

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	
<b>Total</b>	<b>80</b>	

### 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.

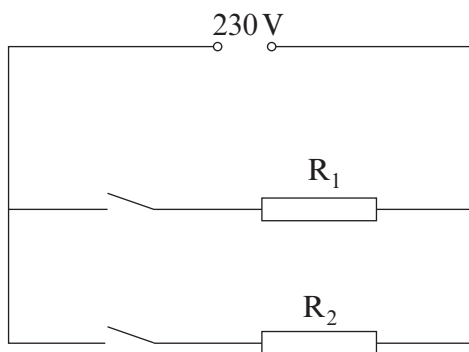
1. (a) (i) State Ohm's law. [2]

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(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  $95 \times 10^{-8} \Omega m$  and diameter  $1.4 \times 10^{-4} m$ .



(i) The length of wire used to make  $R_1$  is 3.2m. Show that the resistance of  $R_1$  is approximately  $200 \Omega$ . [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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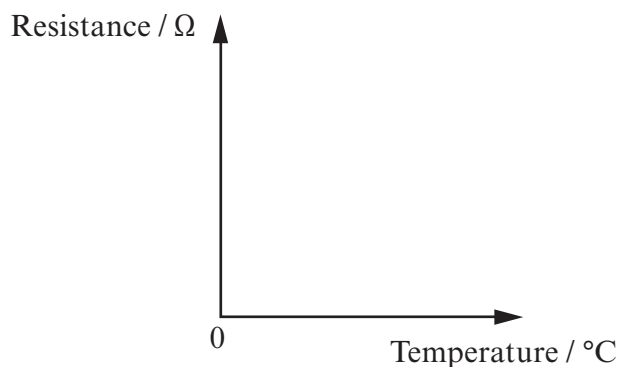
(v) Calculate the total current with both elements switched on. [1]

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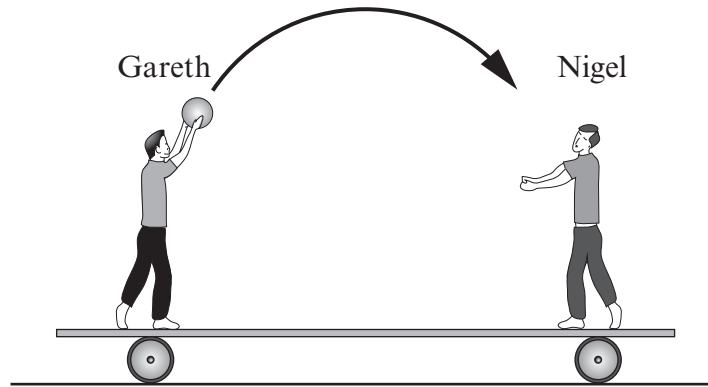
(ii) Hence suggest an explanation for your results to the experiment in part (a). [2]

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3. Two boys stand each end of a trolley as shown. The trolley is initially at rest and can move without resistance on a horizontal surface.



- (a) (i) Define acceleration. [1]

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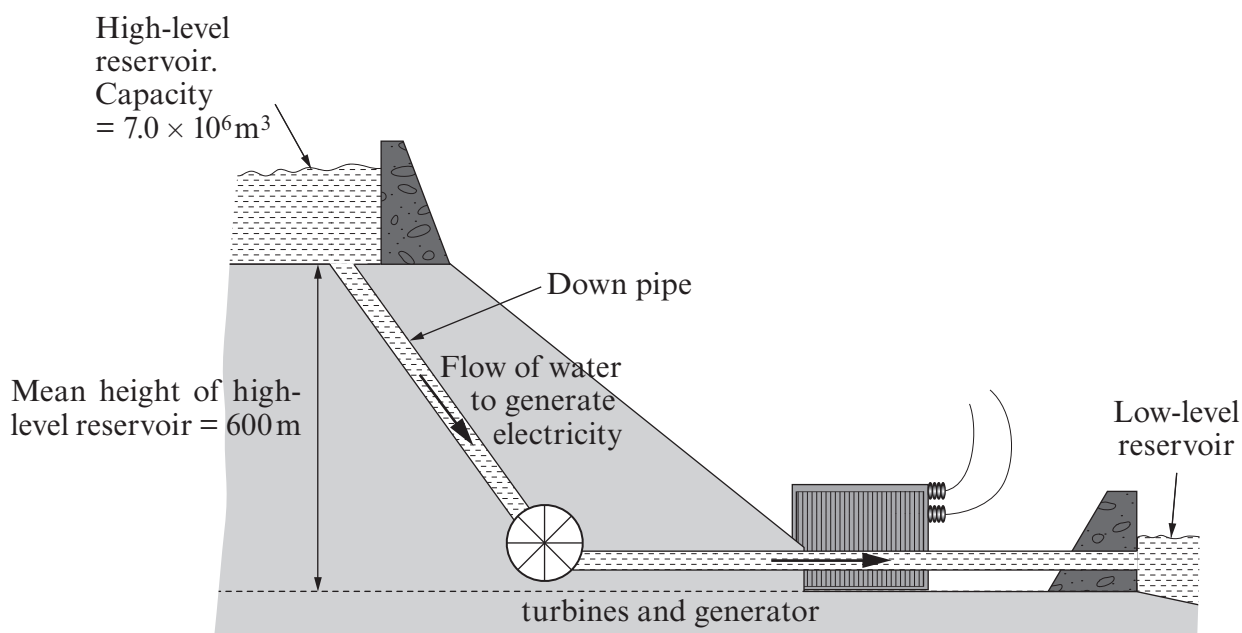
- (ii) Gareth takes 0.80s to throw a ball from rest to a speed of 6.0 ms<sup>-1</sup>. Calculate the acceleration of the ball. [2]

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- (b) Describe and explain in terms of forces, the motion of the trolley from the instant the ball is released by Gareth until after it is caught by Nigel. [4]

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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  $4 \times 10^{13}$  J.  
 [Density of water =  $1000 \text{ kg m}^{-3}$ ]. [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  $\text{kg s}^{-1}$ ) 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  $20\text{ms}^{-1}$ . 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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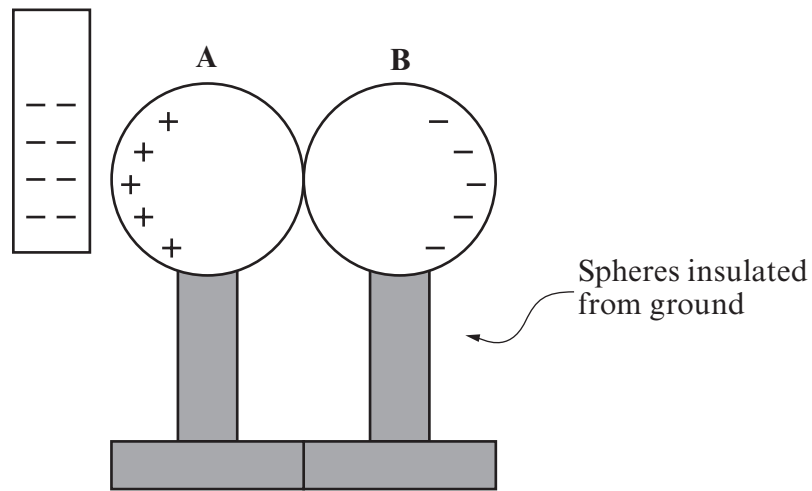
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(v) Where else would energy be wasted during the generating process? [1]

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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]

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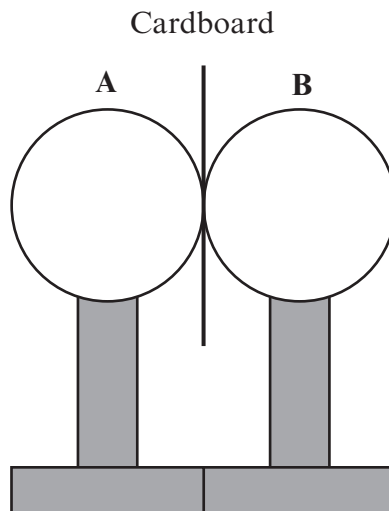
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- (iii) The following procedure is carried out:
- A thin insulating piece of cardboard is placed in between the spheres.
  - The negatively charged rod is then removed.

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  $300 \times 10^9$  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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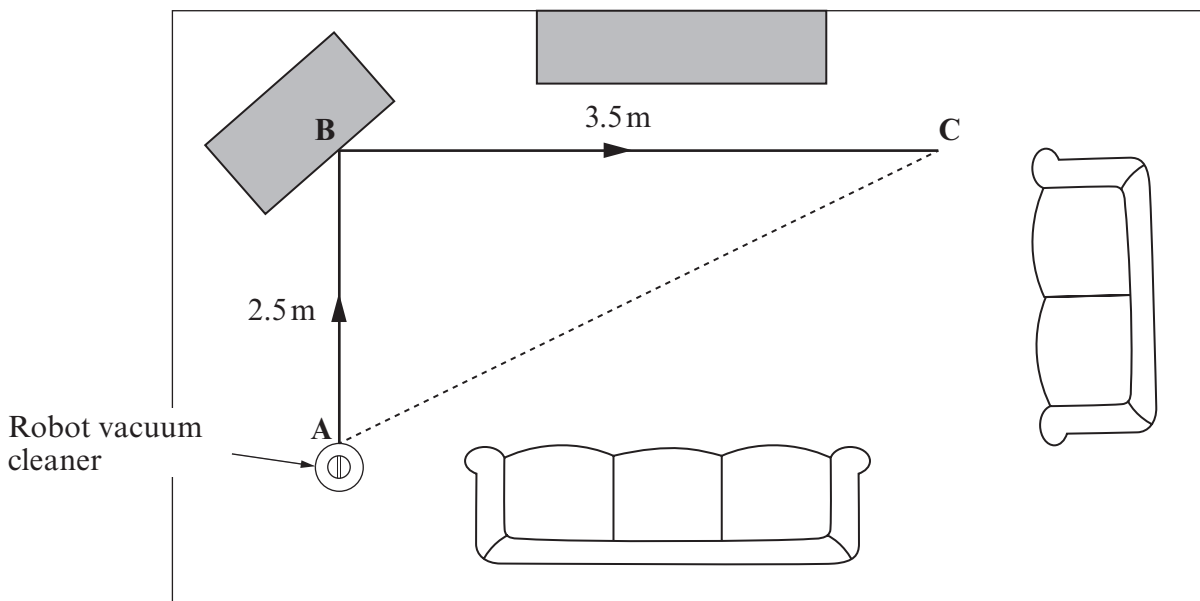
(ii) mean velocity.

[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 25s. 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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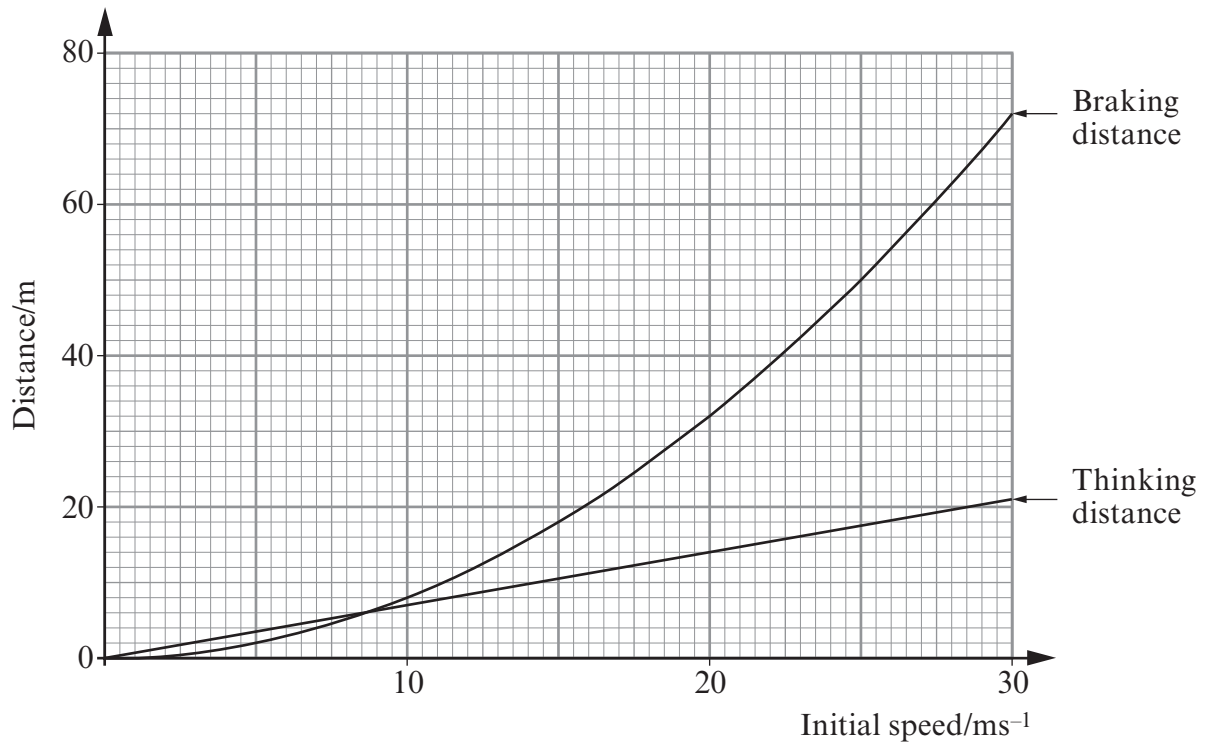
(ii) Calculate  $F$ , given that the mechanical power is 9 W. [2]

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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)<sup>2</sup>. [3]

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- (b) (i) Calculate the mean deceleration of a car as it slows down from 15 ms<sup>-1</sup> to rest. [3]

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- (ii) Hence calculate the mean braking force acting on the car given that it has a mass of 800 kg. [1]

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- (c) Suggest why the graph of thinking distance against speed is a straight line. [2]

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- (d) (i) What is the **total** stopping distance for a car initially travelling at  $30 \text{ m s}^{-1}$ ? [1]

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- (ii) Ineffective brakes would increase the total stopping distance. Explain, in terms of thinking distance and braking distance why this would be the case. [2]

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- (e) ‘Average speed areas’ are now found on many motorways. One such stretch of motorway has a speed limit of 50 km/hour. The average speed is monitored between two cameras placed 10 km apart. The driver of a car notes that he has travelled 6.0 km from the first camera at a speed of 80 km/hour. Determine the speed with which he has to travel the remaining 4.0 km in order that his average speed for the whole 10 km is 50 km/hour. [4]

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**THERE ARE NO MORE QUESTIONS IN THIS EXAMINATION**

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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

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

$$v = u + at$$

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

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

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

$$\Sigma F = ma$$

$$W = Fx \cos \theta$$

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

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

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

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

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

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

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

$$I = nAve$$

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

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

$$P = IV$$

$$V = E - Ir$$

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

$$c = f\lambda$$

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

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

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

$$n_1 v_1 = n_2 v_2$$

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

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

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

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

Particle Physics

particle (symbol)	Leptons		Quarks	
	electron (e <sup>-</sup> )	electron neutrino (ν <sub>e</sub> )	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**

$$F = \frac{1}{4\pi\epsilon_0} \frac{Q_1 Q_2}{r^2}$$

$$E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r^2}$$

$$V_E = \frac{1}{4\pi\epsilon_0} \frac{Q}{r}$$

$$W = q \Delta V_E$$

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

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

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

$$W = m \Delta V_g$$

**Orbiting Bodies**

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:**  $c = \frac{1}{\sqrt{\mu_0 \epsilon_0}}$ ;  $\Delta t = \frac{\Delta \tau}{\sqrt{1 - \frac{v^2}{c^2}}}$

**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:**  $\frac{\Delta Q}{\Delta t} = -AK \frac{\Delta \theta}{\Delta x}$ ;  $U = \frac{K}{\Delta x}$ ;  $\frac{Q_2}{Q_1} = \frac{T_2}{T_1}$ ; 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	$\mu$
$10^{-3}$	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

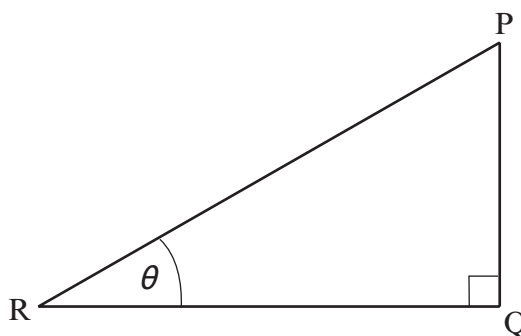
**Areas and Volumes**

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

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

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

**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  $\log_{10}$ .]

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

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

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

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

$\log_e 2 = \ln 2 = 0.693$