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

1321
010001

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	

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

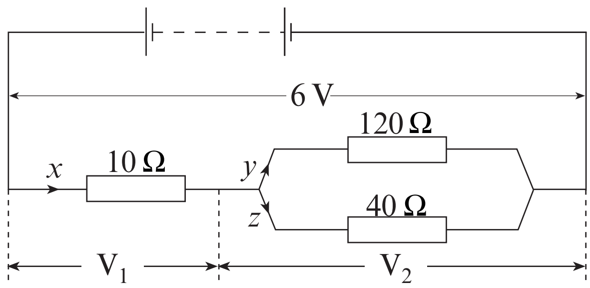
1. *(a)* (i) Using the idea of electric charge explain what is meant by *the electric current* in a conductor. [1]

....

(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]

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

(b)



(i) Write down the relationship between the currents x, y and z in the circuit. [1]

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(ii) The relationship you wrote down in *(b)*(i) is a consequence of which conservation law? [1]

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(c) Calculate

(i) the resistance of the combination of the three resistors, [3]

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(ii) the current x, [1]

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(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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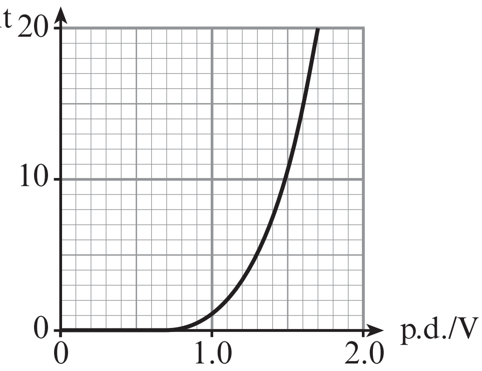
2. The current-voltage characteristics of a diode also apply to a light emitting diode (LED). A graph of current against potential difference for an LED is shown.

(a) (i) Calculate the resistance of the LED when the p.d. is 1.6 V. [2]

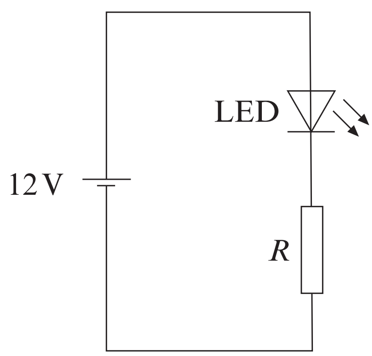


(ii) Comment on the resistance of the LED at voltages below 1.0 V. Calculations are not required. [1]

(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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Examiner only

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 $1.7 \times 10^{-6}\,m^2$ when a current of 2.0 A flows. [$n_{copper} = 1.0 \times 10^{29}\,m^{-3}$]. [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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(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	

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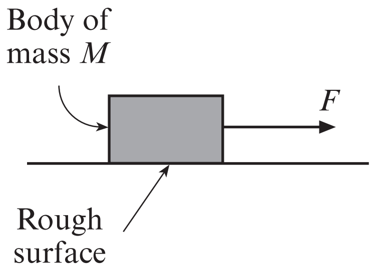
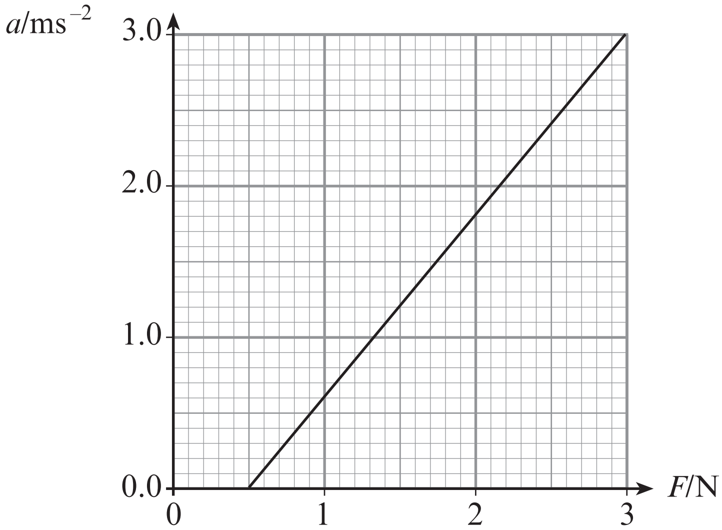
4. A body of mass M is placed on a rough surface and a horizontal force, F, is applied to it as shown. Data-logging apparatus is used to determine the acceleration of the body for different values of F. The results are shown in the graph.





(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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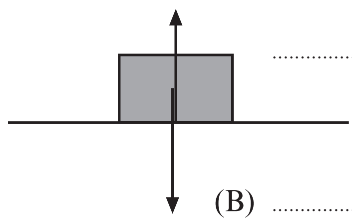
(b) (i) Label forces (A) and (B) also acting on the body. [2]



(A) ....

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(B) ....

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(ii) State the Newton third law reaction to force (B) and the body upon which it acts. [2]

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Turn over.

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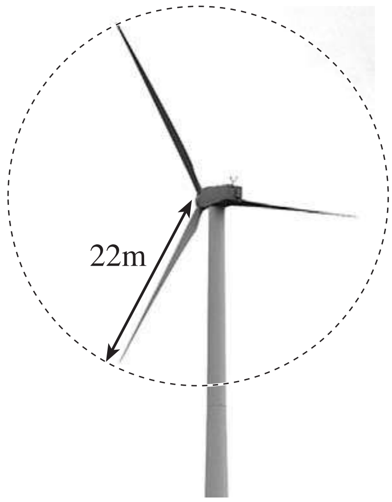
5. A wind turbine, designed to generate electricity, has blades which sweep out an area of radius 22 m. The turbine turns "into the wind" so that the area swept out by the blades is always at right angles to the wind direction.



(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 $m^3 s^{-1}$, when the wind speed is $14 m s^{-1}$. [2]

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(ii) Hence calculate the mass of air passing though the blades every second. [1]
[density of air = $1.2 kg m^{-3}$].

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Examiner only

(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]

(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]

Examiner only

6. *(a)* Define *velocity.* [1]

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(b) (i) Stacey walks with a velocity of $1.0\,\text{ms}^{-1}$ 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]

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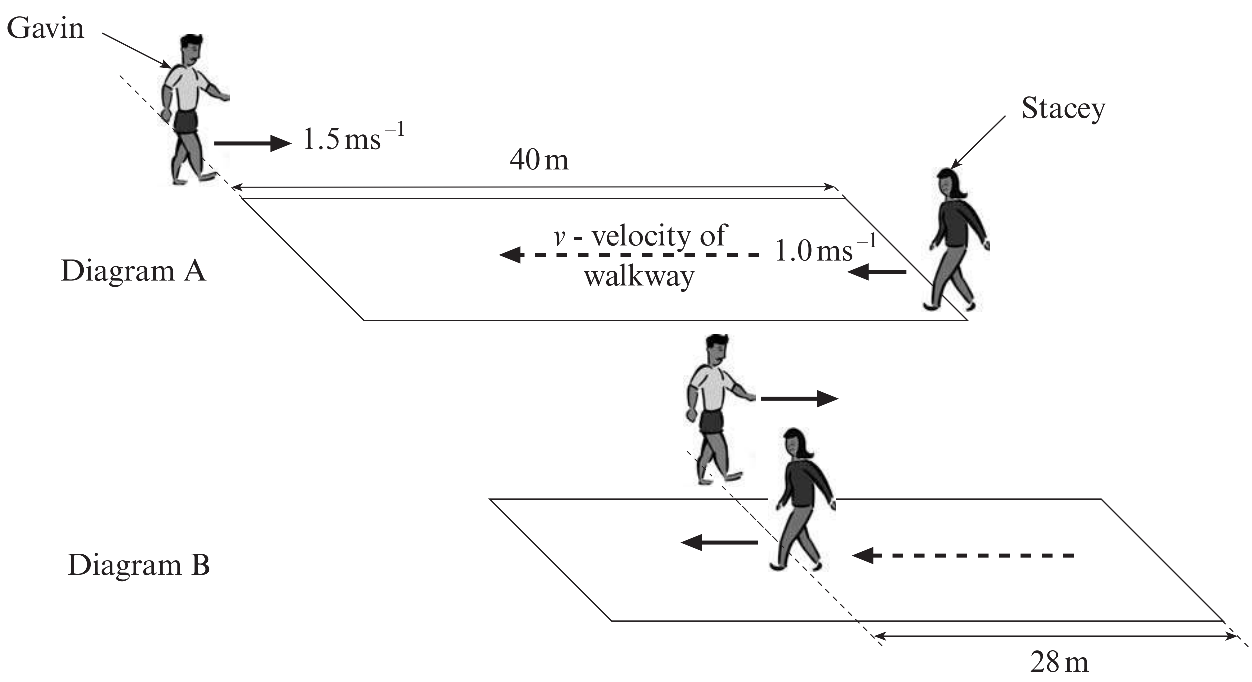
(ii) Gavin walks with a velocity of $1.5\,\text{ms}^{-1}$ in the opposite direction to Stacey. He **does not** get on the walkway but instead walks in a straight line beside the walkway as shown in diagram A. At the instant Stacey steps onto the walkway, Gavin is positioned at the far end, 40 m away.



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]

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(iii) Hence or otherwise calculate the velocity, v, of the walkway. [3]

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(iv) Calculate the velocity with which Gavin and Stacey approach each other. [1]

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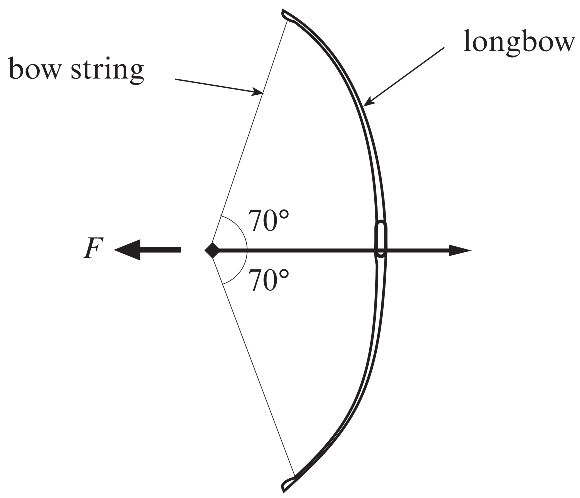
7. *(a)* The medieval longbow was a devastatingly effective weapon. Assuming that a horizontal force F of 800 N is needed to draw back the bow string, show that the tension T in the string is approximately 1170 N. [2]



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(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]

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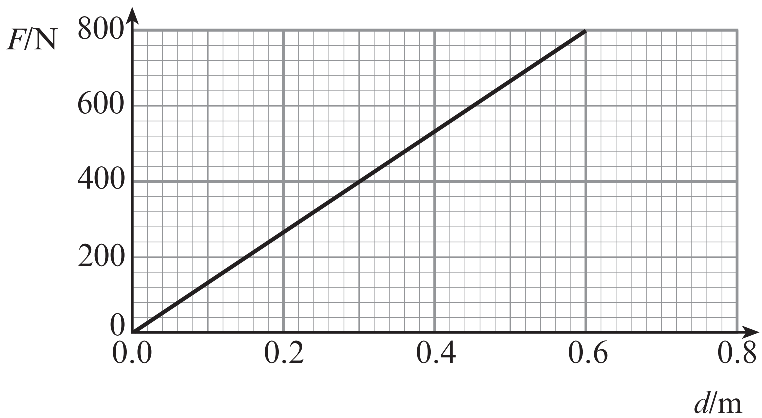

(ii) Hence, **stating any assumptions you make**, show that the speed of the arrow as it leaves the bow is about $100\,\mathrm{m\,s^{-1}}$. Take the mass of the arrow to be 50×10^{-3} kg. [3]

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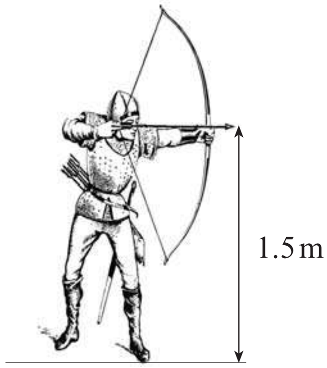
Examiner only

(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]

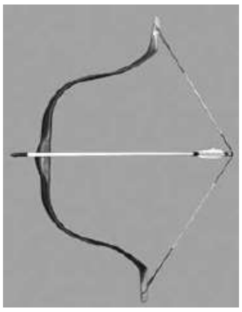
(ii) the horizontal distance *D*, [2]

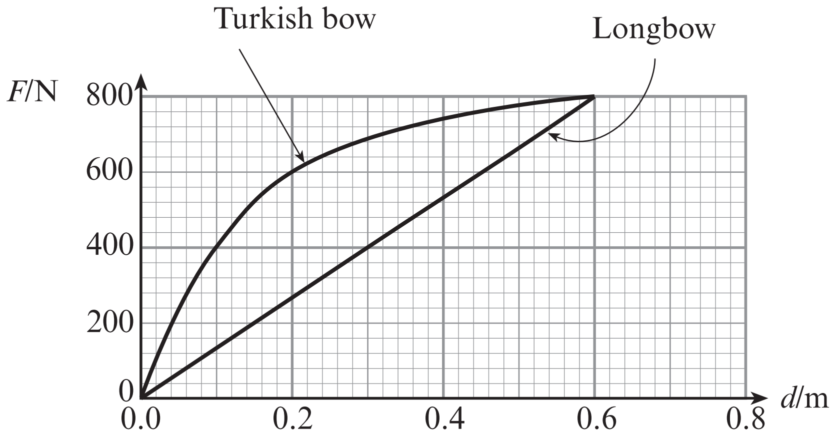
(iii) the **resultant velocity** of the arrow when it hits the ground. [5]

QUESTION 7 CONTINUES ON PAGE 16

Examiner only

(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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Turn over.

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

$T/\text{K} = \theta/°\text{C} + 273{\cdot}15$

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

AS

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

$v = u + at$

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

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

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

$\Sigma F = ma$

$W = Fx\cos\theta$

$\Delta E = mg\Delta h$

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

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

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

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

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

$I = nAve$

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

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

$P = IV$

$V = E - Ir$

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

$c = f\lambda$

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

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

$d\sin\theta = n\lambda$

$n_1 v_1 = n_2 v_2$

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

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

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

$P = A\sigma T^4$

$$\text{Efficiency} = \frac{\text{Useful energy transfer}}{\text{total energy input}} \times 100\%$$

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

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

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

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

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 $= \frac{(Q_1 - Q_2)}{Q_1}$

Turn over.

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

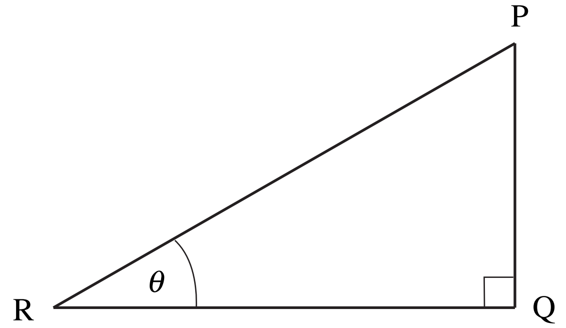
Areas and Volumes

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

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

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

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

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

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

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