

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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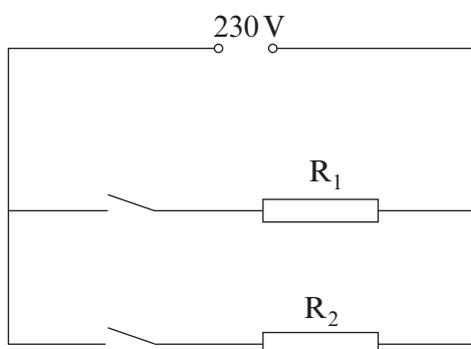
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- (ii) What can be said about the resistance of a conductor that obeys Ohm's law? [1]

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- (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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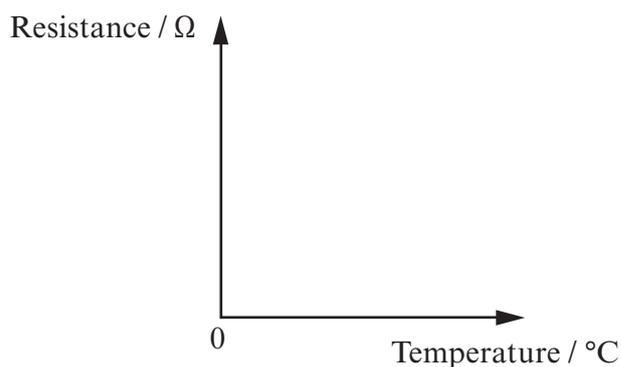
(v) Calculate the total current with both elements switched on. [1]

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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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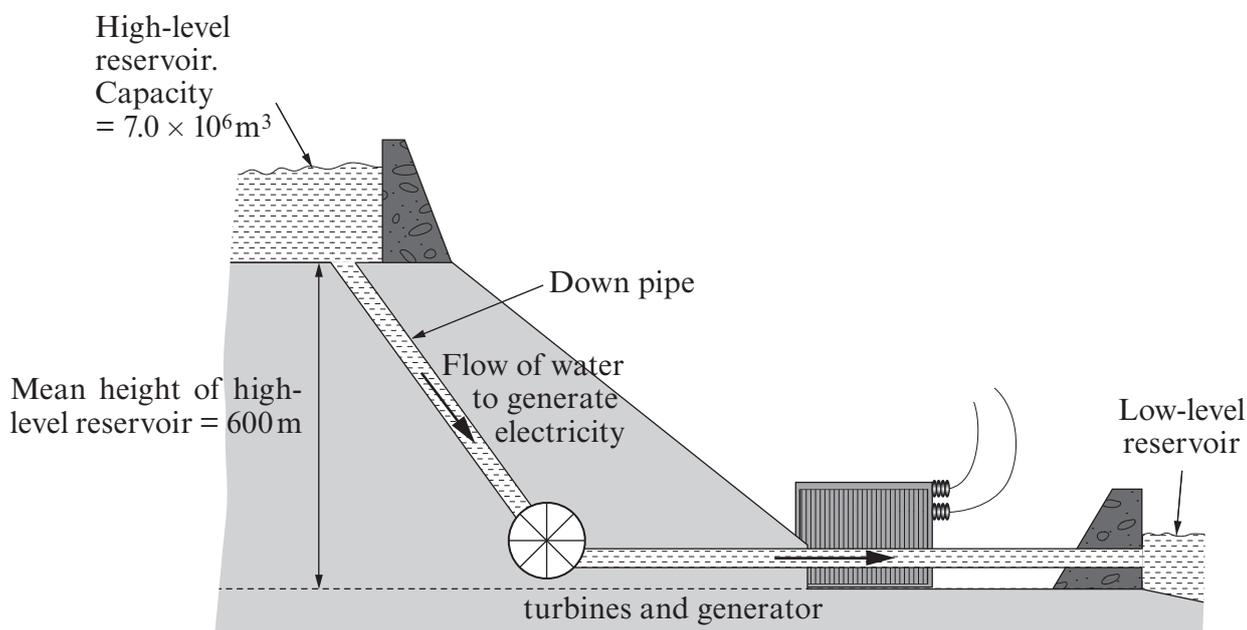
(ii) Hence suggest an explanation for your results to the experiment in part (a). [2]

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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 4×10^{13} J.
[Density of water = 1000 kg m^{-3}]. [2]

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- (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]

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- (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 20ms^{-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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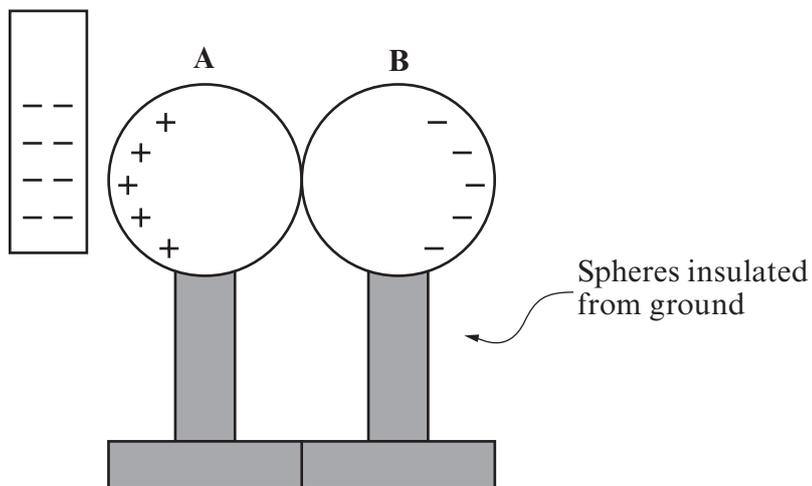
- (iv) Hence show that your answer to (c)(ii) represents between 30% and 40% of the wasted power. [1]

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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.



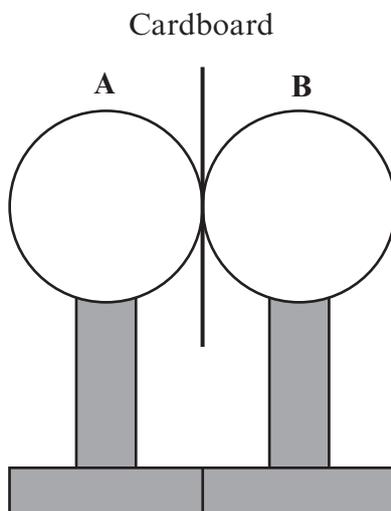
- (a) (i) State the particle which carries the negative charge. [1]

- (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 ps 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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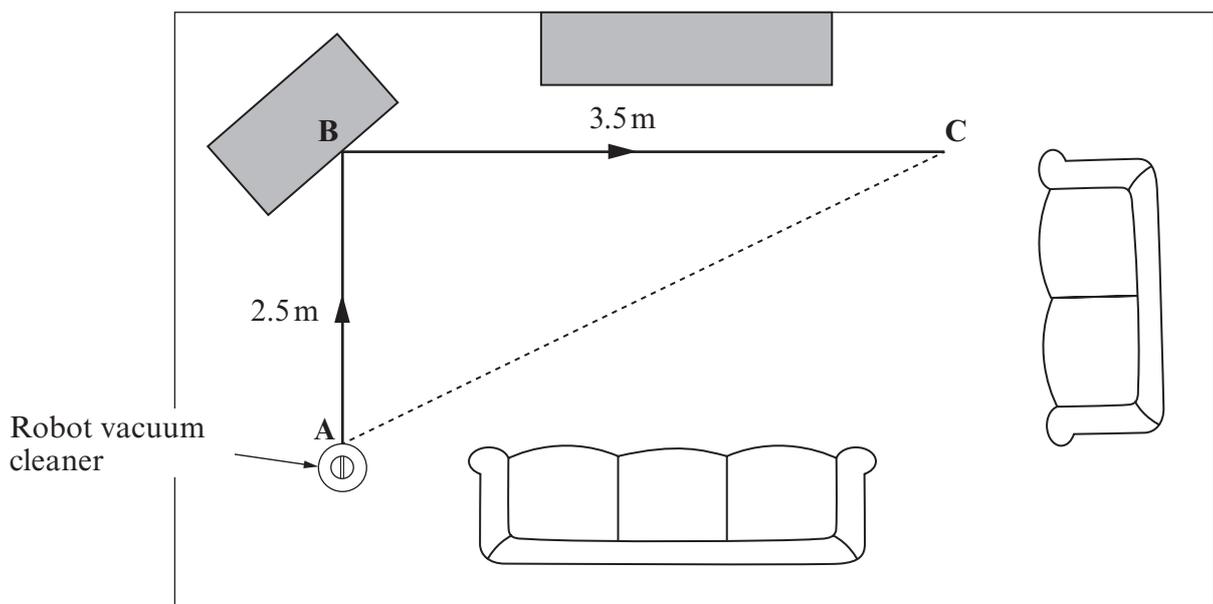
(ii) mean velocity.

[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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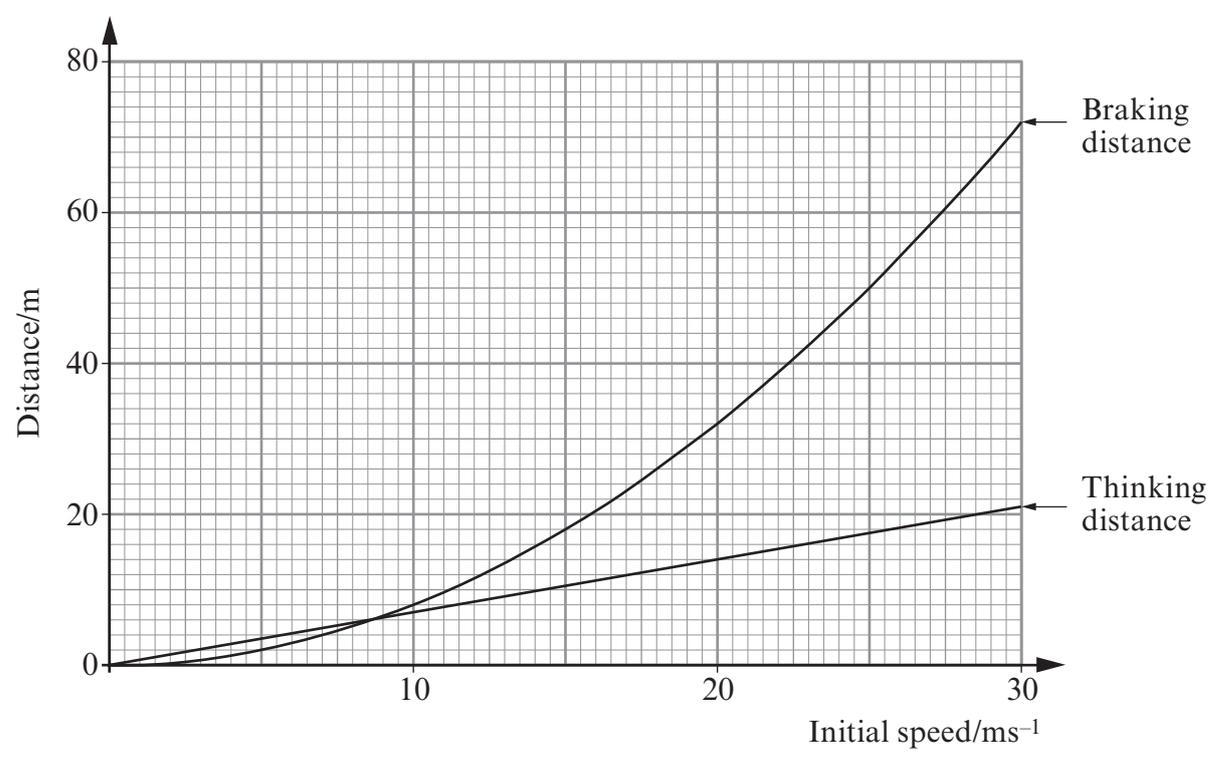
- (ii) Calculate F , given that the mechanical power is 9 W. [2]

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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

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

$$v = u + at$$

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

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

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

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

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

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

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

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

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

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

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

$$I = nAve$$

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

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

$$P = IV$$

$$V = E - Ir$$

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

$$c = f\lambda$$

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

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

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

$$n_1 v_1 = n_2 v_2$$

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

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

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

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

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

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

$$v = \omega r$$

$$a = \omega^2 r$$

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

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

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

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

$$p = mv$$

$$Q = mc \Delta \theta$$

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

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

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

$$pV = nRT$$

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

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

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

$$W = p \Delta V$$

$$\Delta U = Q - W$$

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

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

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

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

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

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

$$B = \mu_0 nI$$

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

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

$$A = \lambda N$$

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

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

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

$$E = mc^2$$

Fields

$$F = \frac{1}{4\pi\varepsilon_0} \frac{Q_1 Q_2}{r^2}$$

$$E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r^2}$$

$$V_E = \frac{1}{4\pi\varepsilon_0} \frac{Q}{r}$$

$$W = q \Delta V_E$$

$$F = G \frac{M_1 M_2}{r^2}$$

$$g = \frac{GM}{r^2}$$

$$V_g = \frac{-GM}{r}$$

$$W = m \Delta V_g$$

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

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

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

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

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

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

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

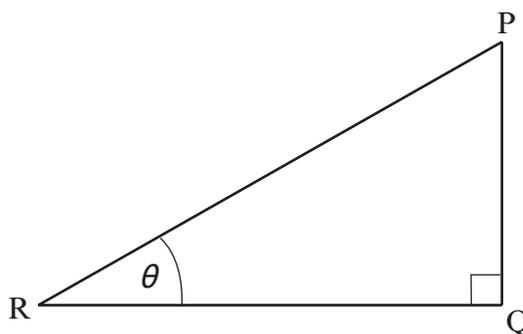
Areas and Volumes

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

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

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} .]

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

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

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

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

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