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**	

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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.

Examiner only

1. *(a)* (i) State Ohm's law. [2]

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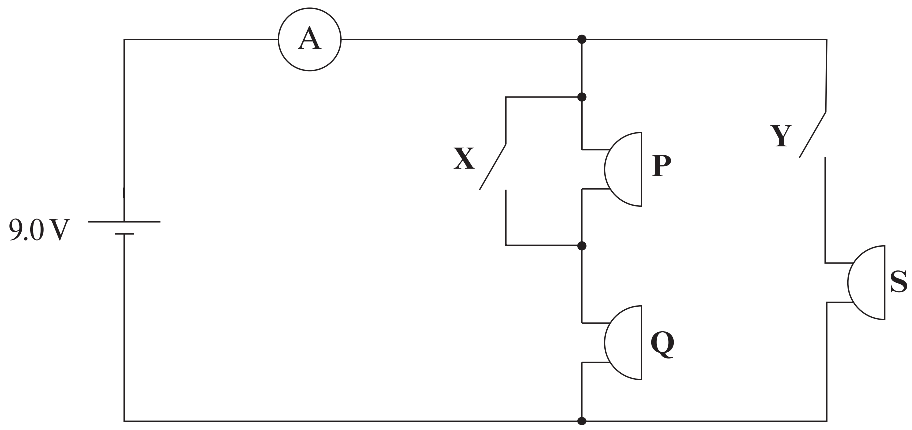
(ii) The unit of resistance is the ohm (Ω). One of the following is a correct alternative unit to the ohm. Circle the correct one. [1]

$V\,A^{-1}$ $\quad A\,V^{-1}$ $\quad J\,C^{-1}$ $\quad J\,s^{-1}$

(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

power used by **S** = 4 × power used by **Q** [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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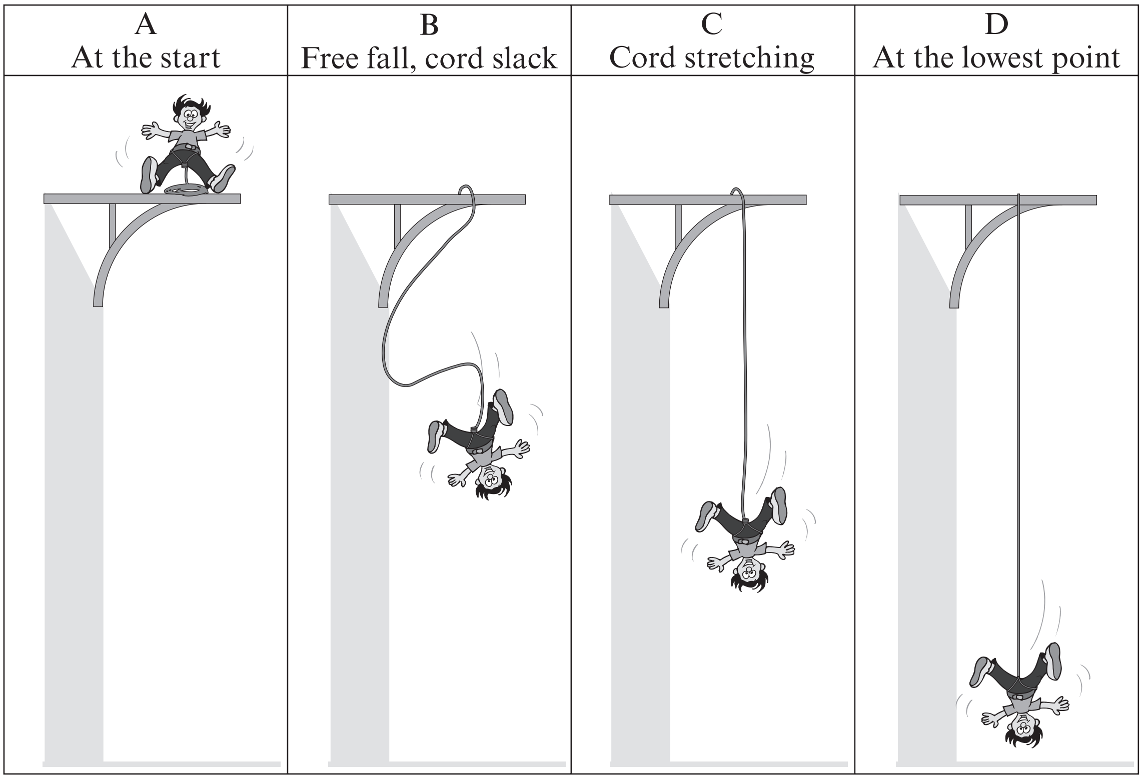
4. *(a)* By referring to the diagrams, discuss some of the energy changes involved in a bungee jump. You should make reference to *gravitational potential energy*, *kinetic energy* and *elastic potential energy* in your answer. [5]



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(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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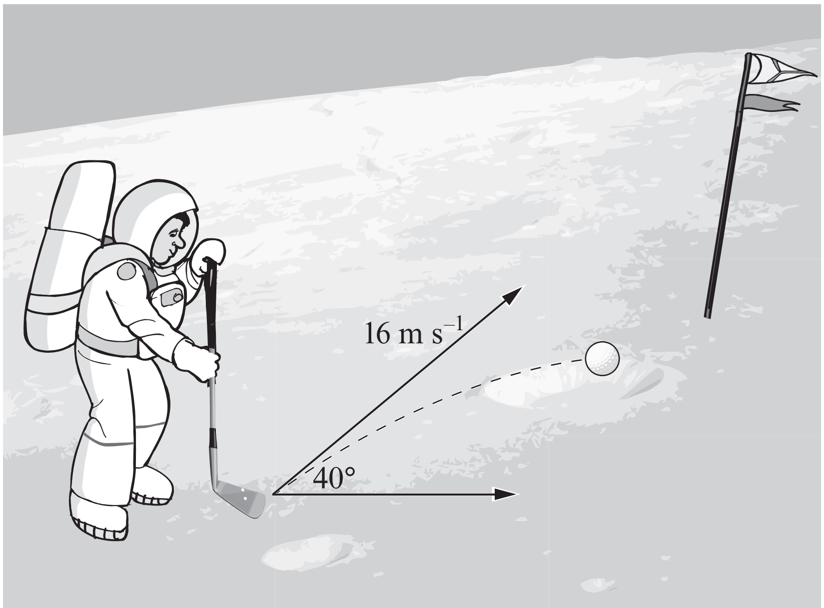
5. The astronauts of Apollo 14 played golf on the Moon. They struck a number of shots such as the one shown below.



(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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(c) A similar golf shot is played on Earth. Give two reasons why your answer to *(b)*(iii) would be different. [2]

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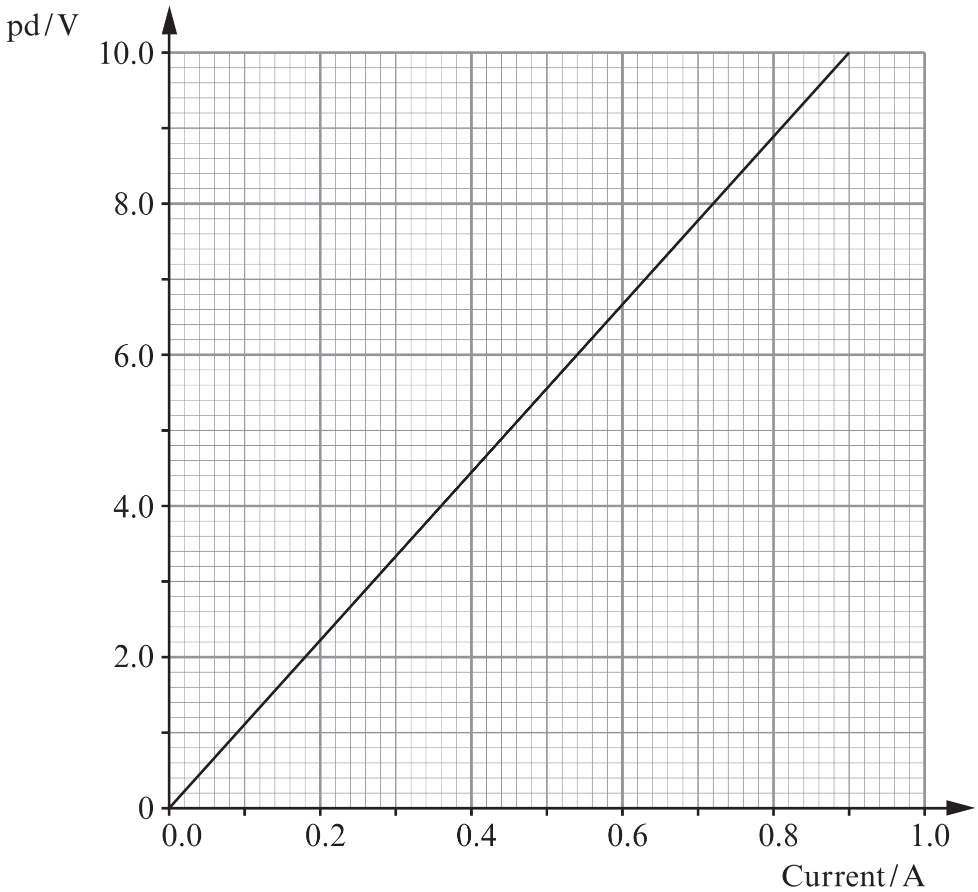
6. Experiments are carried out to determine the material from which a metal wire is made. Initially the resistivity of the metal is found. The wire's density is then determined and the results compared with known values of resistivity and density.

(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]

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(ii) The wire has length 3.2 m and **diameter** 0.20 mm. 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 / Ω 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

$$F_{air} = \frac{\rho D v^2}{2}$$

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 **metre^2**. [4]

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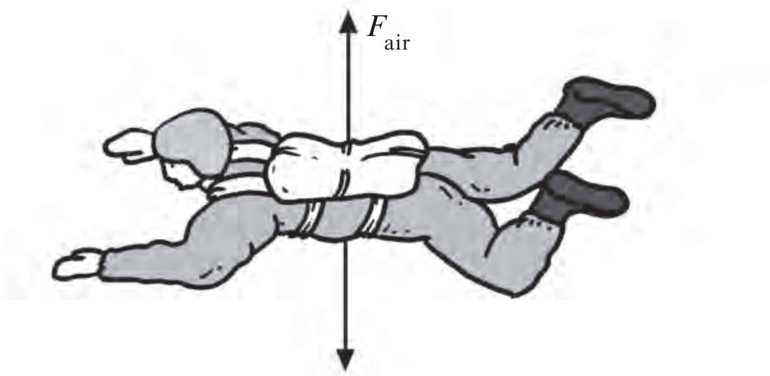
(b) The diagram shows two of the main forces acting on the skydiver during her descent.



(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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Examiner only

(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]

(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]

(d) (i) Draw a graph of acceleration (y-axis) against time (x-axis) for the skydiver. [3]

Examiner only

(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
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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

$$\rho = \frac{m}{V}$$
$$v = u + at$$
$$x = \tfrac{1}{2}(u+v)t$$
$$x = ut + \tfrac{1}{2}at^2$$
$$v^2 = u^2 + 2ax$$
$$\Sigma F = ma$$
$$W = Fx\cos\theta$$
$$\Delta E = mg\Delta h$$
$$E = \tfrac{1}{2}kx^2$$
$$E = \tfrac{1}{2}mv^2$$
$$Fx = \tfrac{1}{2}mv^2 - \tfrac{1}{2}mu^2$$

$$P = \frac{W}{t} = \frac{\Delta E}{t}$$
$$I = \frac{\Delta Q}{\Delta t}$$
$$I = nAve$$
$$R = \frac{\rho l}{A}$$
$$R = \frac{V}{I}$$
$$P = IV$$
$$V = E - Ir$$
$$\frac{V}{V_{\text{total}}}\left(\text{or } \frac{V_{\text{OUT}}}{V_{\text{IN}}}\right) = \frac{R}{R_{\text{total}}}$$

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

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

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

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

$v = \omega r$

$a = \omega^2 r$

$a = -\omega^2 x$

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

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

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

$p = mv$

$Q = mc\Delta\theta$

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

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

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

$pV = nRT$

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

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

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

$W = p\Delta V$

$\Delta U = Q - W$

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

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

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

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

$F = BIl\sin\theta$ and $F = Bqv\sin\theta$

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

$B = \mu_o nI$

$\Phi = AB\cos\theta$

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

$A = \lambda N$

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

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

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

$E = mc^2$

Fields

$F = \frac{1}{4\pi\varepsilon_0}\frac{Q_1 Q_2}{r^2}$ $\quad E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r^2}$ $\quad V_E = \frac{1}{4\pi\varepsilon_0}\frac{Q}{r}$ $\quad W = q\Delta V_E$

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

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

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

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

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

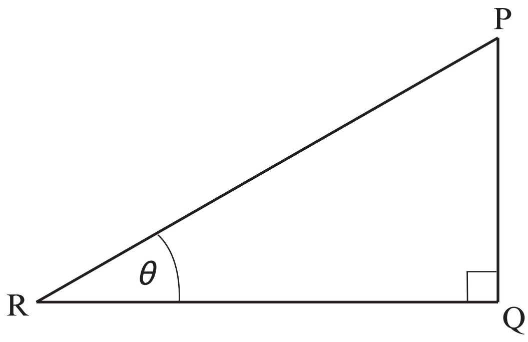
Areas and Volumes

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

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

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

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

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

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