Surname	Centre Number	Candidate Number
Other Names		2

GCE AS/A level

1321/01

S15-1321-01

PHYSICS – PH1
Motion, Energy and Charge

A.M. TUESDAY, 19 May 2015

1 hour 30 minutes

For Examiner's use only		
Question	Maximum Mark	Mark Awarded
1.	9	
2.	11	
3.	15	
4.	11	
5.	9	
6.	8	
7.	17	
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.

Examiner only

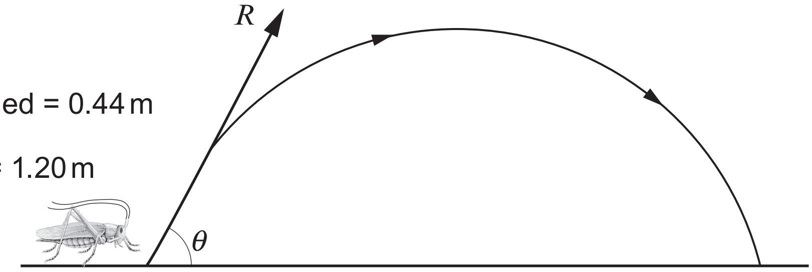
Answer **all** *questions.*

1. A science student is investigating the jump characteristics of a grasshopper. She makes the following observations when analysing one particular jump.

Maximum vertical height obtained = 0.44 m

Maximum horizontal distance = 1.20 m

Time of flight = 0.60 s



Air resistance can be ignored for parts *(a)* to *(c)*.

(a) Use the information to calculate:

(i) the horizontal component of the velocity of the grasshopper; [1]

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(ii) the initial vertical component of the velocity of the grasshopper. [2]

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(b) Hence calculate:

(i) the magnitude of the velocity at take-off, marked R in the diagram; [2]

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(ii) the angle of take-off, marked θ in the diagram. [1]

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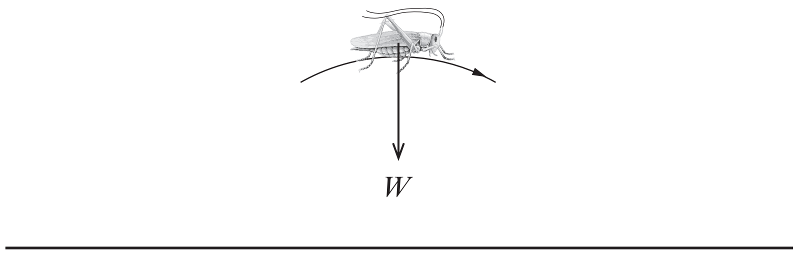
(c) The diagram below shows the grasshopper of mass 3.0×10^{-5} kg at the instant when it is at its maximum height above the ground.



(i) The arrow labelled W represents the force of gravity on the grasshopper due to the Earth. Identify the Newton third law 'equal and opposite' force to W. [1]

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(ii) Calculate the magnitude of the force you identified in *(c)*(i). [1]

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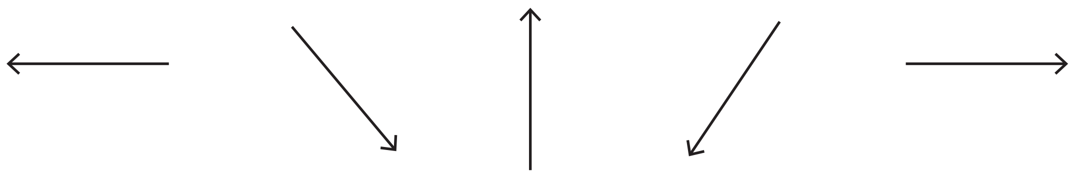
(d) Assume air resistance does act. **Circle the arrow** which correctly shows the direction of the force due to air resistance on the grasshopper at the instant it is at its maximum height. [1]



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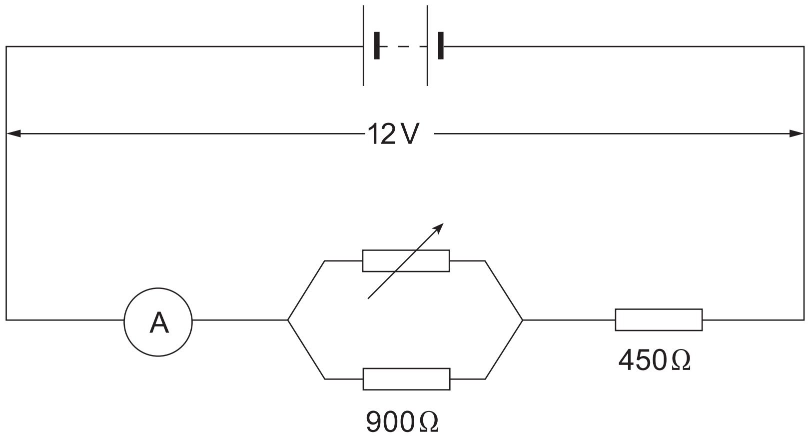
2. *(a)* The unit of electrical resistance is the ohm (Ω). Two of the following are correct alternative units to the ohm. **Circle the correct two.** [2]

$\mathbf{VA^{-1}}$ $\mathbf{V^{-1}A}$ $\mathbf{WA^{-2}}$ $\mathbf{Cs^{-1}}$

Space for working if needed.

(b) The circuit shows a variable resistor connected to two fixed resistors, an ammeter and a battery of emf 12 V. The battery has negligible internal resistance.



The variable resistor is adjusted so that the ammeter reads 0.01 A.

(i) Calculate the potential difference across the 450 Ω resistor. [1]

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(ii) Calculate the potential difference across the 900 Ω resistor. [1]

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(iii) Calculate the resistance of the parallel combination of the 900 Ω resistor and the variable resistor. [2]

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(iv) Calculate the resistance of the variable resistor. [2]

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(c) The variable resistor is adjusted so that its resistance decreases. Explain in clear steps what happens to the potential difference across the 900 Ω resistor. [3]

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3. *(a)* (i) The current in a wire depends on its **resistance**. Explain, in terms of free electrons, how this resistance arises when a potential difference is applied across the wire. [2]

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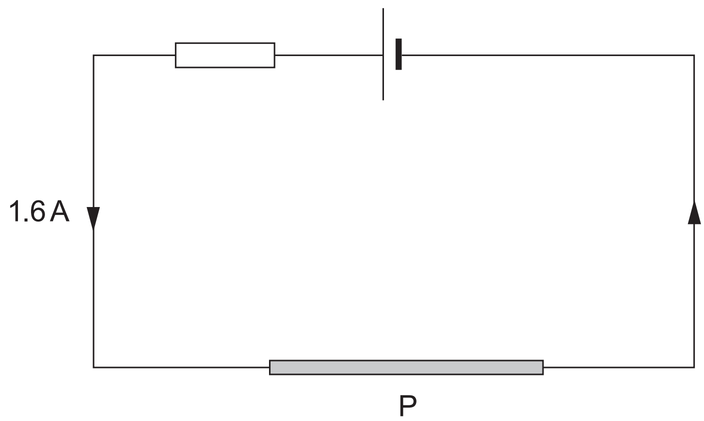
(ii) The wire (labelled P in the diagram) is connected to a fixed voltage source and a resistor to limit the current as shown. The wire is 0.4 m long and has a cross-sectional area of $2.0 \times 10^{-6}\,m^2$. When the current is 1.6 A it dissipates 1.8 J of energy in 1 minute. Calculate its resistivity. [4]



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(b) (i) The current, I, in a wire of cross-sectional area, A, is given by the formula:

$$I = nAve$$

Derive the formula. You may include a clearly labelled diagram. [4]

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(ii) Calculate the drift velocity of the free electrons in the wire in *(a)*(ii) when the current through it is 1.6 A. [$n = 6.4 \times 10^{28}\,\text{m}^{-3}$] [2]

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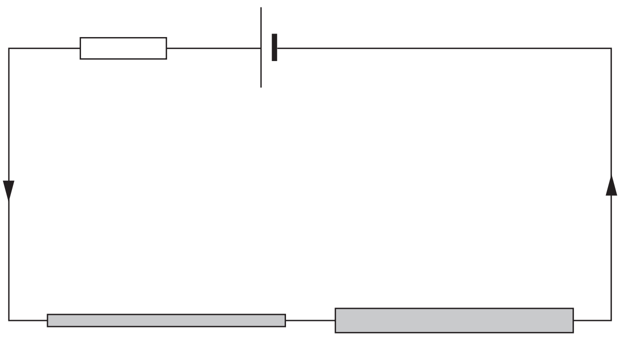
(iii) Wire P is now connected to another wire, Q, of the same material but with **twice** the cross-sectional area. The wires are connected to the same fixed voltage source and resistor.



Complete the following sentences by **circling the correct option** given in brackets.

(I) The current in the circuit containing both wires is **[less than 1.6 A] [equal to 1.6 A] [more than 1.6 A]**. [1]

(II) The current in P is **[less than] [the same as] [greater than]** the current in Q. [1]

(III) The electron drift velocity in Q is **[half] [the same as] [twice] [four times]** the electron drift velocity in P. [1]

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4. *(a)* (i) Draw a labelled diagram of a suitable arrangement that would enable a student to investigate how the resistance of a metal wire changes between a temperature of **0 °C** and **100 °C**. [3]

(ii) Describe how the student would:

- obtain measurements of resistance across the full temperature range;
- ensure accurate results;
- analyse the data obtained. [5]

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Examiner only

(b) (i) A certain metal alloy has a *superconducting transition temperature* of –163 °C. Explain what is meant by the words in italics. [2]

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(ii) State how this alloy can be kept below its superconducting transition temperature. [1]

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Examiner only

5. *(a)* (i) Define *power*. [1]

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(ii) Show how the unit **W** can be expressed in terms of the SI base units **kg**, **m** and **s**. [2]

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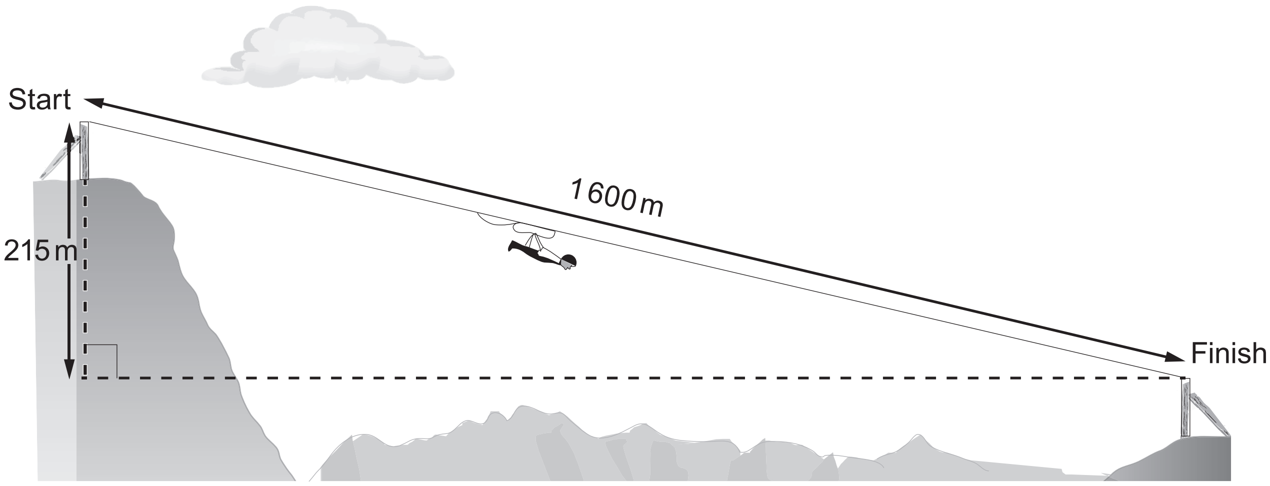
(b) The longest zip-wire ride in the UK is in Snowdonia, North Wales. It is 1600 m long and the vertical drop from start to finish is 215 m as shown. The diagram is not to scale.



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(i) A person of mass 70 kg arrives at the finish travelling at 35 m s^{-1}, having started from rest. Use this data and information from the diagram opposite to determine the mean force opposing the motion of the person. [4]

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(ii) The time taken to travel from start to finish is 46 s. Calculate the mean rate at which energy is transferred to the surroundings during the journey. [2]

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Examiner only

6. *(a)* Explain, with the aid of a diagram, what is meant by the moment of a force about a point. [2]

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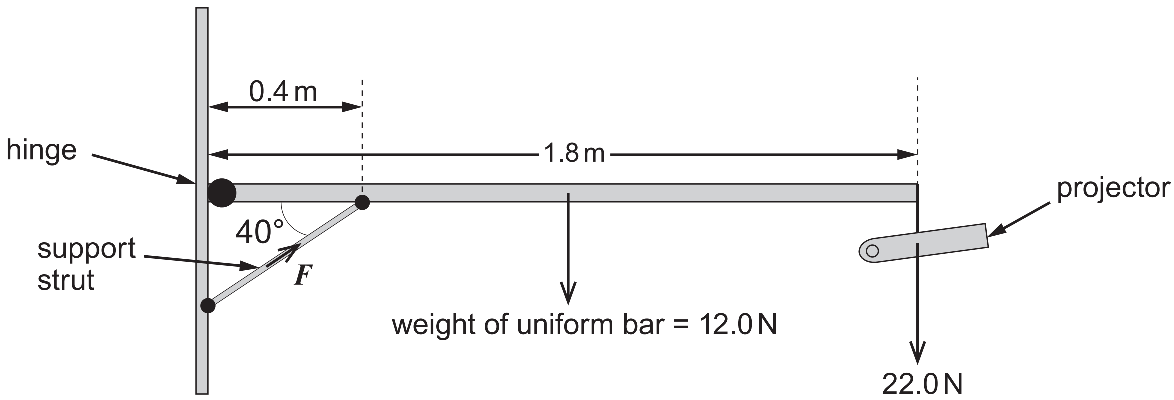
(b) A classroom projector is set up as shown.



(i) By taking moments about the hinge, show that the force, ***F***, exerted by the support strut on the uniform bar is approximately 200 N. [3]

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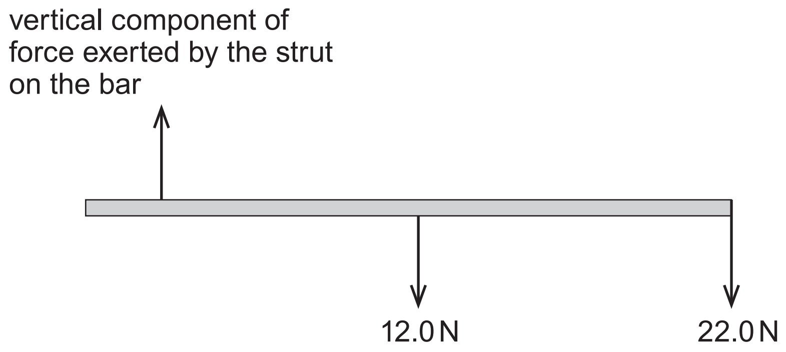
Examiner only

(ii) The free body diagram below shows **some of the vertical forces** acting on the uniform bar.



(I) Calculate the value of the **vertical component** of the force exerted by the strut on the bar. [1]

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(II) Indicate, with an arrow **on the diagram**, the direction of the vertical force on the bar due to the hinge. [1]

(III) Calculate the size of the vertical force on the bar due to the hinge. [1]

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Examiner only

7. *(a)* (i) Define *displacement.* [1]

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(ii) The distance between two towns A and B is 300 km. A train travels from A to B at a mean speed of 40 km/h and then back from B to A at a mean speed of 60 km/h.

(I) Calculate the mean speed for the **whole** journey. [3]

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(II) What is the mean velocity for the whole journey? Explain your answer. [2]

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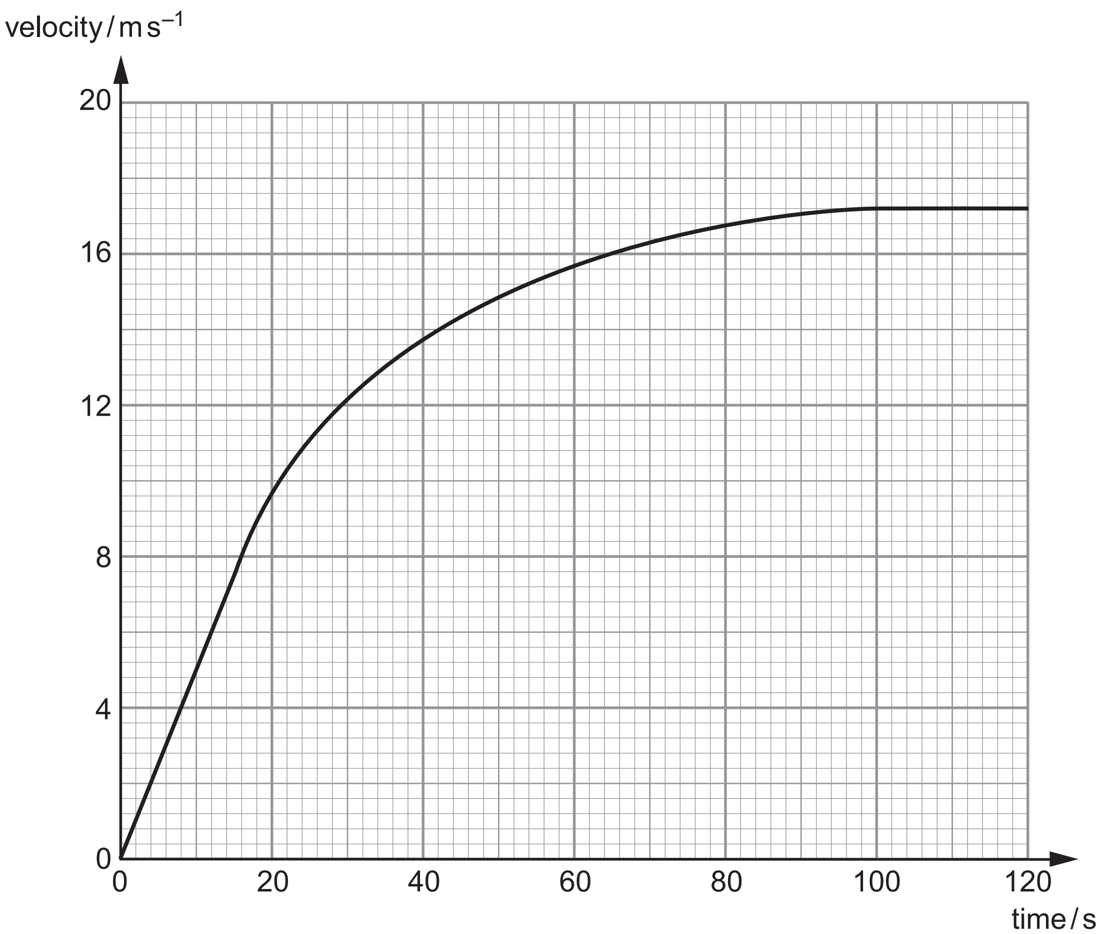
(b) The graph represents the motion of the train over a 120 second period as it departs from a station.



Examiner only

(i) By drawing a suitable tangent, determine the resultant force ($\sum F$) acting on the train at t = 40 s. [Mass of train = 1.2×10^6 kg.] [3]

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(ii) Label clearly on the graph a time when $\sum F = 0$. [1]

(iii) Describe and explain the motion of the train when $\sum F = 0$. [2]

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(c) (i) The useful power output, P, of the engine is 4.5 MW. Show that:

$$P = Fv$$

where F is the driving force and v is the instantaneous velocity. [1]

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(ii) Calculate the driving force when $\sum F = 0$. [2]

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(d) Using your answers to *(b)*(i) and *(c)*(ii) and the assumption that the driving force remains constant throughout the motion, calculate the resistive force acting on the train at t = 40 s. [2]

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GCE AS/A level

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S15-1321-01A

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	=	$6{\cdot}02 \times 10^{23}$ 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

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

$v = u + at$

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

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

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

$\Sigma F = ma$

$W = Fx\cos\theta$

$\Delta E = mg\Delta h$

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

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

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

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

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

$I = nAve$

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

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

$P = IV$

$V = E - Ir$

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

$c = f\lambda$

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

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

$d\sin\theta = n\lambda$

$n_1 v_1 = n_2 v_2$

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

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

$\lambda_{\max} = W\,T^{-1}$

$P = A\sigma T^4$

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

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 $A = \frac{A_o}{2^x}$

$\lambda = \frac{\log_e 2}{T_{½}}$

$E = mc^2$

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

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

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

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

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

$$r_P v_P = r_A v_A$$

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

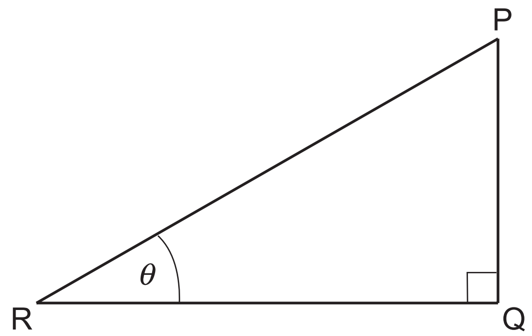
Areas and Volumes

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



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

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

Logarithms (A2 only)

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

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

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

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

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

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