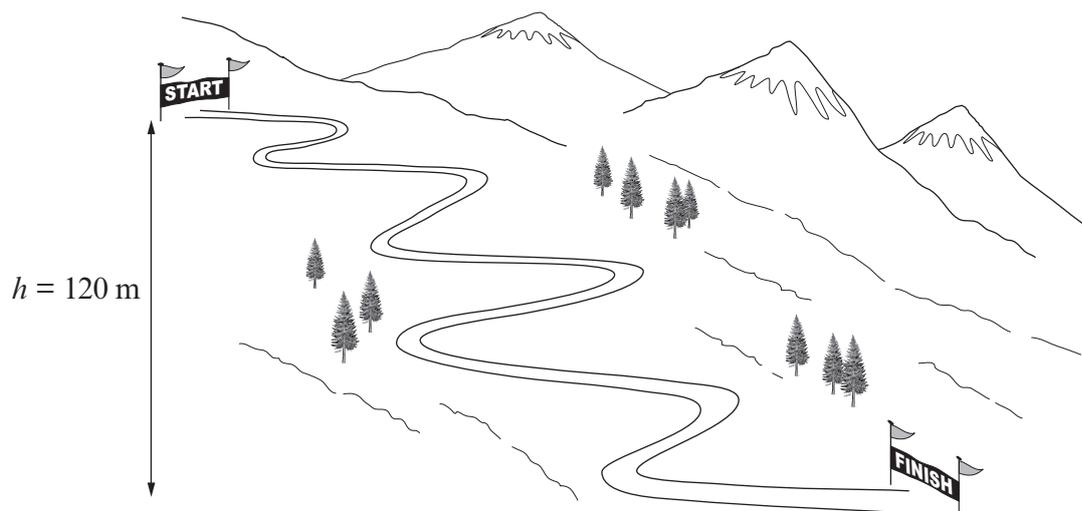
(i) Assuming no resistive forces, show that the maximum possible speed, *v*, of a bobsleigh at the finish line is given by [2]

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

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

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11

(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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6. A man pulls a tree trunk with a force of 600 N inclined at 40º to the horizontal.
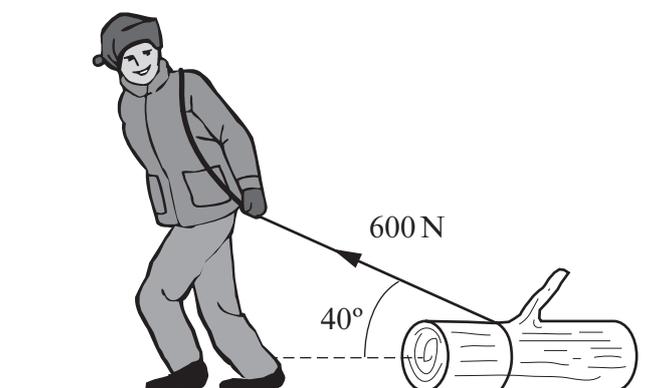
(a) (i) Calculate the horizontal component of the 600 N force pulling the tree trunk forwards. [2]

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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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(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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14

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]

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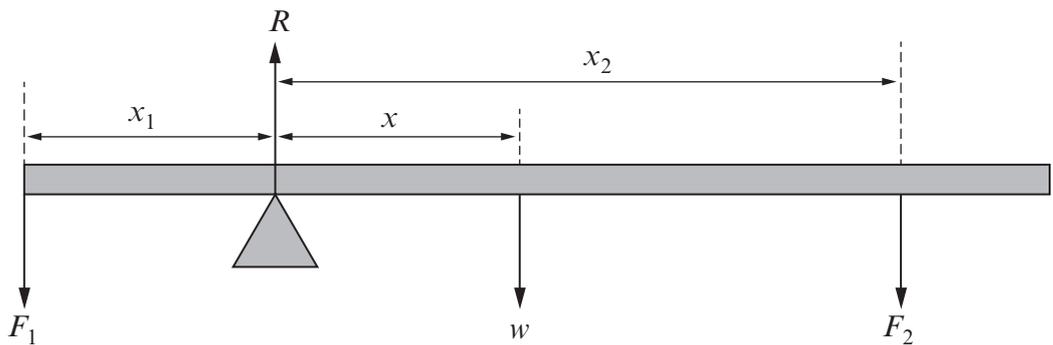
Applying the principle of moments about the pivot, complete the equation: [1]

$$F_1 x_1 = \text{...}$$

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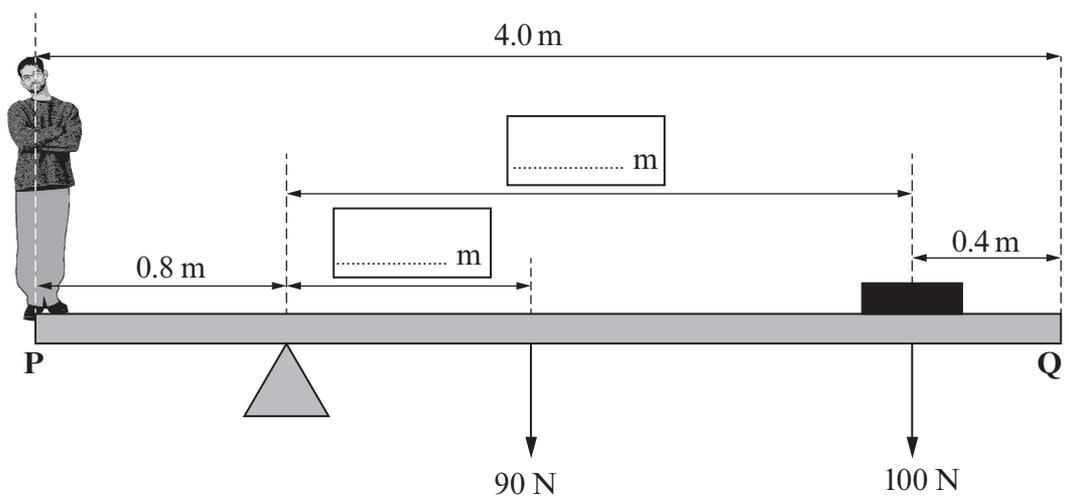
(i) Use the information given to fill in the two blank boxes with relevant distances. [1]

(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 =	$6{\cdot}02 \times 10^{23}$ 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_o =	$8{\cdot}85 \times 10^{-12}$ F m^{-1}
Permeability of free space	μ_o =	$4\pi \times 10^{-7}$ 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

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

$$v = u + at$$

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

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

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

$$\Sigma F = ma$$

$$W = Fx\cos\theta$$

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

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

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

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

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

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

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

$$I = nAve$$

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

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

$$P = IV$$

$$V = E - Ir$$

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

$$c = f\lambda$$

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

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

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

$$n_1 v_1 = n_2 v_2$$

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

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

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

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

Particle Physics

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

A2

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

$$v = \omega r$$

$$a = \omega^2 r$$

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

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

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

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

$$p = mv$$

$$Q = mc\Delta\theta$$

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

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

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

$$pV = nRT$$

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

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

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

$$W = p\Delta V$$

$$\Delta U = Q - W$$

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

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

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

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

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

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

$$B = \mu_o nI$$

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

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

$$A = \lambda N$$

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

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

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

$$E = mc^2$$

A2

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: $r_1 = \dfrac{M_2}{M_1 + M_2}d$;

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

Options

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

B: Electromagnetism and Space-Time

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

B: The Newtonian Revolution

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

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

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

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

$$r_P v_P = r_A v_A$$

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

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

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

4

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 $= \pi r^2 = \dfrac{\pi d^2}{4}$ Area of a triangle $= \dfrac{1}{2}$ base $\times$ height

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

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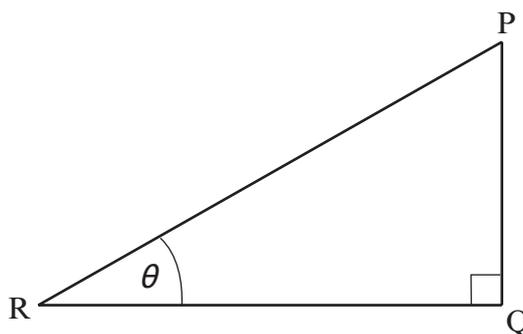
$$\sin\theta = \frac{PQ}{PR}, \quad \cos\theta = \frac{QR}{PR}, \quad \tan\theta = \frac{PQ}{QR}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

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

Logarithms (A2 only)

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

$\log(ab) = \log a + \log b$ $\log\left(\dfrac{a}{b}\right) = \log a - \log b$

$\log x^n = n\log x$ $\log_e e^{kx} = \ln e^{kx} = kx$

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