Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1321/01

PHYSICS – PH1

Motion Energy and Charge

A.M. TUESDAY, 20 May 2014

1 hour 30 minutes

For Examiner's use only		
Question	**Maximum Mark**	**Mark Awarded**
1.	**9**	
2.	**11**	
3.	**9**	
4.	**14**	
5.	**13**	
6.	**14**	
7.	**10**	
Total	**80**	

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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.

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Answer **all** *questions.*

1. *(a)* (i) State the principle of conservation of energy. [1]

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(ii) Explain how the principle applies to an object falling from rest **through the air**. [3]

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(b) A child of mass 16 kg starts from rest at the top of a playground slide and reaches the bottom of the slide with a speed of 6.0 m s^{-1}. The slide is 4.0 m long and there is a difference in height of 2.4 m between the top and the bottom.

(i) Calculate the work done against friction. [3]

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(ii) Use your answer to *(b)*(i) to calculate the mean frictional force acting on the child. [2]

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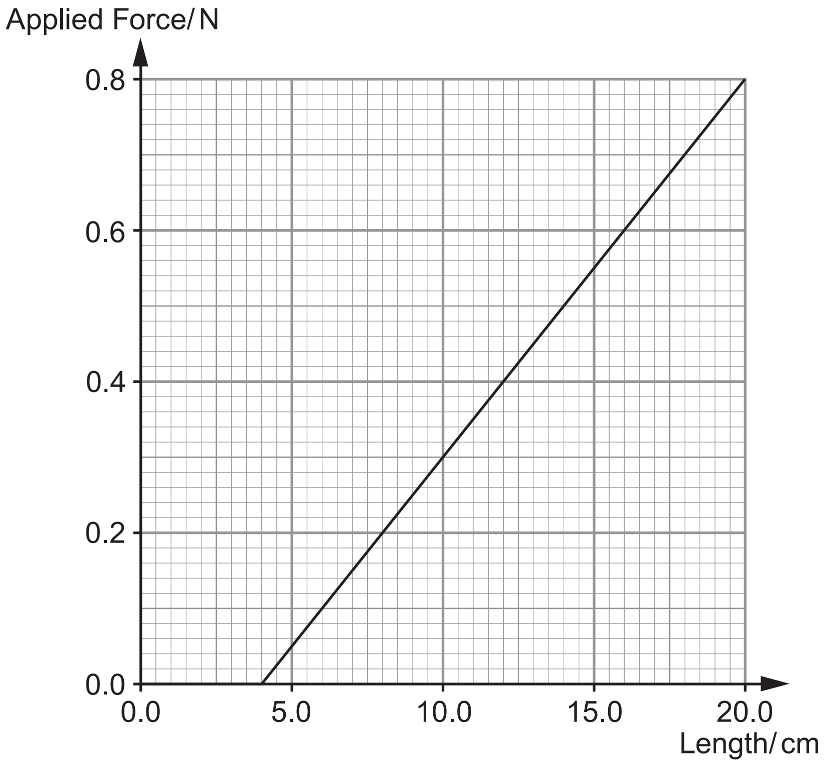
2. The following graph shows how the length of a spring varies with the applied force. Hooke's law is obeyed throughout.



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

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(ii) Determine the spring's unstretched length. [1]

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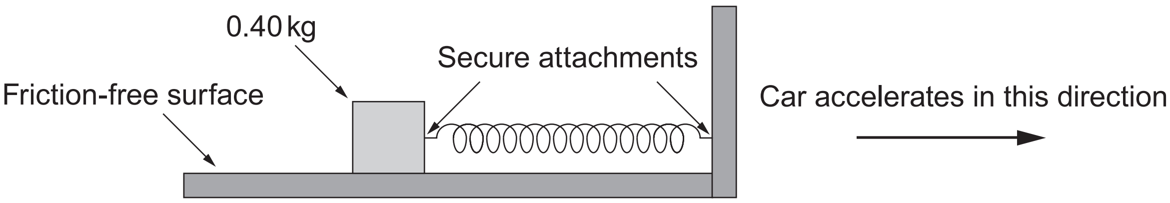
(b) The spring is used in a simple accelerometer (a device for measuring acceleration). The spring is attached to a 0.40 kg mass which is placed on a friction-free surface as shown. The device is installed in a car.



The car accelerates uniformly from rest. During the acceleration the spring is **extended** by 12.0 cm. Use this information and the graph to calculate the car's acceleration. [2]

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(c) Calculate the elastic potential energy stored in the spring when:

(i) the car's acceleration is the same as in *(b)*; [2]

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(ii) the car travels at constant velocity. Explain your answer. [2]

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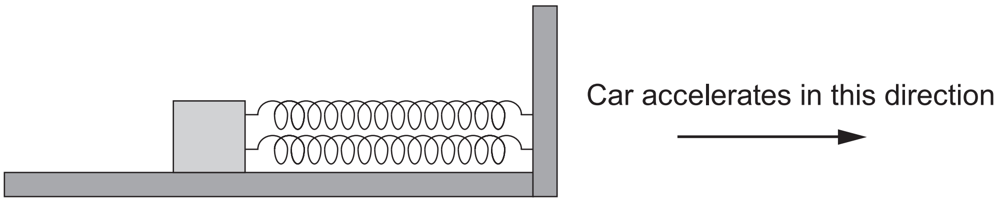
(d) The accelerometer is now modified by attaching a second identical spring to the mass as shown.



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Explain the effect that adding the second spring has on the **extension** and **total elastic potential energy** when the car's acceleration is the same as in *(b).* [3]

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3. *(a)* A list of electrical units is given below:

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

From the list, choose the unit for:

(i) electrical power; .... [1]

(ii) electrical resistance; .... [1]

(iii) electrical charge. .... [1]

(b) A torch battery converts 6480 J of chemical energy into electrical energy while supplying a current of 0.15 A for 2 hours. In this time only 5832 J of this energy is supplied to the bulb. Calculate:

(i) the charge that flows; [2]

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(ii) the emf of the battery; [1]

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(iii) the potential difference across the bulb; [1]

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(iv) the battery's internal resistance. [2]

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4. *(a)* Define the *potential difference* between two points in an electric circuit. [2]

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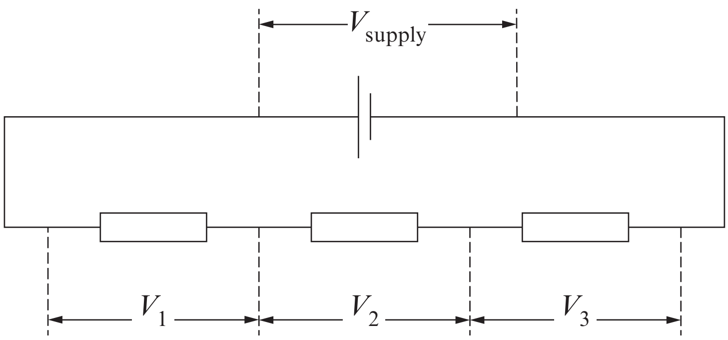
(b) Three resistors are connected as shown.



(i) Complete the equation that relates **all** of the potential differences in the circuit: [1]

V_{supply} = ...

(ii) The equation you wrote down in *(b)*(i) is an example of which conservation law? [1]

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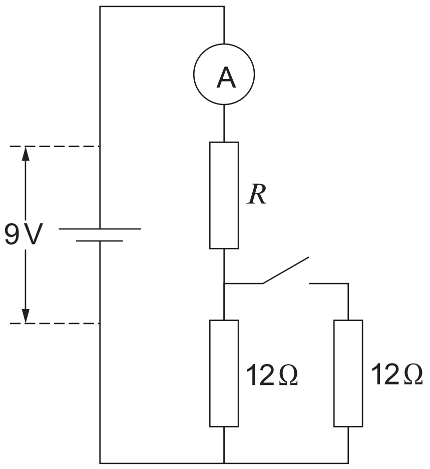
(c)



(i) In the circuit shown, with the **switch open**, the ammeter reads 0.5 A. Show that $R = 6\,\Omega$. [2]

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(ii) The switch is now **closed**.

(I) Calculate the (new) potential difference across R. [2]

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(II) Calculate the (new) current through the ammeter. [2]

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(III) More 12 Ω resistors can be connected in parallel with the 12 Ω resistors. Determine the **total** number of 12 Ω resistors needed for the current through the ammeter to be 1.2 A. [4]

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5. *(a)* (i) Draw a **labelled** diagram of the apparatus you would use to determine the relationship between the resistance and length of a metal wire. [3]

(ii) Sketch a graph of your expected results. [1]

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(iii) Explain how you would use an accurately drawn graph of resistance against length, as well as any other measurements, to obtain a value for the *resistivity* of the metal in the wire. [3]

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(b) (i) A simple heater is made of a metallic wire of resistivity $48 \times 10^{-8}\,\Omega\,m$ and cross-sectional area $4.0 \times 10^{-8}\,m^2$. When it is in use the potential difference across the heater is 12.0 V and its power is 32 W. Calculate the length of the wire in the heater. [3]

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(ii) Calculate the drift velocity of the electrons in the wire when the heater is in use. [The number of free electrons per unit volume is $3.4 \times 10^{28}\,m^{-3}$ for the material in the wire.] [3]

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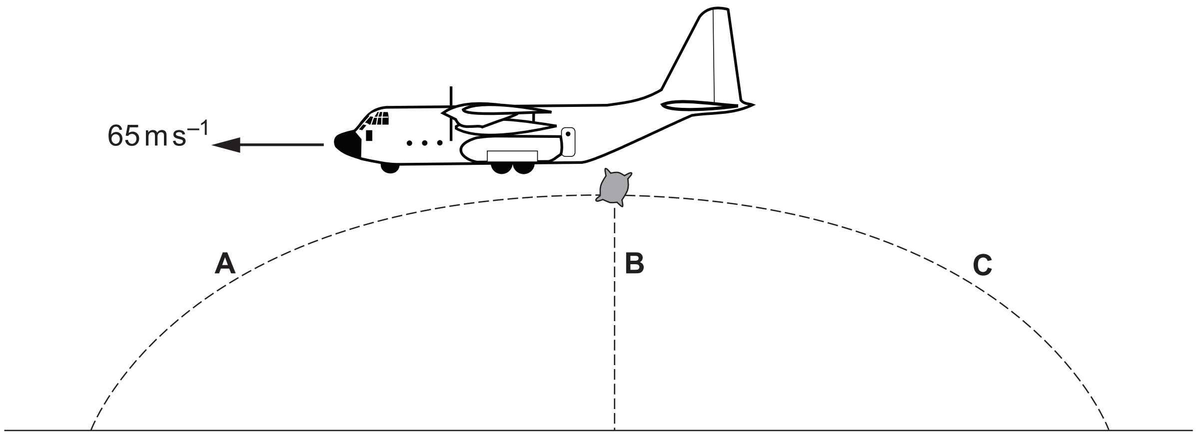
6. *(a)* (i) Show that $v = u + at$ is consistent with the definition of acceleration. [2]

(ii) $x = \frac{1}{2}(u + v)t$ is another equation of uniformly accelerated motion. Use this equation and $v = u + at$ to show clearly that:

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

[2]

(b) The aeroplane shown below is travelling **horizontally** at 65 m s^{-1}. It is used to drop sacks of flour as emergency supplies. A sack is shown at the instant it is released from the low flying aeroplane. Ignore air resistance for this question. The diagram is not to scale.



(i) A villager standing to the side observes the flight path of the sack. Which path, **A**, **B** or **C** shows the path of the sack? Explain your answer. [3]

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(ii) (I) To avoid damaging the sack, the maximum **vertical** component of the sack's velocity must not exceed 30 m s^{-1}. Show that the maximum height from which the sack can be dropped is about 46 m. [2]

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(II) Calculate the time taken for the sack to reach the ground if it is dropped from a height of 46 m. [2]

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(iii) Calculate the resultant velocity of the sack on impact with the ground when it is dropped from 46 m. [3]

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7. *(a)* A student gives the following **incorrect** and **incomplete** definition of the moment of a force about a point.

Moment of a force about a point = mass × distance

Correct the definition. [2]

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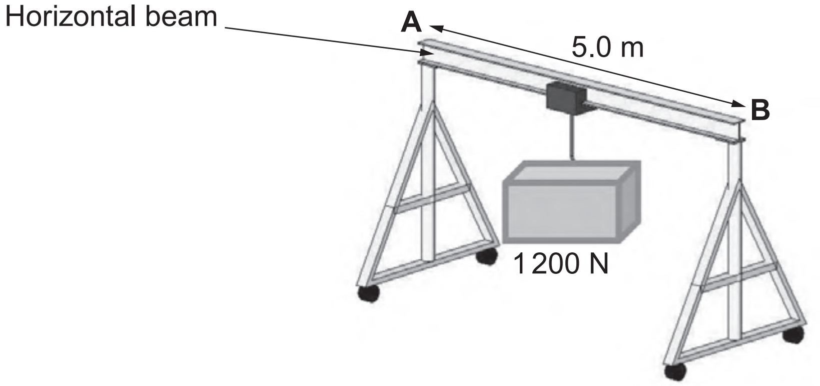
(b) A simple gantry crane is used to transport heavy loads. It consists of a horizontal beam (**AB**) of length 5.0 m fixed at each end to a vertical pillar as shown. It is possible to move the load along the horizontal beam.



When the gantry crane supports a load of 1200 N **at its centre**, a force of 700 N is exerted on each pillar. Calculate the weight of the horizontal beam. [2]

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(c) The same load is now **moved 1.0 m towards B**.

(i) Draw arrows on the diagram below to show the forces now acting on the beam. [2]

(ii) By taking moments about a suitable point, calculate the force on the beam at **B**. [3]

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(iii) Hence calculate the force on the beam at **A**. [1]

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END OF PAPER

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

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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

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

$v = \omega r$

$a = \omega^2 r$

$a = -\omega^2 x$

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

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

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

$p = mv$

$Q = mc\Delta\theta$

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

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

$M/\text{kg} = \frac{M_r}{1\,000}$

$pV = nRT$

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

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

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

$W = p\Delta V$

$\Delta U = Q - W$

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

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

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

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

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

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

$B = \mu_o nI$

$\Phi = AB\cos\theta$

$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$

$A = \lambda N$

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

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

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

$E = mc^2$

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

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: Electromagnetism and Space-Time

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

B: The Newtonian Revolution

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

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

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

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

$$r_Pv_P = r_Av_A$$

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	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

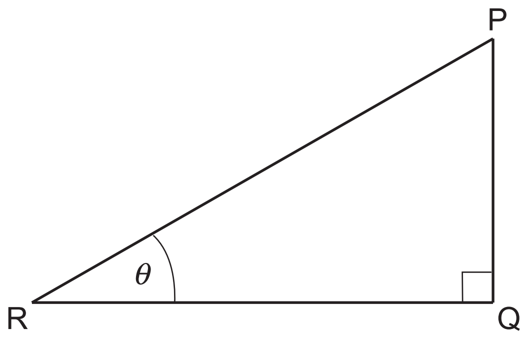
Areas and Volumes

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

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

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

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

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

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