Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A Level

1321/01 – LEGACY

S16-1321-01

PHYSICS – PH1
Motion, Energy and Charge

A.M. TUESDAY, 24 May 2016

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	12	
4.	15	
5.	11	
6.	11	
7.	11	
Total	80	

1321 010001

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.

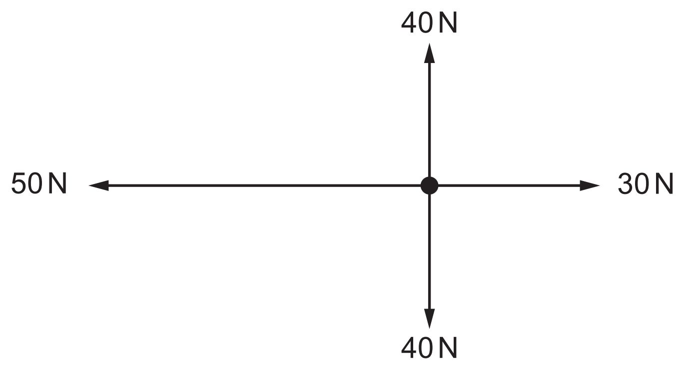
Examiner only

Answer **all** *questions.*

1. *(a)* Newton's second law of motion can be expressed by the equation:

$$\sum F = ma$$

Showing your reasoning, determine $\sum F$ in the free body diagram below. [2]

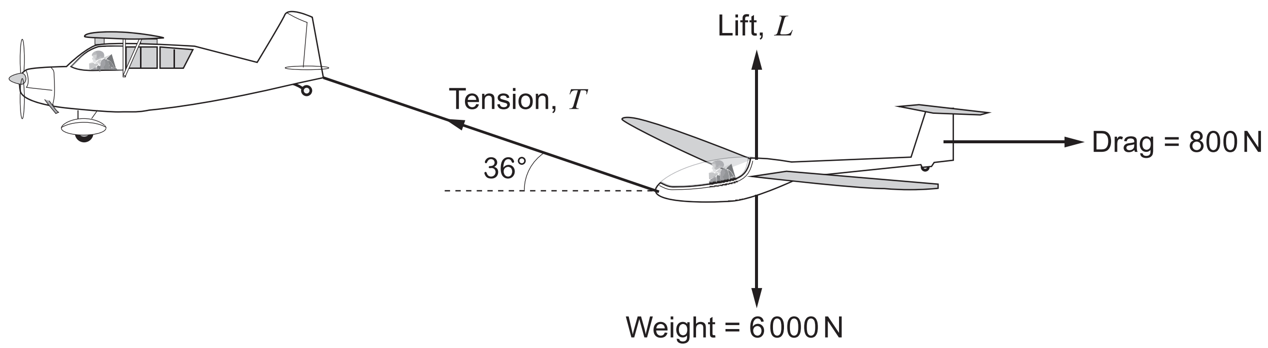


....

....

....

(b) A glider is being towed **horizontally** through the air **at constant velocity**. The diagram shows the forces acting on the glider.



(i) Calculate the tension, T, in the tow line. [2]

....

....

....

Examiner only

(ii) Calculate the lift force, L, on the glider. [3]

....

....

....

....

(c) The power used to tow the glider is 40 kW. Determine the horizontal velocity of the towing aircraft. [2]

....

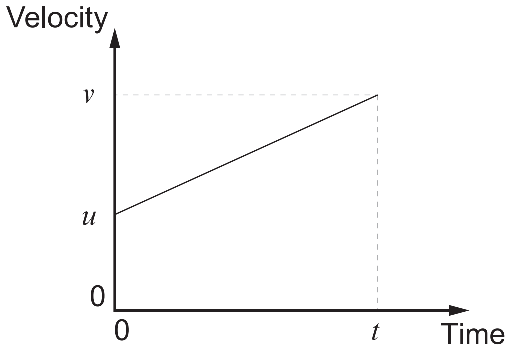
....

....

1321 010003

Examiner only

2. *(a)* A velocity-time graph is given for a body which is accelerating.



Using the symbols given on the graph, show that:

$$v = u + at$$ [2]

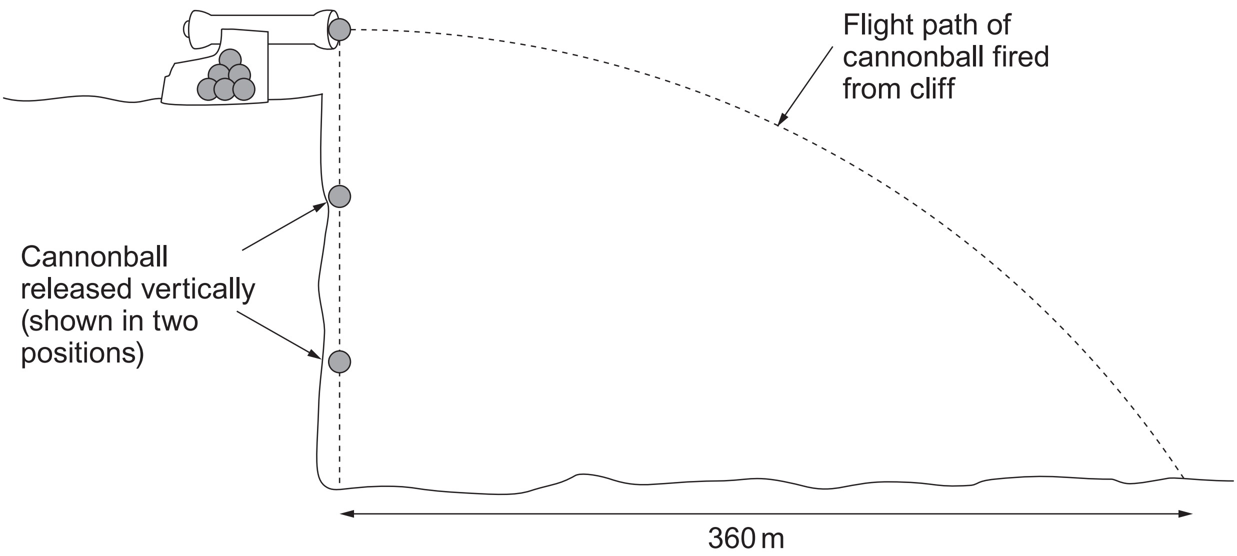
....

....

....

....

(b) The flight path for a cannonball fired horizontally from the top of a cliff is shown. **At the same instant**, a second cannonball is released and falls vertically from the same initial height. The second cannonball is shown at two positions during its descent.



Examiner only

(i) Draw on the diagram the expected positions of the fired cannonball at the same instants as **each** of the positions indicated by the dropped cannonball. Explain your reasoning. Ignore air resistance. [3]

(ii) The cannonball fired from the cannon impacts with the ground 3.20 s after being fired.

I. Calculate the height from which the cannonball was fired. [2]

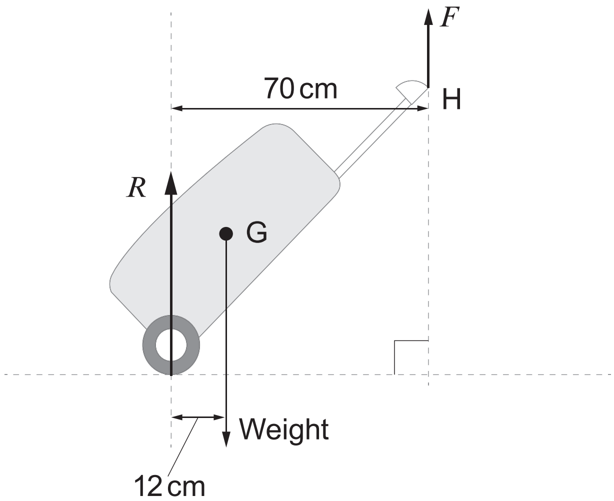
II. Calculate the velocity with which the **fired** cannonball impacts with the ground. [4]

1321 010005

Examiner only

3. A passenger at an airport pulls a travel case as shown.

(a) When the passenger is stationary, a free body diagram for the travel case is shown below. It is held at rest by the passenger's hand at H and its centre of gravity is at G. The mass of the case is 8.5 kg.



(i) Define the *moment of a force.* [1]

....

....

(ii) Calculate the size of the upward pull, F, of the hand on the case. [3]

....

....

....

....

(iii) Calculate the value of R, the force of the ground on the case. [1]

....

Examiner only

(iv) Explain how repacking the case so as to move the centre of gravity further away from the wheel would affect the size of force F. [2]

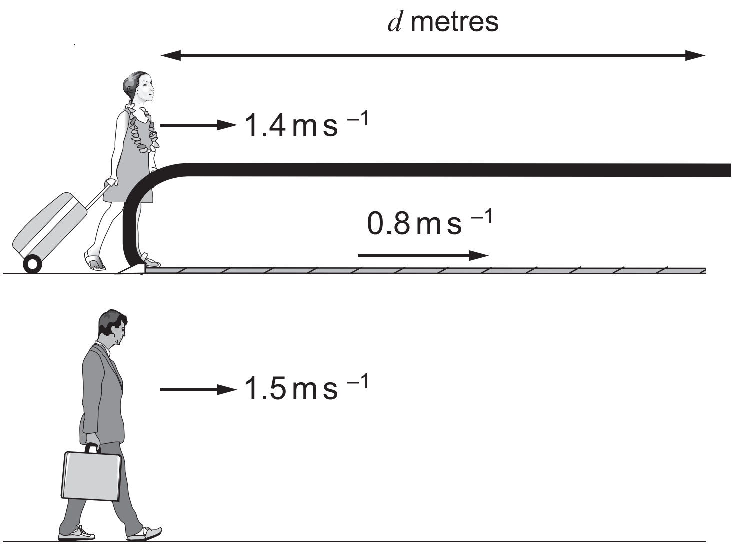
....

....

....

....

(b) The passenger now walks at $1.4\,\text{m}\,\text{s}^{-1}$ onto a walkway of length d metres which is itself moving at $0.8\,\text{m}\,\text{s}^{-1}$. At the instant she steps on the walkway, another passenger initially alongside decides not to take the walkway, but instead walks alongside it at a speed of $1.5\,\text{m}\,\text{s}^{-1}$. The passenger on the walkway takes a time, t, to reach the end. The passenger walking alongside takes an **additional 14 seconds** before reaching the end of the walkway.



(i) Write down an expression for the distance, d, travelled by the passenger on the walkway. [1]

....

(ii) Write down an expression for the distance, d, travelled by the passenger walking alongside the walkway. [1]

....

(iii) Hence, determine the length, d, of the walkway. [3]

....

....

....

....

1321 010007

Examiner only

4. *(a)* A student is asked to carry out an experiment to determine the resistivity of tin in the form of a wire.

As a first step the student takes readings of the current in the wire against applied potential difference. The results are shown in the table.

Applied pd / V	0.10	0.20	0.30	0.40	0.50	0.60
Current / A	0.08	0.16	0.24	0.32	0.40	0.48

(i) Draw a circuit diagram of the arrangement that could have been used to obtain the readings. [2]

(ii) Plot a graph of current (y-axis) against potential difference (x-axis). [2]

Examiner only

(iii) The student measures the length of the wire to be 1.45 m and the **diameter** to be 4.0×10^{-4} m. Show that the resistivity of tin is approximately $1 \times 10^{-7}\,\Omega$ m. [3]

....

....

....

....

(iv) **Draw on the same grid** (opposite) the current against potential difference graph for a metal wire of the same length and diameter but with **double** the resistivity of tin. [1]

(b) (i) Calculate the mass of wire used in the experiment given that the density of tin is $7\,310\,\mathrm{kg\,m^{-3}}$. [2]

....

....

....

....

(ii) Determine the total number of free electrons in this wire given that an atom of tin has a mass of 1.97×10^{-25} kg and each atom contributes 4 free electrons. [2]

....

....

....

....

(iii) Calculate the mean drift velocity of the electrons in the wire when the current in it is 0.32 A. [3]

....

....

....

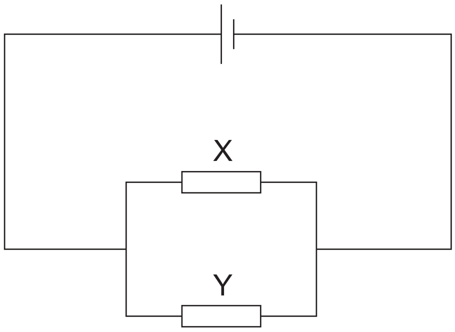
....

....

Examiner only

5. *(a)* In the following circuits the resistance of X is **greater than** the resistance of Y.

Circuit A



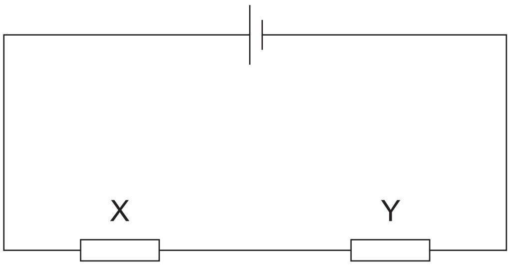
(i) For Circuit A, compare the current through, and the potential difference across X and Y. [1]

....

....

(ii)

Circuit B



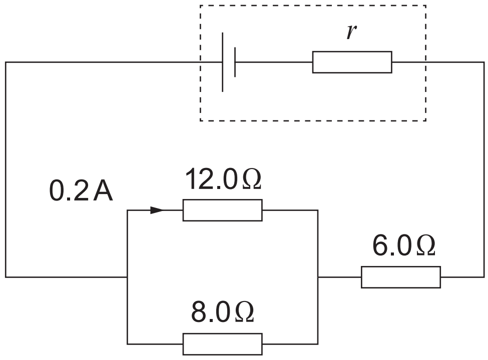
For Circuit B, compare the current through, and the potential difference across X and Y. [1]

....

....

Examiner only

(b) The diagram below shows three resistors connected together as part of a circuit. The internal resistance, r, of the cell is also shown.



(i) Show in clear steps that the current in the 8.0 Ω resistor is 0.3 A. [2]

....

....

....

(ii) Show that the potential difference across the combination of three resistors is 5.4 V. [3]

....

....

....

....

(iii) Explain why the potential difference across the combination of three resistors is less than the emf of the cell. [2]

....

....

....

....

(iv) Calculate the internal resistance, r, of the cell given that its emf is 6.0 V. [2]

....

....

....

....

Examiner only

6. *(a)* (i) Compare the movement of free electrons in a metal **before** and **after** a potential difference is applied to the metal. [4]

....

....

....

....

....

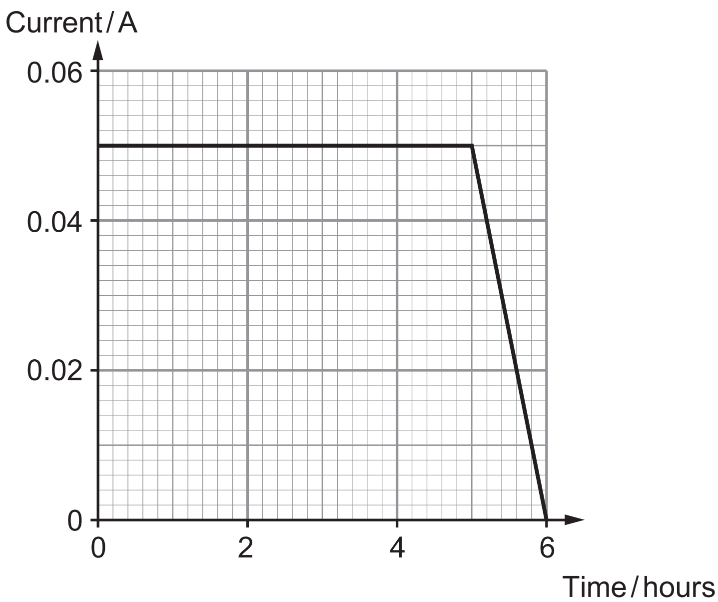
....

....

(ii) Hence explain how resistance arises in a metal when a potential difference is applied to it. [1]

....

(b) A resistor is connected for many hours to a cell. The graph shows the variation of current, I, through the resistor with time, t.



(i) Calculate the charge which passes through the resistor:

I. during the first 5 hours; [2]

....

....

....

Examiner only

II. in the last hour. [1]

....

....

(ii) Calculate the energy dissipated by the resistor during the first 5 hours given that the cell has an emf of 3.2 V. [Assume internal resistance = 0 Ω.] [2]

....

....

....

(iii) Calculate the rate at which the resistor dissipates energy during the first 5 hours. [1]

....

....

Examiner only

7. *(a)* (i) State what is meant by the spring constant, k. [1]

....

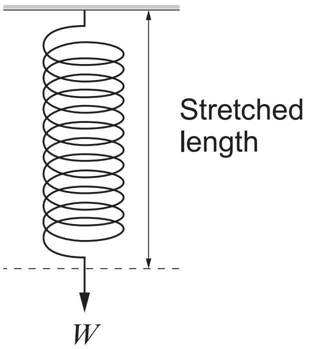
(ii) Show that the unit of k may be written as kg s^{-2}. [2]

....

....

....

(b) A brief experiment is carried out in order to determine k for a spring. The following results are obtained.



Weight, W, attached to spring / N	Stretched **length** of spring / m
1.0	0.25
5.0	0.45

(i) Determine the value of k, stating any assumptions you make. [3]

....

....

....

....

(ii) Determine the unstretched length of the spring. Show your reasoning. [2]

....

....

....

(iii) Calculate the elastic potential energy stored in the spring when W = 5.0 N. [3]

....

....

....

END OF PAPER

BLANK PAGE

GCE AS/A level

1321-1325/01-A – LEGACY

S16-1321-01A

PHYSICS – 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	=	$6{\cdot}02 \times 10^{23}\ \mathrm{mol^{-1}}$
Fundamental electronic charge	e	=	$1{\cdot}60 \times 10^{-19}\ \mathrm{C}$
Mass of an electron	m_e	=	$9{\cdot}11 \times 10^{-31}\ \mathrm{kg}$
Molar gas constant	R	=	$8{\cdot}31\ \mathrm{J\,mol^{-1}\,K^{-1}}$
Acceleration due to gravity at sea level	g	=	$9{\cdot}81\ \mathrm{m\,s^{-2}}$
Gravitational field strength at sea level	g	=	$9{\cdot}81\ \mathrm{N\,kg^{-1}}$
Universal constant of gravitation	G	=	$6{\cdot}67 \times 10^{-11}\ \mathrm{N\,m^2\,kg^{-2}}$
Planck constant	h	=	$6{\cdot}63 \times 10^{-34}\ \mathrm{J\,s}$
Boltzmann constant	k	=	$1{\cdot}38 \times 10^{-23}\ \mathrm{J\,K^{-1}}$
Speed of light *in vacuo*	c	=	$3{\cdot}00 \times 10^{8}\ \mathrm{m\,s^{-1}}$
Permittivity of free space	ε_0	=	$8{\cdot}85 \times 10^{-12}\ \mathrm{F\,m^{-1}}$
Permeability of free space	μ_0	=	$4\pi \times 10^{-7}\ \mathrm{H\,m^{-1}}$
Stefan constant	σ	=	$5{\cdot}67 \times 10^{-8}\ \mathrm{W\,m^{-2}\,K^{-4}}$
Wien constant	W	=	$2{\cdot}90 \times 10^{-3}\ \mathrm{m\,K}$

$T/\mathrm{K} = \theta/^{\circ}\mathrm{C} + 273{\cdot}15$

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

AS

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

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

$$c = f\lambda$$
$$T = \frac{1}{f}$$
$$\lambda = \frac{ay}{D}$$
$$d\sin\theta = n\lambda$$
$$n_1v_1 = n_2v_2$$
$$n_1\sin\theta_1 = n_2\sin\theta_2$$
$$E_{k\max} = hf - \phi$$
$$\lambda_{\max} = W\,T^{-1}$$
$$P = A\sigma T^4$$

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

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

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

$$M/\text{kg} = \frac{M_r}{1\,000}$$
$$pV = nRT$$
$$p = \tfrac{1}{3}\rho\overline{c^2}$$
$$U = \tfrac{3}{2}nRT$$
$$k = \frac{R}{N_A}$$
$$W = p\Delta V$$
$$\Delta U = Q - W$$
$$C = \frac{Q}{V}$$
$$C = \frac{\varepsilon_o A}{d}$$
$$U = \tfrac{1}{2}QV$$
$$Q = Q_0 e^{-t/RC}$$

$$F = BIl\sin\theta \text{ and } F = Bqv\sin\theta$$
$$B = \frac{\mu_o I}{2\pi a}$$
$$B = \mu_o nI$$
$$\Phi = AB\cos\theta$$
$$V_{\text{rms}} = \frac{V_0}{\sqrt{2}}$$
$$A = \lambda N$$
$$N = N_o e^{-\lambda t} \text{ or } N = \frac{N_o}{2^x}$$
$$A = A_o e^{-\lambda t} \text{ or } A = \frac{A_o}{2^x}$$
$$\lambda = \frac{\log_e 2}{T_{1/2}}$$
$$E = mc^2$$

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

Period of Mutual Orbit: $T = 2\pi\sqrt{\dfrac{d^3}{G(M_1 + M_2)}}$

Options

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

B: Electromagnetism and Space-Time

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

B: The Newtonian Revolution

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

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

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

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

$$r_P v_P = r_A v_A$$

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

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

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

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

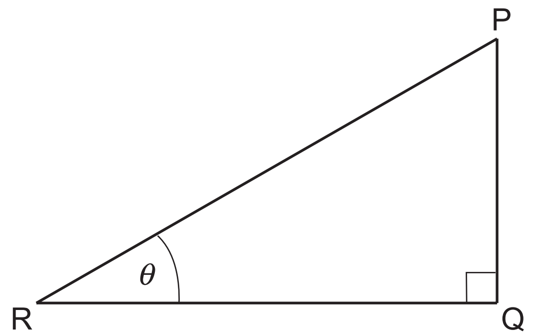
Areas and Volumes

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



$$\sin\theta = \frac{\text{PQ}}{\text{PR}}, \quad \cos\theta = \frac{\text{QR}}{\text{PR}}, \quad \tan\theta = \frac{\text{PQ}}{\text{QR}}, \quad \frac{\sin\theta}{\cos\theta} = \tan\theta$$

$$\text{PR}^2 = \text{PQ}^2 + \text{QR}^2$$

Logarithms (A2 only)

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

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

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

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

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

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

