DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/01

Paper 1 Multiple Choice

25 September 2017

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use staples, paper clips, highlighters, glue or correction fluid.
Write your name, class and index number on the Answer Sheet in the spaces provided unless this has been done for you.

DO **NOT** WRITE IN ANY BARCODES.

There are **thirty** questions on this paper. Answer **all** questions. For each question there are four possible answers **A**, **B**, **C** and **D**.
Choose the **one** you consider correct and record your choice in **soft pencil** on the separate Answer Sheet.

Read the instructions on the Answer Sheet very carefully.

Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.

The use of an approved scientific calculator is expected, where appropriate.

This document consists of **16** printed pages and **0** blank page.

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_o	=	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_o	=	8.85×10^{-12} F m^{-1}
			$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e	=	1.60×10^{-19} C
the Planck constant,	h	=	6.63×10^{-34} J s
unified atomic mass constant,	u	=	1.66×10^{-27} kg
rest mass of electron,	m_e	=	9.11×10^{-31} kg
rest mass of proton,	m_p	=	1.67×10^{-27} kg
molar gas constant,	R	=	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A	=	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k	=	1.38×10^{-23} J K^{-1}
gravitational constant,	G	=	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g	=	9.81 m s^{-2}

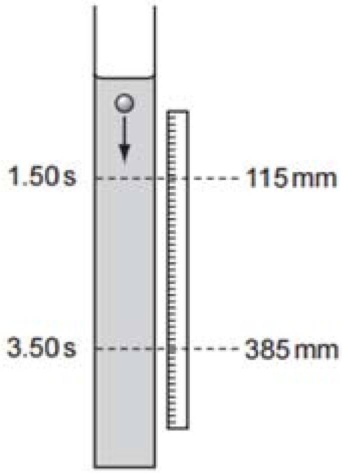
Formulae

uniformly accelerated motion,	s	=	$ut + \frac{1}{2}at^2$
	v^2	=	$u^2 + 2as$
work done on/by a gas,	W	=	$p\Delta V$
hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	T/°C + 273.15
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}<c^2>$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 N I}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 n I$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A car is travelling along the Pan-Island Expressway under smooth traffic conditions. What is the order of magnitude of its kinetic energy, in joules?

A 10^3 **B** 10^5 **C** 10^7 **D** 10^9

2 The diagram shows an experiment to measure the speed of a small ball falling at constant speed through a clear liquid in a glass tube.



There are two marks on the tube. The top mark is positioned at 115 ± 1 mm on the adjacent rule and the lower mark at 385 ± 1 mm. The ball passes the top mark at 1.50 ± 0.02 s and passes the lower mark at 3.50 ± 0.02 s.

The constant speed of the ball is calculated to be 135 mm s^{-1}.
What is the fractional uncertainty in the value of this speed?

A 0.014 **B** 0.027 **C** 1.9 **D** 3.7

3 An aeroplane travels at an average speed of 600 km h^{-1} on an outward flight and at 800 km h^{-1} on the return flight over the same distance.

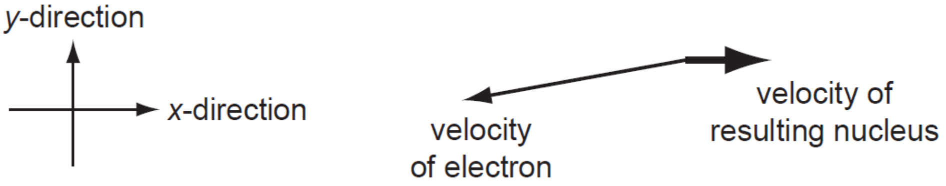
What is the average speed of the whole flight?

A 111 m s^{-1} **B** 167 m s^{-1} **C** 686 km h^{-1} **D** 700 km h^{-1}

4 What is the angle of projection for a bullet fired over a horizontal plane, when the horizontal range is four times the maximum height?

A 15° **B** 30° **C** 45° **D** 75°

5 A stationary nucleus undergoes beta-decay. The diagram shows the velocities of the resulting nucleus and the emitted electron.



How does this diagram support the idea that a third, unseen particle is also emitted?

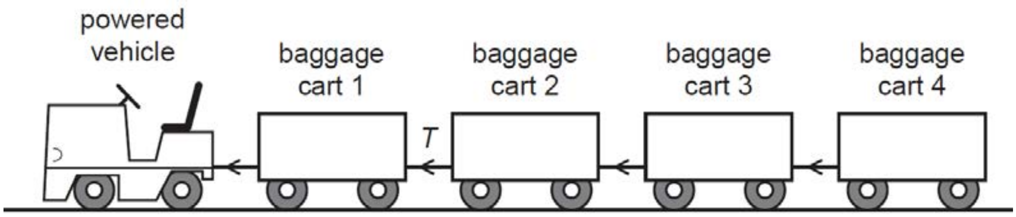
A If there were only two particles involved, their velocities should be equal and opposite.

B It is clear that linear momentum is not conserved in the x-direction.

C The third particle must carry away the extra energy.

D The original nucleus had no y-component of linear momentum.

6 A transport system, used to move luggage from the airport terminal to the aircraft, consists of a powered vehicle connected to four baggage carts by a series of connecting bars.



The mass of the powered vehicle is 200 kg and each of the baggage carts has a mass of 400 kg. The system starts with an acceleration of 2.0 m s^{-2}.

What is the tension T in the connecting bar between baggage carts 1 and 2?
(Ignore any friction forces on the carts.)

A 800 N **B** 12000 N **C** 2400 N **D** 3600 N

7 A soccer ball approaches a player at v = 12 m s^{-1}. At what velocity u should the player's foot move in order to stop the ball upon contact? Assume that the mass of the foot is much greater than that of the ball and that the collision is elastic.

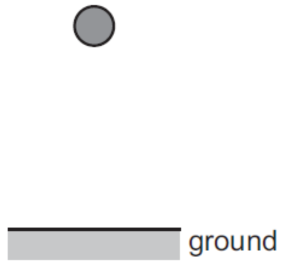
A u = 12 m s^{-1} in the direction opposite to the original velocity of the ball.

B u = 6 m s^{-1} in the direction opposite to the original velocity of the ball.

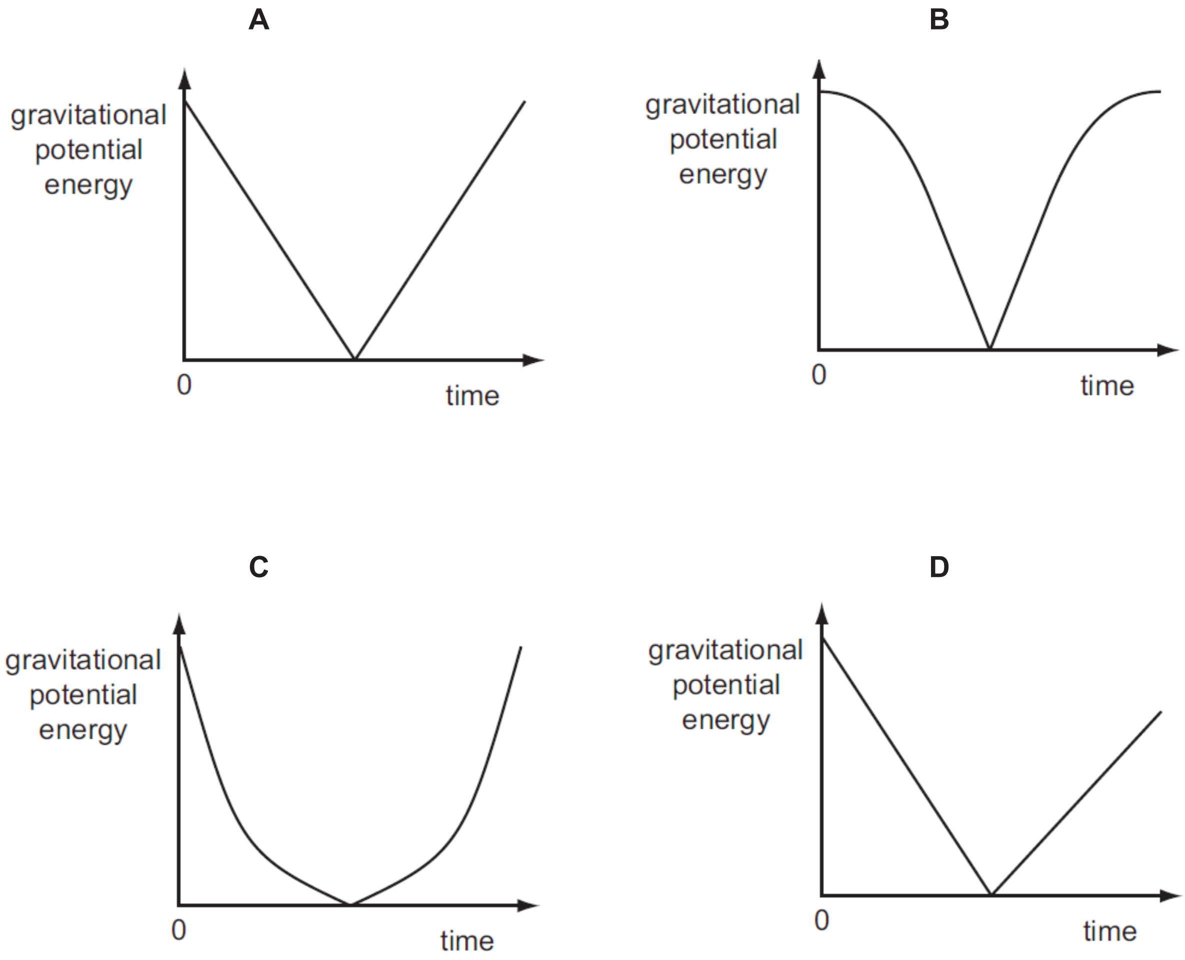
C u = 6 m s^{-1} in the same direction as the original velocity of the ball.

D u = 0 m s^{-1}, he should hold his foot very still.

8 A ball is released from rest. It falls vertically, hits the ground and bounces back up. Energy losses are negligible.



Which graph shows how the gravitational potential energy of the ball changes during the bounce?



9 A mass m_1 is attached to one end of an elastic string of unstretched length L. When the mass is rotating with a linear speed of v on a smooth horizontal table in a horizontal circle, an extension e is obtained.

Which of the following shows the correct expression for mass m_2, if it is rotated with the same linear speed v but rotates at twice the radius as that produced by mass m_1?

A $m_2 = \frac{2m_1(L+e)}{e}$

B $m_2 = \frac{2m_1(2L+e)}{e}$

C $m_2 = \frac{2m_1(2L+2e)}{e}$

D $m_2 = \frac{2m_1(L+2e)}{e}$

10 A rocket is travelling away from Earth at a speed of 11 km s^{-1} in a direction at 60° to the Earth's surface at a point where the gravitational field strength is 9.3 N kg^{-1}.

If the mass of the rocket at this moment is 4.0 x 10^6 kg, at what rate is the rocket gaining gravitational potential energy?

A 4.2 x 10^8 W

B 3.6 x 10^{10} W

C 2.1 x 10^{11} W

D 3.5 x 10^{11} W

11 Object X has a mass of 10 kg and object Y has a mass of 60 kg. The gravitational field strength on the Moon is 1.6 N kg^{-1}.

Which statement about objects X and Y is correct?

A The inertia of X on the Earth is greater than its inertia on the Moon.

B The weights of X and Y do not change when they are taken from the Earth to the Moon.

C X experiences the same gravitational field strength as Y on the Moon.

D X has about the same weight on the Moon as Y has on the Earth.

12 The density of argon at a pressure of 1.00 x 10^5 Pa is 1.60 kg m^{-3}. What is the root mean square speed of argon molecules at this temperature?

A 216 m s^{-1} **B** 250 m s^{-1} **C** 306 m s^{-1} **D** 433 m s^{-1}

13 Before the invention of the modern refrigerator, ice was manufactured industrially and delivered to households. One method used the evaporation of ammonia. Energy was required to make the ammonia evaporate and 75% of this energy came from liquid water at 0 ^oC, turning the water into ice. In six hours 8.0 x 10^4 kg of ice was produced.

At what rate did the ammonia need to be evaporated?

The specific latent heat of fusion of water is 330 kJ kg^{-1}.
The specific latent heat of vaporisation of ammonia is 1370 kJ kg^{-1}.

A 0.67 kg s^{-1} **B** 1.2 kg s^{-1} **C** 12 kg s^{-1} **D** 20 kg s^{-1}

14 A particle is oscillating in simple harmonic motion. When the particle is mid-way between the equilibrium position and amplitude position, what is ratio of its kinetic energy to its potential energy?

A 1:3

B 1:1

C 3:1

D 1:7

15 A pendulum clock is being operated in a lift. What will happen to the pendulum when the lift cable snaps?

A The pendulum bob will hit the ceiling of the lift.

B Oscillations will continue but the period will increase.

C Oscillations will continue but the period will decrease.

D Oscillations will stop.

16 Two sources of radio waves are at a distance of 1.0×10^{15} m from Earth. The sources are separated by 1.0×10^{12} m and emit radio waves of wavelength 0.030 m.

What is the estimate for the diameter of a dish of a radio telescope on Earth that will just resolve the two sources?

A 3.0×10^{-5} m

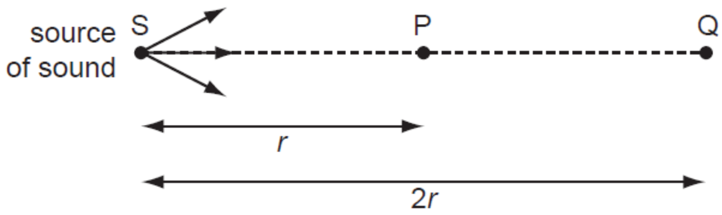
B 3.0×10^{-2} m

C 3.0 m

D 30 m

17 The intensity I of a sound at a point P is inversely proportional to the square of the distance x of P from the source of the sound. That is

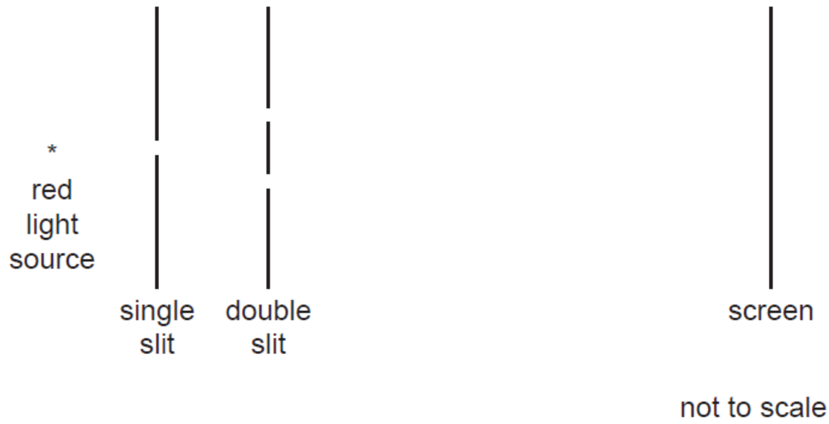
$$I \propto \frac{1}{x^2}.$$



Air molecules at P, a distance r from S, oscillate with amplitude 8.0 μm.
Point Q is situated a distance $2r$ from S.
What is the amplitude of oscillation of air molecules at Q?

A 1.4 μm **B** 2.0 μm **C** 2.8 μm **D** 4.0 μm

18 A double-slit interference experiment is set up as shown.



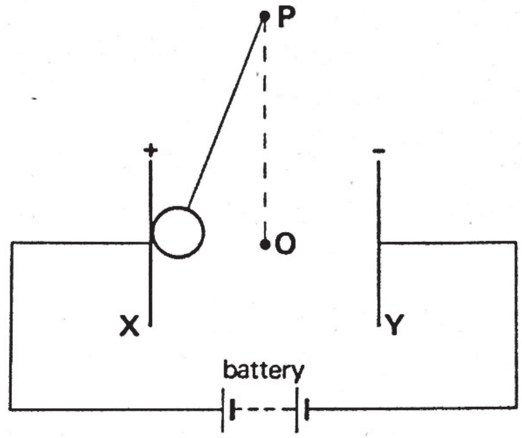
Fringes are formed on the screen. The distance between successive bright fringes is found to be 4 mm.

Two changes are then made to the experimental arrangement. The double slit is replaced by another double slit which has half the spacing. The screen is moved so that its distance from the double slit is twice as great.

What is now the distance between successive bright fringes?

A 1 mm **B** 4 mm **C** 8 mm **D** 16 mm

19 Two parallel plates **X** and **Y** are mounted vertically and given equal and opposite charges. A light uncharged conducting sphere is suspended by an insulating thread from point **P** vertically above the mid-point **O** of the line joining the centre of the plates.



If the sphere is initially placed in contact with **X** as shown in the diagram, which statement best describe its subsequent motion?

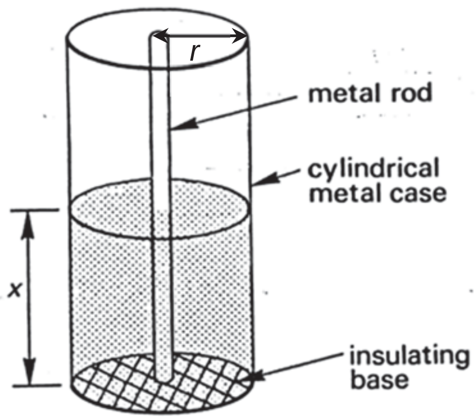
A It remains in contact with plate **X**.

B It moves to plate **Y** and sticks to it.

C It moves back and forth continuously, touching each plate in turn.

D It oscillates as a simple pendulum.

20 A conducting liquid fills a cylindrical metal case to a depth x as shown in the diagram.



The resistance between the case and the metal rod is

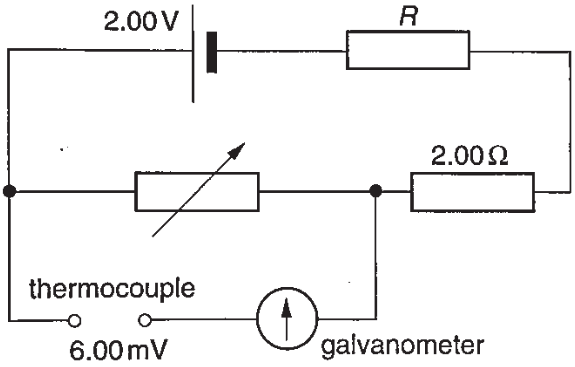
A proportional to x.

B proportional to r.

C inversely proportional to x.

D inversely proportional to r^2.

21 The diagram shows a circuit for measuring a small e.m.f. produced by a thermocouple.

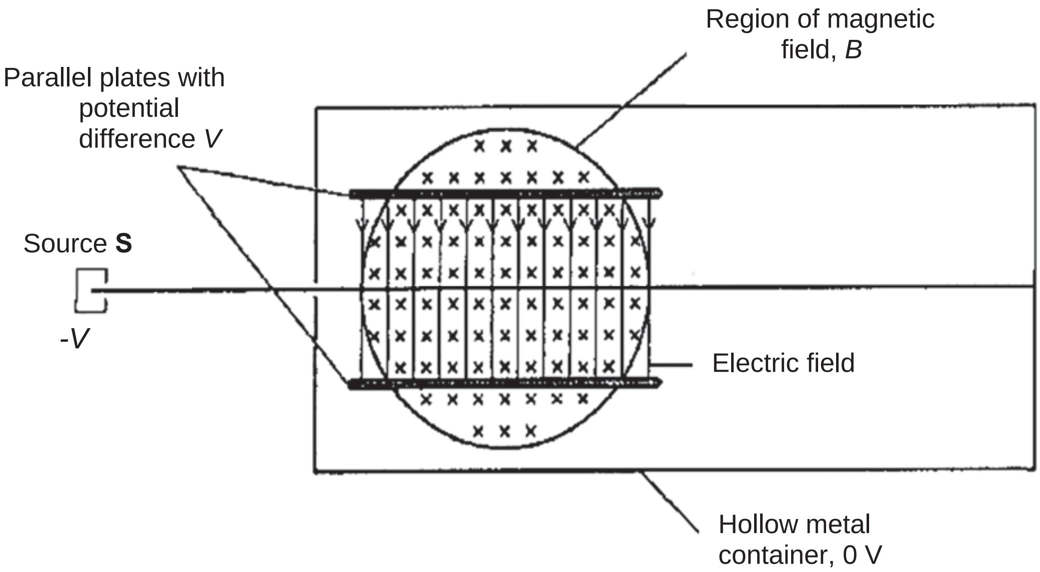


There is zero current in the galvanometer when the variable resistor is set at 3.00 Ω.

What is the value of the resistance R?

A 195 Ω **B** 495 Ω **C** 995 Ω **D** 1995 Ω

22 A part of a mass spectrometer is shown in the figure below. Negative ions are generated at the source **S**, which is at a potential of $-V$ with respect to the hollow metal container. Inside the container, there are parallel plates separated by distance d and a uniform magnetic field B is applied to the region between the parallel plates.

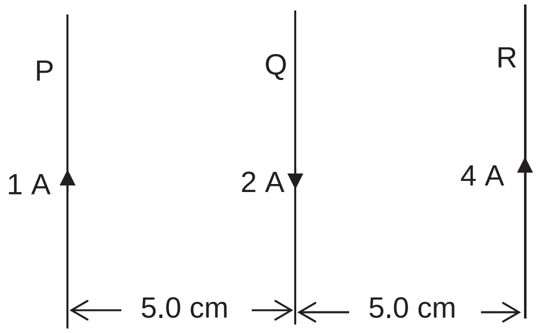


If the potential difference between the parallel plates is V, what is the charge to mass ratio of the ions that can pass through the fields undeviated?

A $\dfrac{V}{2B^2d^2}$ **B** $\dfrac{2V}{B^2d^2}$

C $\dfrac{2B^2d^2}{V}$ **D** $\dfrac{B^2d^2}{2V}$

23 Three long, parallel, straight wires P, Q and R are placed in the same plane in a vacuum as shown in the diagram below.



What is the force per unit length acting on wire P?

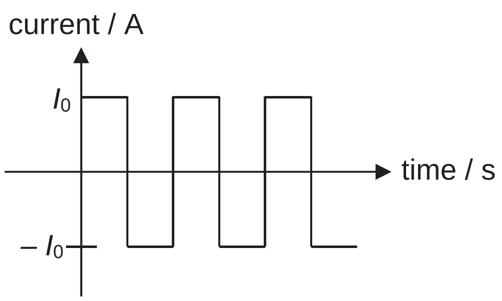
A 0

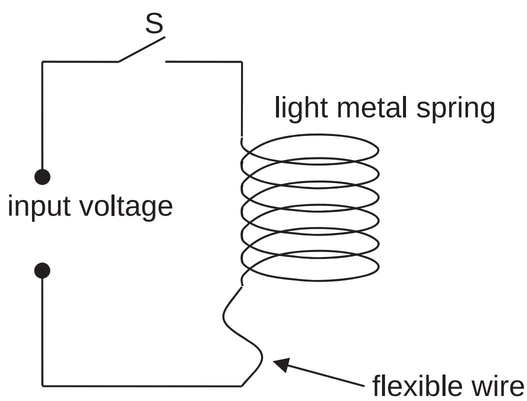
B 8.0×10^{-6} N m^{-1}

C 1.6×10^{-7} N m^{-1}

D 1.6×10^{-5} N m^{-1}

24 The diagram below shows a light metal spring being connected to a circuit. The variation with time of the current produced by the input voltage is shown in the graph below.





What will happen to the spring when switch S is closed?

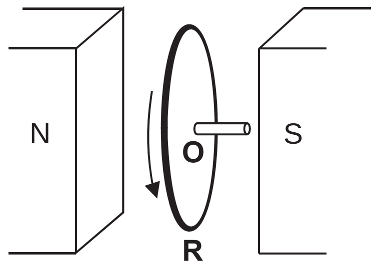
A The spring will be compressed slightly.

B The spring will be extended slightly.

C The spring will oscillate with the same frequency as the input signal.

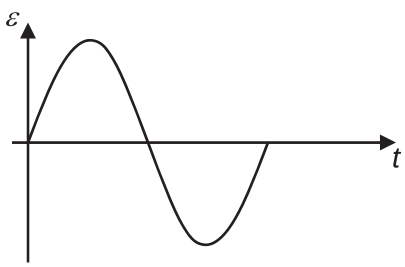
D Nothing will happen.

25 The figure below shows a copper disc rotating steadily about its centre **O** in a uniform magnetic field between two bar magnets. The magnetic field is acting perpendicularly to the disc.

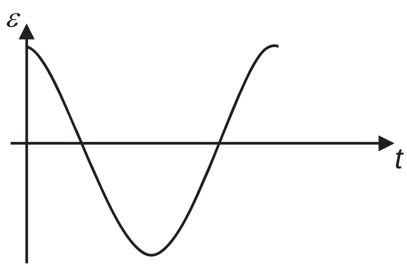


Which of the following graphs correctly shows the variation of the induced e.m.f. ε between the centre **O** and a point **R** on the rim of the disc with time t?

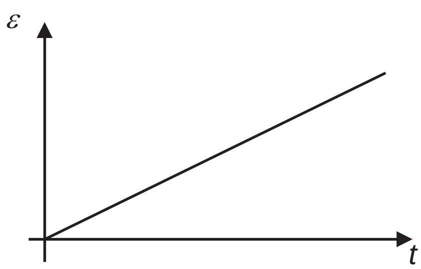
A



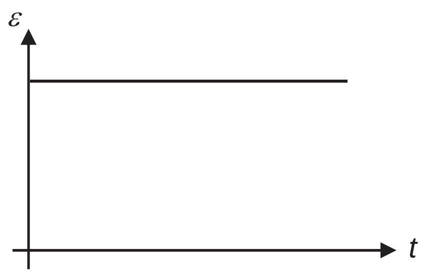
B



C



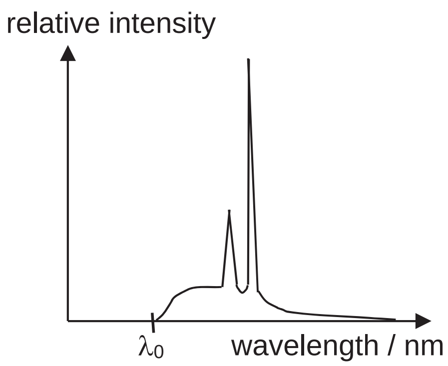
D



26 Ten 12 V 24 W lamps are connected in parallel to the secondary coil of a step down transformer whose primary coil is connected to the mains supplying 240 V. The lamps are operating normally at the given rating. If the primary current drawn from the mains is 1.1 A, what is the efficiency of the transformer?

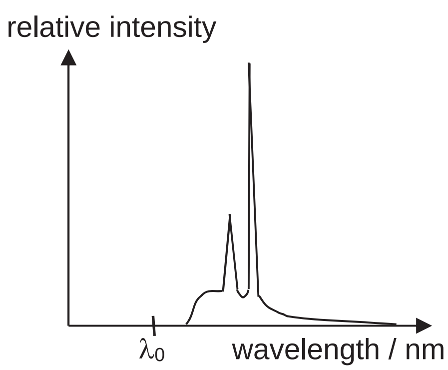
A 91 %
B 9 %
C 53 %
D 86 %

27 An X-ray spectrum is taken from an X-ray tube. The relative intensity of the X-rays is plotted against the wavelength and is shown below.

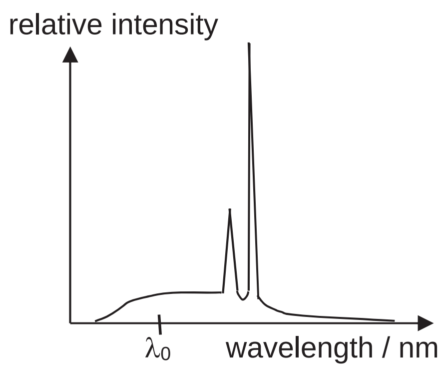


If a higher tube voltage is used, which one of the following graphs shows the new variation of the relative intensity with wavelength?

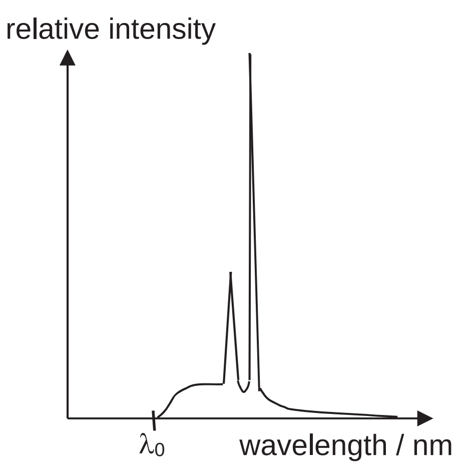
A



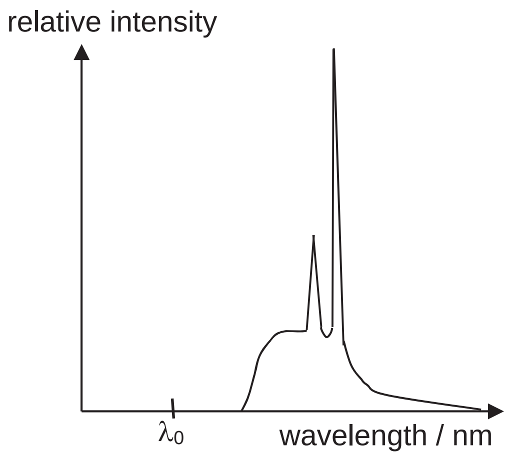
B



C



D



28 Which one of the following statements about the photon is **incorrect**?

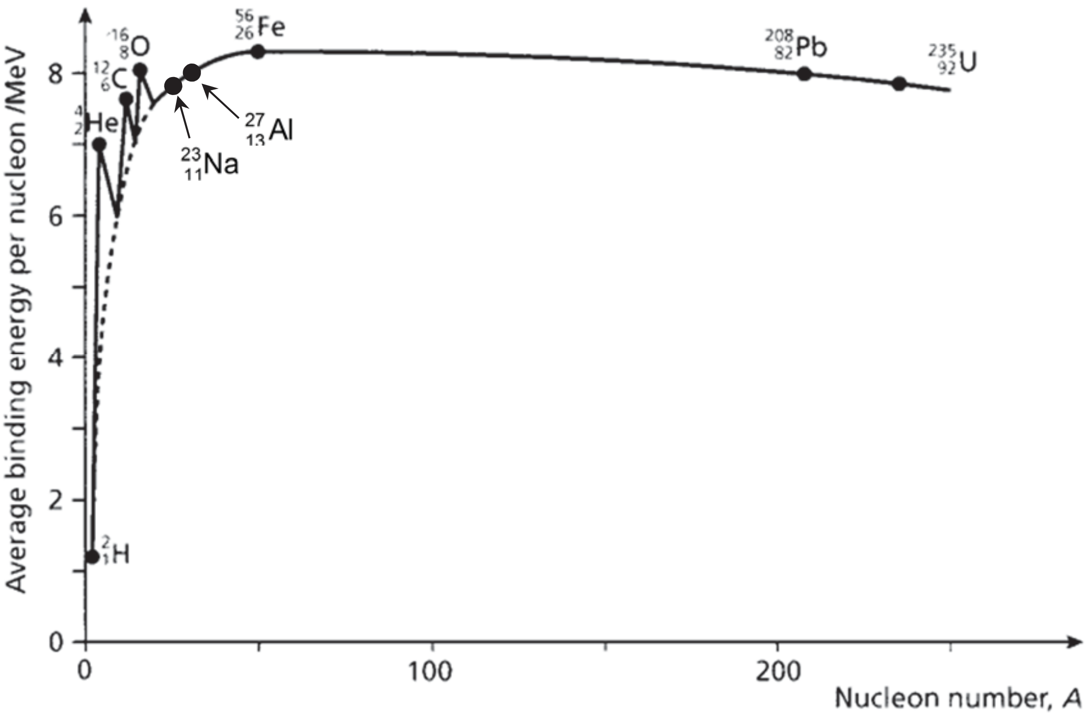
A A photon has no mass.

B A photon has no momentum.

C All photons move with the same speed in free space.

D Photons are emitted when a high energy electron beam is stopped by a piece of molybdenum metal.

29 The diagram shows a graph of the binding energy per nucleon for a number of naturally occurring nuclides plotted against their nucleon number.



Which of the following statements is a correct deduction from the graph?

A Of the nucleus plotted, $^{2}_{1}H$ is the most stable.

B $^{27}_{13}Al$ will not spontaneously emit an alpha particle to become $^{23}_{11}Na$.

C Energy will be released if a nucleus with a nucleon number greater than about 56 undergoes fusion with any other nucleus.

D Energy will be released if a nucleus with a nucleon number less than about 56 undergoes fission as a result of particle bombardment.

30 A strontium-90 nucleus emits a α– particle and decays to yttrium (Y). The decay has a half-life of 28 years. In a laboratory source of strontium-90, the number of atoms present in January 2016 was 2.36×10^{13}.

What is the number of strontium atoms that will be present in the source in January 2128?

A 7.38×10^{11}

B 1.48×10^{12}

C 3.93×10^{12}

D 5.90×10^{12}

END OF PAPER

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

14 September 2017

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

The use of an approved scientific calculator is expected, where appropriate.

Answer **all** questions.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	/ 7
2	/ 8
3	/ 7
4	/ 13
5	/ 11
6	/ 8
7	/ 6
8	/ 20
Total	/ 80

This document consists of **21** printed pages and **1** blank page.

Data

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permittivity of free space,	ε_o =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

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hydrostatic pressure,	p	=	ρgh
gravitational potential,	ϕ	=	$-Gm/r$
temperature,	T/K	=	$T/^{\circ}\text{C} + 273.15$
pressure of an ideal gas,	p	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
mean translational kinetic energy of an ideal gas molecule,	E	=	$\frac{3}{2}kT$
displacement of particle in s.h.m.,	x	=	$x_0 \sin \omega t$
velocity of particle in s.h.m.,	v	=	$v_0 \cos \omega t$
		=	$\pm\omega\sqrt{x_o^2 - x^2}$
electric current,	I	=	$Anvq$
resistors in series,	R	=	$R_1 + R_2 + \ldots$
resistors in parallel,	$1/R$	=	$1/R_1 + 1/R_2 + \ldots$
electric potential,	V	=	$\frac{Q}{4\pi\varepsilon_o r}$
alternating current / voltage,	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	B	=	$\frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	B	=	$\frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	B	=	$\mu_0 nI$
radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 A 20 kg monkey has a firm hold on a light rope that passes over a frictionless pulley and is attached to a 20 kg bunch of bananas, as shown in Fig. 1.1. The monkey looks up, sees the bananas, and starts to climb the rope to get them.

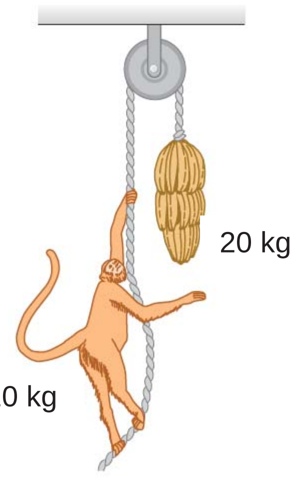


Fig. 1.1

(a) As the monkey climbs,

(i) State the forces acting on the monkey.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

(ii) Hence or otherwise, state and explain whether the bananas move up, down or remain at rest.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………[3]

(iii) State and explain whether the vertical separation between the monkey and the bananas decrease, increase or remain constant.

…………………………………………………………………………………………………

…………………………………………………………………………………………………[1]

(b) The monkey releases her hold of the rope and both the monkey and bananas fall.

Before reaching the ground, the monkey grabs the rope to stop her fall. State and explain the motion of the bananas while monkey slows down to a complete stop.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

2 A block of mass 0.40 kg slides in a straight line with a constant speed of 0.30 m s^{-1} along a horizontal surface, as shown in Fig. 2.1.

Fig. 2.1

The block hits a spring and decelerates. The speed of the block becomes zero when the spring is compressed by 8.0 cm.

(a) Calculate the initial kinetic energy of the block.

kinetic energy = …………………… J [1]

(b) The variation of the compression *x* of the spring with the force *F* applied to the spring is shown in Fig. 2.2.

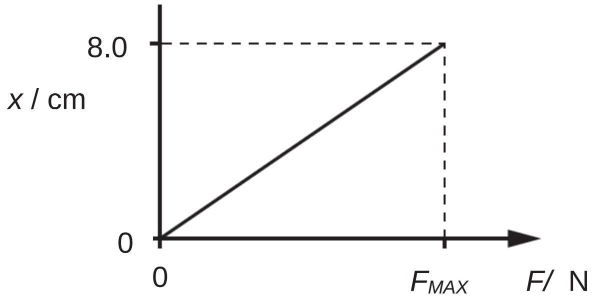


Fig. 2.2

Use your answers in **(a)** to determine the maximum force F_{MAX} exerted on the spring by the block.

F_{MAX} = …………………….. N [1]

(c) Calculate the maximum deceleration of the block.

decceleration = …………………….. m s^{-2} [1]

(d) State and explain whether the block is in equilibrium when its speed becomes zero.

………………………………………………………………………………………………

……………………………………………………………………………………………..[1]

(e) The length of the spring is then cut in half. The same block travelling at the same speed of 0.30 m s^{-1} hits the spring.

Suggest and explain the change, if any, on the length of compression of the spring when the speed of the block becomes zero.

………………………………………………………………………………………………

………………………………………………………………………………………………

……………………………………………………………………………………………..[2]

For Examiner's Use

(f) The mass *m* of the block is now varied. The initial speed of the block remains constant and the spring continues to obey Hooke's law.

On Fig. 2.3, sketch the variation with mass *m* of the maximum compression x_0 of the spring. [2]

Fig. 2.3

For Examiner's Use

3 Body A of mass 6.5 kg is connected to body B of mass 9.5 kg by a light inextensible string that passes over a frictionless pulley. The other end of body A is connected to a light spring of spring constant k equals to 200 N m^{-1}.

At the equilibrium position, the spring is compressed and body A is 20.0 cm above the floor as shown in Fig. 3.1, with the smooth incline making an angle of 40^0 to the horizontal.

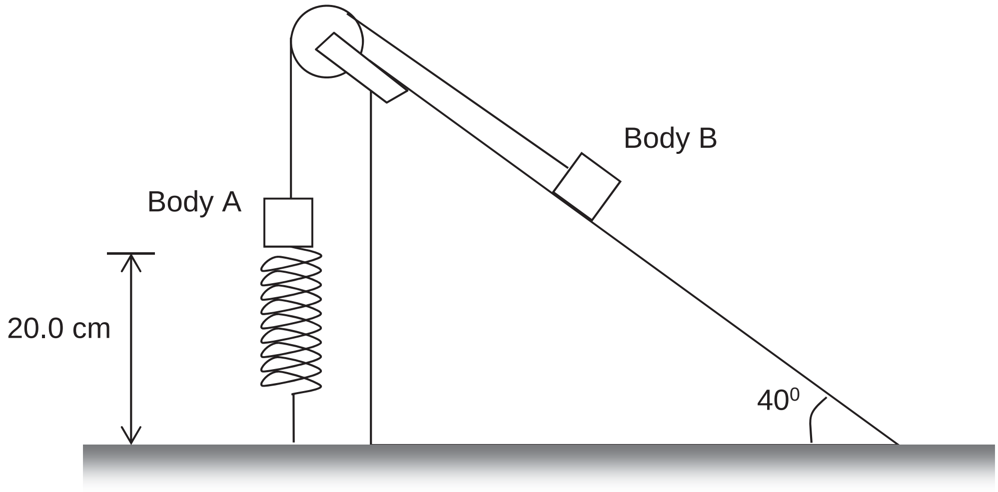


Fig. 3.1

(a) Draw the free body diagrams for A and B separately when the two bodies are in its equilibrium position. Indicate clearly the forces on your diagrams.

[4]

(b) Body B is now given a slight displacement x down the slope and released. Show that its acceleration a is given by

$$a = - 12.5x.$$

[2]

(c) Given that x in **(b)** is 2.0 cm, determine the speed of body A when it is 21.0 cm above the floor.

speed of body A = …………………… m s^{-1} [1]

4 **(a)** Describe the basic difference between the following terms. You may use diagrams to illustrate your answers.

(i) a *transverse* wave and a *longitudinal* wave,

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………..[2]

(ii) a *polarised* wave and a *non-polarised* wave,

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………..[2]

(iii) a *stationary* wave and a *progressive* wave.

……………………………………………………………………………………………

……………………………………………………………………………………………

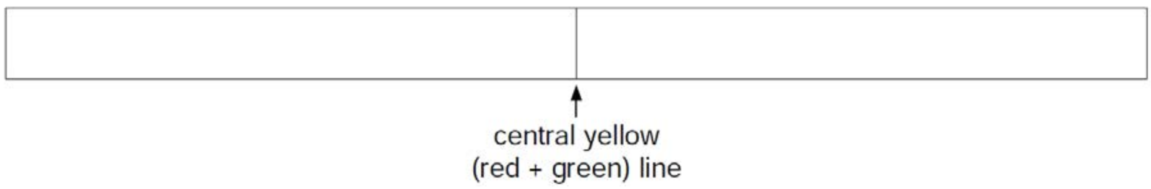
…………………………………………………………………………………………..[2]

(b) Red and green light of wavelengths 640 nm and 520 nm respectively, are simultaneously directed through a diffraction grating. The grating is at right angles to the light and has a line spacing of 1.60 μm.

(i) Complete the table by calculating the values for all the angles of maxima for both colours. [2]

order, n	angle for red maximum / °	angle for green maximum / °
0	0	0
1		
2		
3	-	

(ii) On Fig. 4.1, sketch the approximate pattern that would be seen on a screen behind the diffraction grating. Label the red and green maxima with **R** and **G**, respectively.



[2]

Fig. 4.1

(iii) The grating is replaced with a double slit of the same spacing. Ignoring the change in intensity, describe how the new pattern produced differs from the one for the diffraction grating.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………[3]

5 **(a)** There is a current of 6.0 A through a component for 200 s. Calculate

(i) the charge which flows past a point in the component during this time,

charge = ………………………………… C [1]

(ii) the number of electrons which pass the point during this time.

number = …………………………………… [1]

(b) A student wanted to light a lamp, but only had available a 12 V battery of negligible internal resistance. In order to reduce the battery voltage, he connected the circuit as shown in Fig. 5.1. The maximum value of the resistance of the rheostat XY was 1000 Ω.

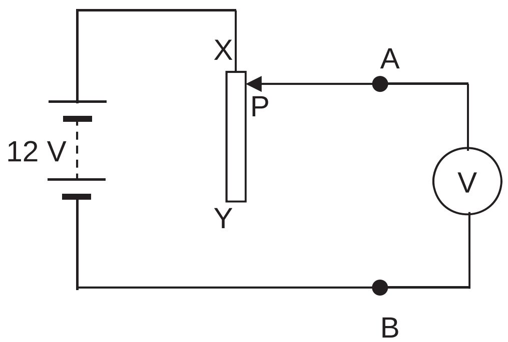


Fig. 5.1

He found that, when the sliding contact P of the rheostat was moved down from X to Y, the voltmeter reading dropped from 12 V to 11 V. Calculate the resistance of the voltmeter.

resistance = ... Ω [2]

(c) He modified the above circuit into the one shown in Fig. 5.2 below, using the rheostat as a potentiometer, and was now able to adjust the rheostat to give a voltmeter reading of 3.0 V.

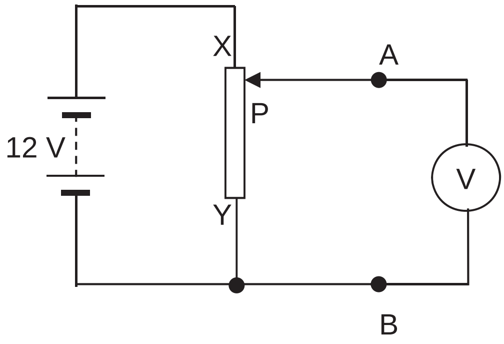


Fig. 5.2

(i) Calculate the current that flows through the voltmeter.

current = ... A [1]

(ii) Assuming that the current in **(i)** is negligible compared with the current through the rheostat, determine how far down from X the sliding contact P would have been moved. Express your answer as a fraction of the length of XY.

fraction of the length of XY = ...[2]

For Examiner's Use

(iii) The student then removed the voltmeter in Fig.5.2 and then connected a lamp rated at 0.60 W, 3.0 V in its place, but it was very dim. With reference to the power delivered to the lamp, explain quantitatively this observation.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………[4]

6 **(a)** An electron travelling with a speed of 1.55×10^6 m s^{-1} enters at an angle of 30^o to a magnetic field of flux density 0.45 mT. Determine

(i) the time taken by the electron to complete a circular path,

time taken = ………………………….. s [3]

(ii) the distance travelled by the electron along the direction of the field when it circulates once in the field.

distance travelled = ………………… m [2]

(b) A small bar magnet is suspended 5.0 cm away from a long straight wire which is orientated in a north-south direction. The magnet is on the right side of the wire. When there is no current in the wire, the north pole of the magnet dips at an angle of 5.0º below the horizontal, as shown in Fig. 6.1.

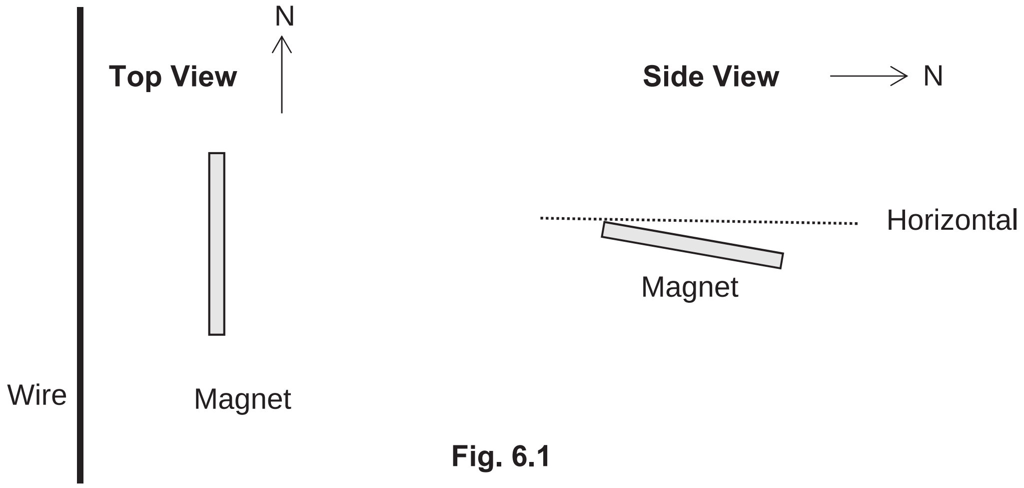


Fig. 6.1

A current is then supplied to the wire to move the magnet back to the horizontal position. Determine the magnitude and the direction of the current required.

The Earth's magnetic field in the region around the magnet is 0.17 mT.

direction = ……………………………..…………………

magnitude = ………………………….. A [3]

For Examiner's Use

7 A photo-multiplier converts the energy of photons of light into an electric signal. Fig. 7.1 below shows the structure of a photo-multiplier that contains nine electrodes, called dynodes, within a vacuum tube. When light is incident on the cathode, it causes photoelectrons to be emitted. These electrons are accelerated and strike the first dynode from which 6 electrons are ejected for every incident electron. These 6 electrons are accelerated to a second dynode, so producing 36 electrons, which are all accelerated to the third dynode, and so on.

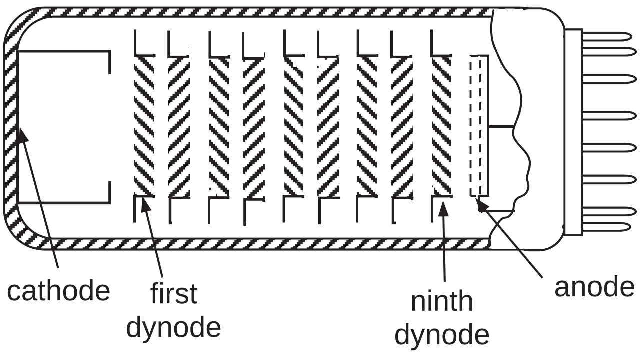


Fig. 7.1

(a) If the electrons from the ninth dynode are collected and constitute a current of 6.3 μA, show that the rate at which photoelectrons are ejected from the cathode is 3.9×10^{6} s^{-1}.

[3]

(b) The incident light has a wavelength of 400 nm. At this wavelength, one in three of the incident photons ejects an electron from the cathode. Calculate the power of the incident beam.

power = ………………………….. W [3]

8 Resistivity and Temperature

Temperature generally affects current in an electrical circuit by changing the speed at which the charge carriers travel. In metals, this is due to an increase in resistance of the circuit that results from the increase in temperature. The opposite effect is seen in semiconductor materials where an increased temperature results in a decrease in resistance due to a change in the number of charge carriers.

Over a limited temperature range, the resistivity of different materials varies linearly with temperature according to the expression

$$\rho = \rho_0[1 + \alpha(T - T_0)]$$

where ρ is the resistivity at some temperature T (in degrees Celsius), ρ_0 is the resistivity at the reference temperature T_0 = 20°C, and α is a constant called the temperature coefficient of resistivity.

The resistivity at 20°C and the temperature coefficients of resistivity for some materials are shown in the table of Fig. 8.1 below.

Material	ρ_0 / Ω m	α / °C^{-1}
Gold	2.44 x 10^{-8}	3.4 x 10^{-3}
Tungsten	5.60 x 10^{-8}	4.5 x 10^{-3}
Silver	1.59 x 10^{-8}	3.8 x 10^{-3}
Platinum	11.0 x 10^{-8}	3.9 x 10^{-3}
X	1.50 x 10^{-6}	0.40 x 10^{-3}
Y	10.0 x 10^{-8}	5.0 x 10^{-3}

Fig. 8.1

(a) Distinguish between electrical *resistance* and *resistivity.*

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[3]

(b) Explain why the resistance of metals increases with temperature.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………[2]

(c) Calculate the resistivity, at 120^{o}C, of

(i) gold

resistivity = ……………………… Ω m [1]

(ii) tungsten

resistivity = ……………………… Ω m [1]

(d) A 5.0 cm length of gold wire, of diameter 0.240 mm, is soldered to a 5.0 cm length of tungsten wire, of diameter 0.140 mm, to form a composite wire, in the configuration as shown in Fig. 8.2.

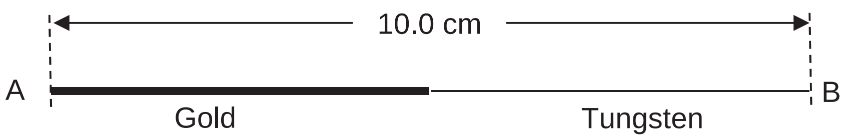


Fig. 8.2

(i) Calculate the resistance across A and B at a temperature of 120^{o}C.

resistance = ……………………… Ω [3]

(ii) The composite wire in Fig 8.2 is now bent into a square loop, as shown in Fig. 8.3.

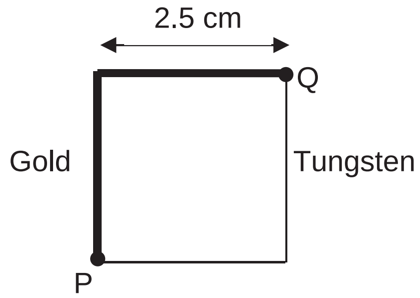


Fig 8.3

Calculate the resistance across P and Q at a temperature of 120°C.

resistance = ……………………………. Ω [2]

(e) A student would like to make an electric kettle with a coil of wire made from either material **X** or **Y**. Suggest with a reason which material, **X** or **Y**, is more suitable to be used as a heating element in an electric kettle.

………

………

………[1]

For Examiner's Use

(f) **(i)** Fig. 8.4 shows the variation with temperature *T* of the resistivity ρ of another material, Germanium. Draw the line of best fit. [1]

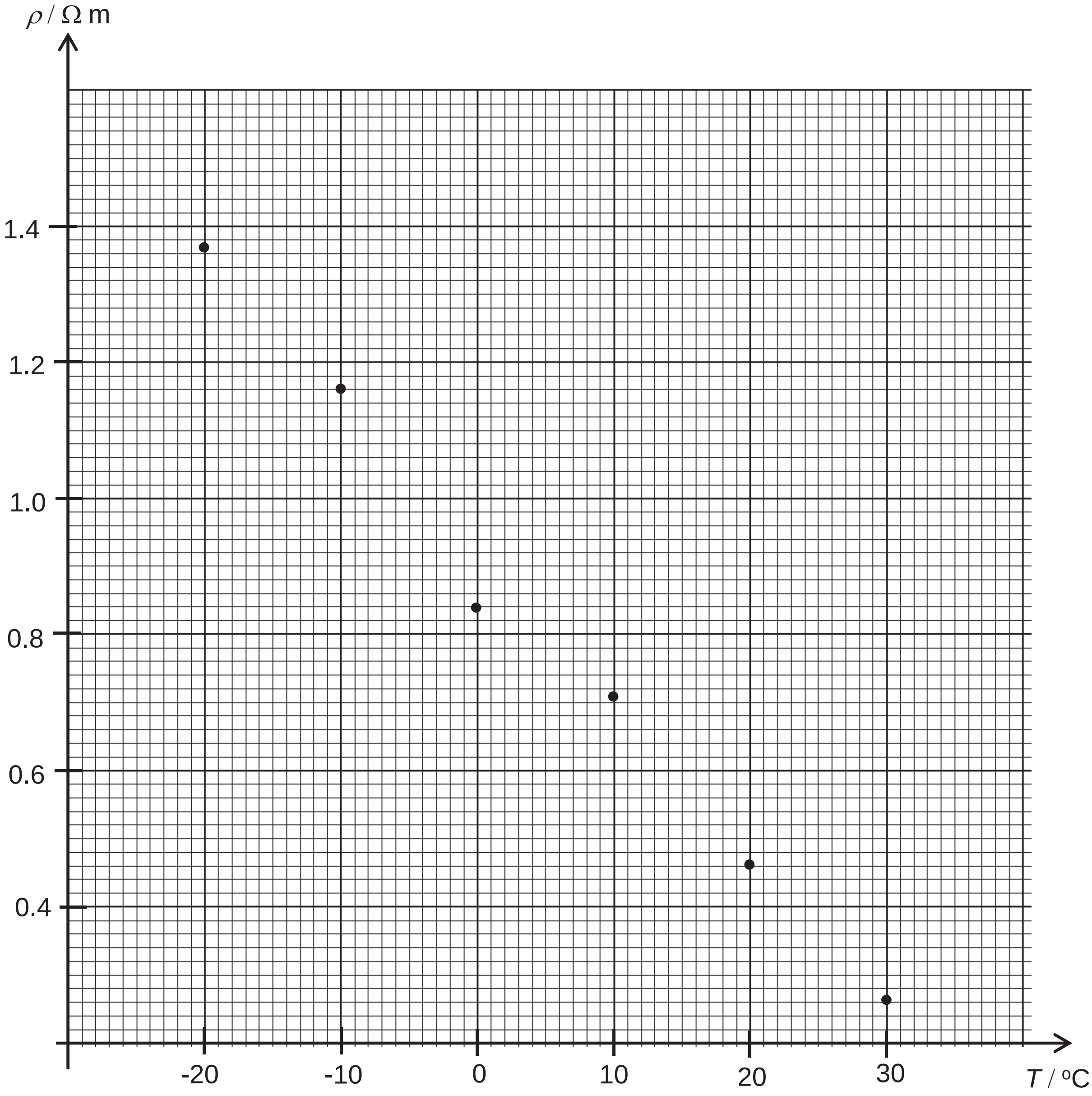


Fig. 8.4

For Examiner's Use

(ii) Use Fig 8.4 to determine the constants ρ_0 and α for germanium.

ρ_0 = ………………………… Ω m

α = ………………………….. $^oC^{-1}$ [4]

(iii) Using your answers from **(ii)**, state and explain whether germanium is a conductor, semiconductor or an insulator.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………..[2]

END OF PAPER

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/03

Paper 3 Longer Structured Questions

20 September 2017

2 hours

Candidates answer on the Question Paper.
No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name in the spaces at the top of this page.
Write in dark blue or black pen on both sides of the paper.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
DO **NOT** WRITE IN ANY BARCODES.

The use of an approved scientific calculator is expected, where appropriate.

Section A
Answer **all** questions.

Section B
Answer any **one** question.

At the end of the examination, fasten all your work securely together.
The number of marks is given in brackets [ ] at the end of each question or part question.

For Examiner's Use	
1	**8**
2	**10**
3	**7**
4	**8**
5	**10**
6	**9**
7	**8**
8	**20**
9	**20**
Total	**80**

This document consists of **25** printed pages and **1** blank page.

Data

speed of light in free space,	c =	3.00×10^{8} m s^{-1}
permeability of free space,	μ_0 =	$4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space,	ε_0 =	8.85×10^{-12} F m^{-1}
		$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge,	e =	1.60×10^{-19} C
the Planck constant,	h =	6.63×10^{-34} J s
unified atomic mass constant,	u =	1.66×10^{-27} kg
rest mass of electron,	m_e =	9.11×10^{-31} kg
rest mass of proton,	m_p =	1.67×10^{-27} kg
molar gas constant,	R =	8.31 J K^{-1} mol^{-1}
the Avogadro constant,	N_A =	6.02×10^{23} mol^{-1}
the Boltzmann constant,	k =	1.38×10^{-23} J K^{-1}
gravitational constant,	G =	6.67×10^{-11} N m^{2} kg^{-2}
acceleration of free fall,	g =	9.81 m s^{-2}

Formulae

uniformly accelerated motion,	$s = ut + \frac{1}{2}at^2$
	$v^2 = u^2 + 2as$
work done on/by a gas,	$W = p\Delta V$
hydrostatic pressure,	$p = \rho gh$
gravitational potential,	$\phi = -Gm/r$
temperature,	$T/\text{K} = T/^{\text{o}}\text{C} + 273.15$
pressure of an ideal gas,	$p = \frac{1}{3}\frac{Nm}{V} < c^2 >$
mean translational kinetic energy of an ideal gas molecule,	$E = \frac{3}{2}kT$
displacement of particle in s.h.m.,	$x = x_0 \sin \omega t$
velocity of particle in s.h.m.,	$v = v_0 \cos \omega t$
	$= \pm\omega\sqrt{\left(x_0^2 - x^2\right)}$
electric current,	$I = Anvq$
resistors in series,	$R = R_1 + R_2 + \ldots$
resistors in parallel,	$1/R = 1/R_1 + 1/R_2 + \ldots$
electric potential,	$V = \frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage,	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire,	$B = \frac{\mu_0 I}{2\pi d}$
magnetic flux denxity due to a flat circular coil,	$B = \frac{\mu_0 NI}{2r}$
magnetic flux density due to a long solenoid,	$B = \mu_0 nI$
radioactive decay,	$x = x_0 \exp(-\lambda t)$
decay constant,	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

Section A

Answer **all** the questions in the spaces provided.

For Examiner's Use

1 A cylindrical container is filled full to the brim with a liquid of density ρ = 8.0 kg m^{-3}. It is placed on a weighing scale and registered a weight W = 100 N. A rigid sphere (which would float on the liquid if allowed to do so) of volume V_s = 0.40 m^3 and mass m_s = 0.50 kg is pushed gently down and held beneath the surface of the liquid with a rigid rod of negligible volume, as shown in Fig. 1.1.

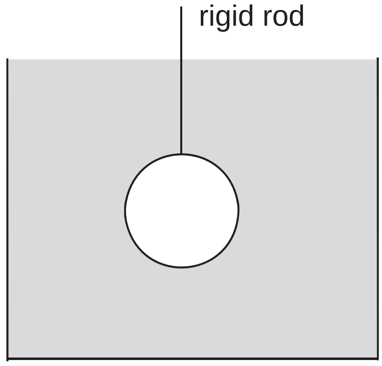


Fig. 1.1

(a) **(i)** Calculate the weight of liquid which overflowed when the sphere is fully submerged in the liquid.

weight = ... N [2]

(ii) Hence determine the reading on the scale.

reading = ... N [2]

(b) If instead of being pushed down by a rod, the sphere is held in place by a thin string attached to the bottom of the container as shown in Fig. 1.2.

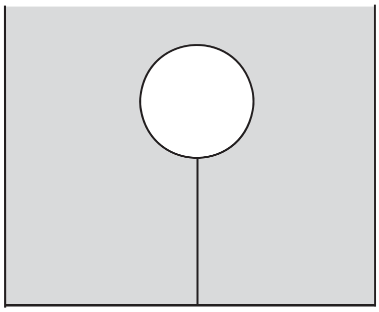


Fig. 1.2

(i) Calculate the tension in the string.

tension = ……………………………………………… N [2]

(ii) Determine the new reading on the scale.

reading = ……………………………………………… N [2]

For Examiner's Use

2 **(a)** Define *gravitational potential*.

....

.... [1]

(b) Explain why values of gravitational potential near to an isolated mass are all negative.

....

....

....

.... [2]

(c) The Earth completes one orbit around the Sun in one year. Saturn takes 29.5 years to complete an orbit around the Sun.
The distance of the Earth from the Sun is 1.50×10^{11} m.

(i) Calculate the distance of the Saturn from the Sun. Assume that both orbits are circular.

distance = ... m [2]

(ii) State the other main assumption you have had to make in order to answer **(c) (i)**.

....

....

.... [1]

(d) The Sun rotates about its axis with a period of 23.4 days. A satellite is placed so that it orbits the Sun with the same angular speed as that of the Sun's rotation.

The mass of the Sun is 1.99×10^{30} kg.

Determine the distance of the satellite from the Sun.

distance = ……... m [2]

(e) It is then required to reposition the satellite at an orbit closer to the Sun than that in **(d)**. State and explain whether the work done on the satellite is positive, negative or zero to change the position of the satellite to a lower orbit.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

For Examiner's Use

3 The volume of some air, assumed to be an ideal gas, in the cylinder of a car engine is 540 cm^3 at a pressure of 1.1×10^5 Pa and a temperature of 27 ^oC. The air is suddenly compressed to a volume of 30 cm^3. The pressure rises to 6.5×10^6 Pa.

(a) Determine the temperature of the gas after the compression.

temperature = ……... ^oC [2]

(b) (i) State the *first law of thermodynamics*.

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [1]

(ii) Use the law in **(b) (i)** to explain why the temperature of the air changed during the compression.

……………………………………………………………………………………………

……………………………………………………………………………………………

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……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [4]

4 **(a)** State the evidence for the assumption that

(i) there are significant forces of attraction between molecules in the solid state,

....

....

.... [1]

(ii) the forces of attraction between molecules in a gas are negligible.

....

....

.... [1]

(b) Explain, on the basis of the kinetic model of gases, the pressure exerted by a gas.

....

....

....

....

....

.... [3]

(c) A cylinder contains 1.0 mol of a monatomic ideal gas.

(i) The volume of the cylinder is constant.
Calculate the energy required to raise the temperature of the gas by 1.0 K.

energy = …….. J [1]

(ii) The volume of the cylinder is now allowed to increase so that the gas remains at constant pressure when it is heated.

Explain whether the energy required to raise the temperature of the gas by 1.0 K is now different from your answer in **(c) (i)**.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

For Examiner's Use

5 **(a)** A metal sphere, A, is connected by a long fine wire to a source of potential of 900 V. An insulated stand supports the sphere sufficiently far above the bench for the effect of the latter to be negligible.

(i) The potential at 300 mm from the centre of the sphere is 450 V. Determine

1. the radius of the sphere,

radius = …….. mm [1]

2. the charge on the sphere.

charge = …….. C [2]

(b) Another identical metal sphere, B, connected to the same source, is similarly supported with its centre 600 mm from that of the first sphere, A, as shown in Fig. 5.1.

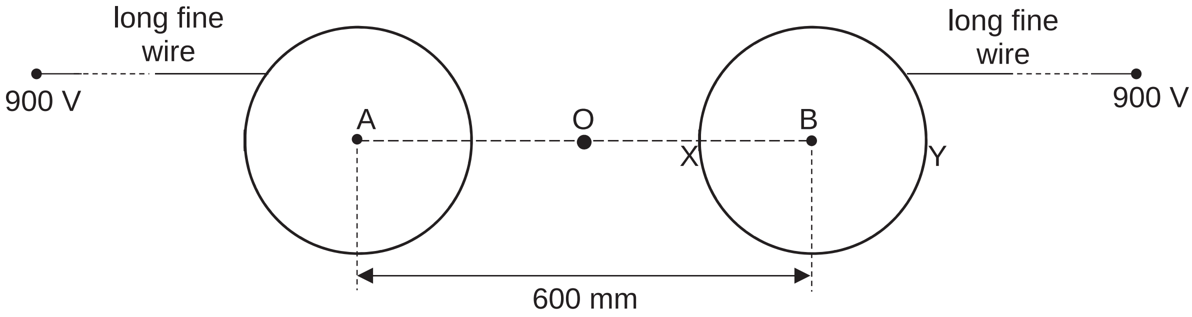


Fig. 5.1

Explain whether the electric potential at O, a point midway between the centres of A and B, is equal to, greater than, or less than 900 V.

....

....

....

.... [2]

(c) Suppose the metal spheres in **(b)** were replaced by insulating spheres which separately had a uniform surface charge density so that the electric potential on the surface of each sphere was 900 V. The spheres are then brought close to each other, as shown in Fig. 5.2. These spheres are no longer connected to any source of charge.

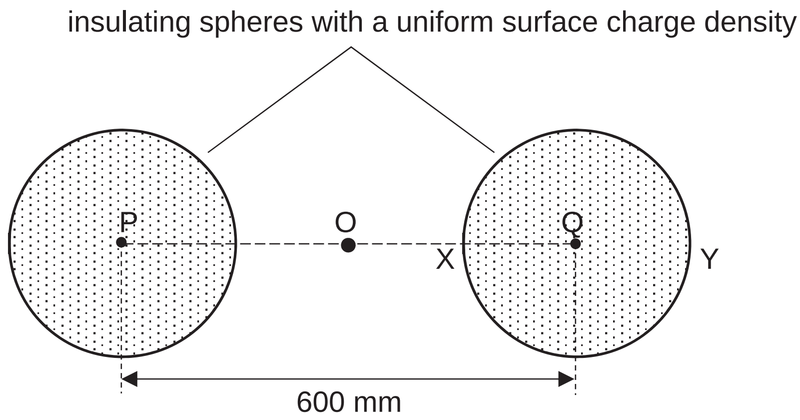


Fig. 5.2

(i) Determine the potential at X and Y on the nearer and far surface of sphere Q.

potential at X = ………... V

potential at Y = ………... V [3]

(ii) Explain if any electric field exists in the sphere Q.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

6 **(a)** Distinguish between the peak value and root-mean-square value of an alternating current.

....

....

....

.... [2]

(b) Express the V_{rms} of the half rectified sinusoidal voltages shown in Fig. 6.1 in terms of V_0.

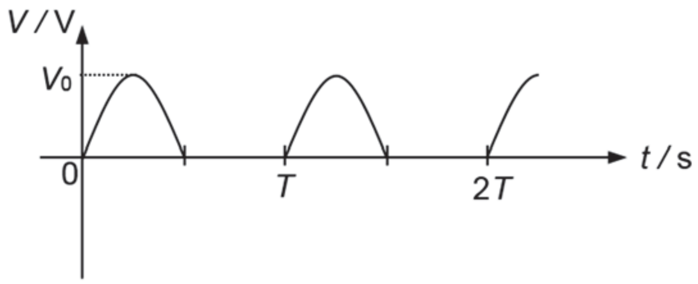


Fig. 6.1

V_{rms} = ... V [2]

(c) A power station needs to deliver 20.0 MW of power to a city 10.0 km away. This power is generated at 16.0 kV and then stepped up to 240 kV using a transformer before transmission. The resistance per unit length of the transmission cables is 20.0 Ω km^{-1}. The operator of the station loses $0.10 for every kWh of electrical power lost.

(i) Calculate the power lost during transmission.

power lost = ... W [2]

For Examiner's Use

(ii) Hence determine the amount of money saved by the station in one day by transmitting power at 240 kV instead of 16.0 kV.

money saved = $…….. [3]

For Examiner's Use

7 **(a)** When free electrons collide with atoms in their ground state, the atoms can be excited or ionised.

(i) State what is meant by *ground state*.

....

....

.... [1]

(ii) Explain the difference between *excitation* and *ionisation*.

....

....

....

....

.... [2]

(b) An atom can also become excited by the absorption of photons. Explain why only photons of certain frequencies cause excitation in a particular atom.

....

....

....

....

....

.... [3]

(c) Fig. 7.1 shows five electron energy levels in an atom and some transitions between them.

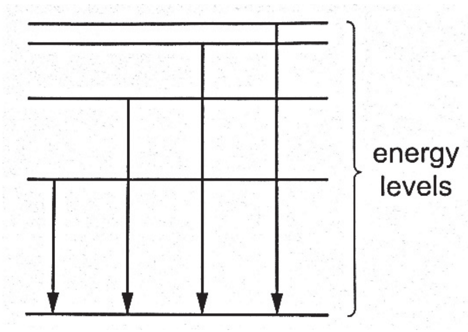


Fig. 7.1

The line spectrum produced is in the visible region of the electromagnetic spectrum.

Sketch on Fig. 7.2 the line emission spectrum corresponds to the four energy level changes, assuming that the energy levels are drawn roughly to scale.

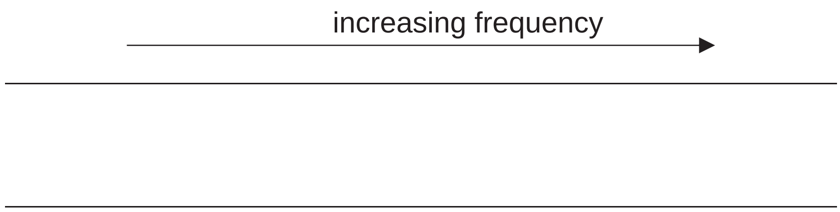


Fig. 7.2

[2]

Section B

Answer **one** question from this Section in the spaces provided.

8 A light spring is suspended from a fixed point. A bar magnet is attached to the end of the spring, as shown in Fig. 8.1.

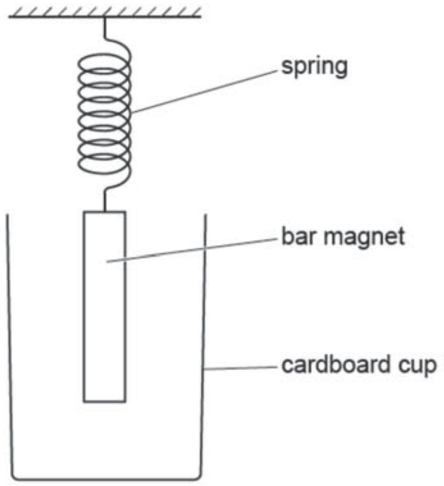


Fig. 8.1

In order to shield the magnet from draughts, a cardboard cup is placed around the magnet but does not touch it. The magnet is displaced vertically and then released. The variation with time t of the vertical displacement y of the magnet is shown in Fig. 8.2.

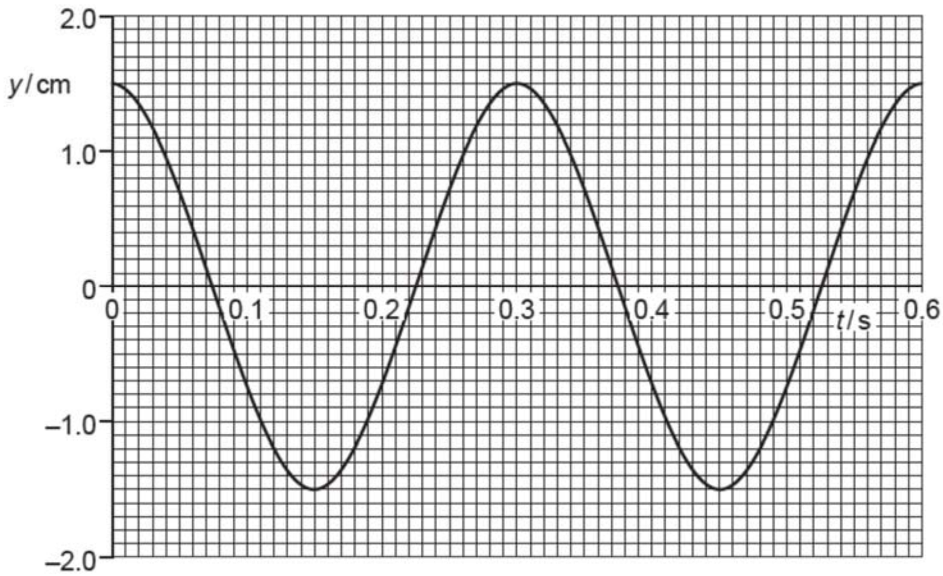


Fig. 8.2

The bar magnet undergoes simple harmonic motion with angular frequency ω.
The mass of the magnet is 130 g.

(a) For the oscillations of the magnet, use Fig. 8.2,

(i) state the times at which the speed of the magnet is maximum.

time = ………………………………………………………… s [1]

(ii) determine the angular frequency ω,

ω = ………………………………………………………… rad s^{-1} [2]

(iii) calculate the maximum potential energy E of the oscillating magnet.

E = ………………………………………………………… J [2]

(iv) Use your answer in **(a)(iii)** to sketch, on the axes of Fig. 8.3, a labelled graph of the variation with displacement y of the potential energy E of the magnet.

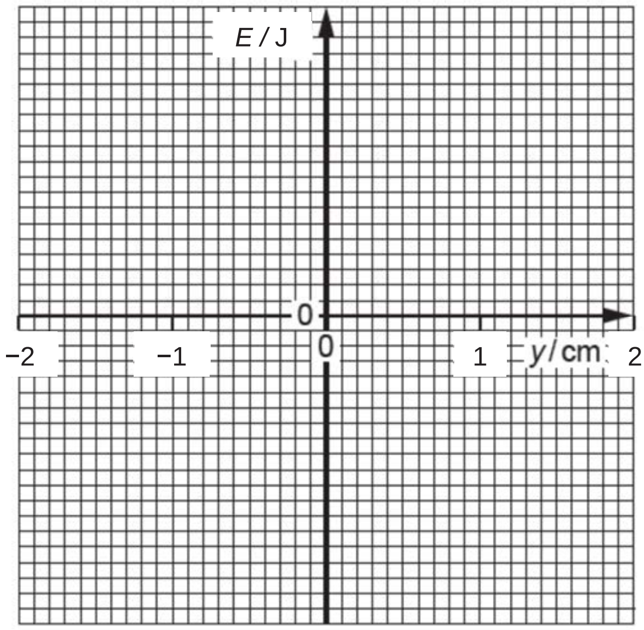


Fig. 8.3

[2]

(b) The spring is now hung vertically to an oscillator.
When the oscillator is switched on, it produces vertical oscillations of constant amplitude but with a frequency that can be varied.

Sketch a labelled graph of the variation with frequency f of the amplitude y_0 of the oscillations of the magnet.

[2]

(c) Archaeologists use an instrument called a geophone, as shown in Fig. 8.4, to detect man-made structures under the ground.

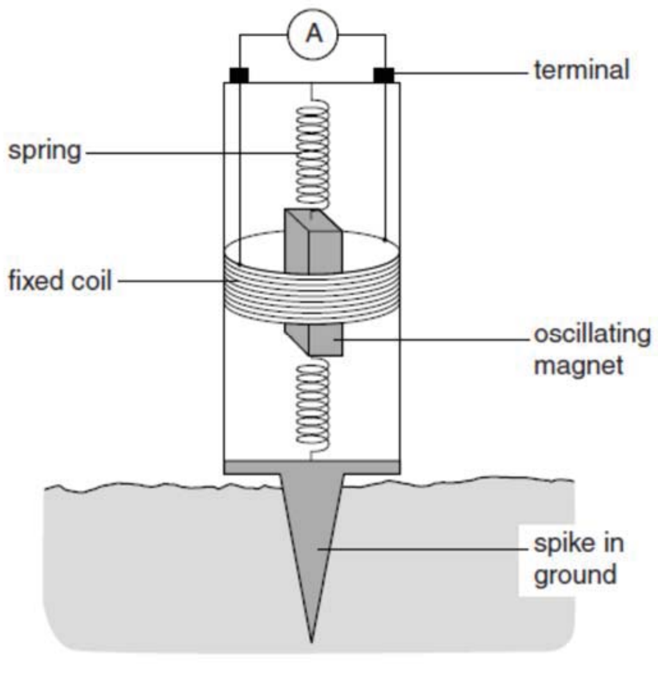


Fig. 8.4

The ground is made to vibrate. The magnet begins to oscillate within the insulated coil of wire fixed to the casing of the geophone. An e.m.f. is induced in the coil, producing a current which is measured by the ammeter.

For Examiner's Use

(i) The coil has 60 turns. The maximum e.m.f. induced in this geophone is 84 mV. Calculate the maximum rate of change of flux linkage in the coil. Give units with your answer.

maximum rate of change of flux linkage = ………... [3]

(ii) The relationship needed to answer part **(c)** **(i)** is a mathematical expression of Faraday's law.

State Faraday's law in words only.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [1]

(iii) Eventually the relative motion of the coil and magnet ceases due to damping. Briefly explain how this damping effect is consistent with Lenz's law.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

………………………………………………………………………………………………… [4]

(d) On the axes of Fig. 8.5, sketch a graph of variation with time *t* of displacement *y* of the magnet for 3 complete oscillations of the damped motion. Numerical values are not required.

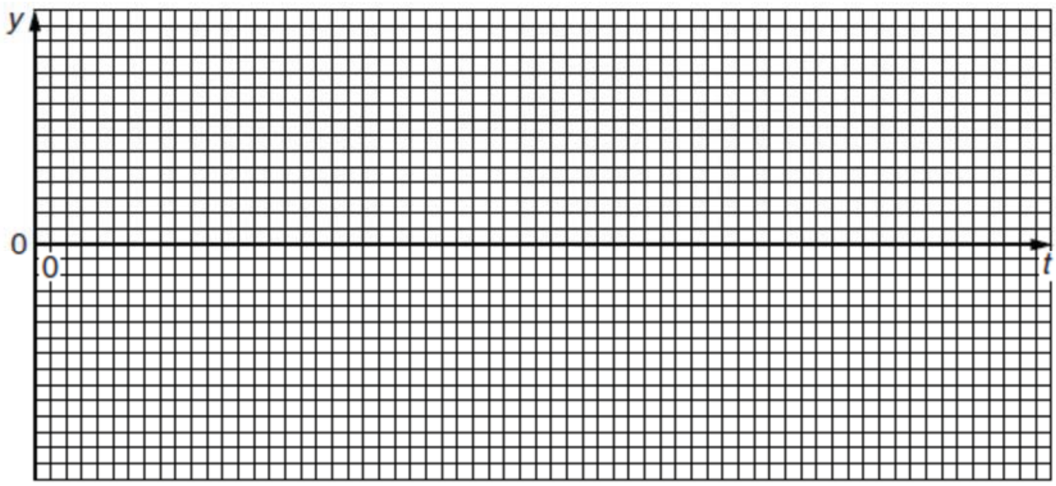


Fig. 8.5

[3]

9 **(a)** Define the *binding energy* of a nucleus.

....

....

.... [2]

(b) A stationary nucleus of uranium-238 ($^{238}_{92}U$) decays to form a nucleus of thorium-234 ($^{234}_{90}Th$). An α-particle and a gamma-ray photon are emitted. The equation representing the decay is

$$^{238}_{92}U \rightarrow \, ^{234}_{90}Th + \, ^{4}_{2}He + \gamma$$

The binding energy per nucleon *E* of the nuclei are given in Fig. 9.1.

nucleus	*E* / MeV
uranium-238	7.570
thorium-234	7.597
helium-4	7.075

Fig. 9.1

(i) State the relationship between the binding energies of the nuclei that is consistent with this reaction being energetically possible.

....

....

.... [1]

(ii) Calculate, for this reaction, the total energy, in J, released.

energy = ... J [2]

For Examiner's Use

(iii) State and explain whether the energy of the gamma-ray photon is equal to the energy released in the reaction.

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

…………………………………………………………………………………………… [2]

(c) When beryllium is bombarded with α-particles of energy 8.0×10^{-13} J, carbon atoms are produced, together with a very penetrating radiation. The nuclear reaction might be

$$^{9}_{4}\mathrm{Be} + {}^{4}_{2}\mathrm{He} \rightarrow {}^{13}_{6}\mathrm{C} + \gamma$$

The energy of the penetrating radiation is found to be at least 8.8×10^{-12} J for each γ produced.

The masses of the nuclei are given in Fig. 9.2.

nucleus	mass / u
$^{9}_{4}\mathrm{Be}$	9.0150
$^{4}_{2}\mathrm{He}$	4.0040
$^{13}_{6}\mathrm{C}$	13.0075

Fig. 9.2

For the nuclear reaction, determine the total energy, in J,

(i) before the nuclear reaction,

energy = ……………………………………………… J [2]

(ii) after the nuclear reaction.

energy = ……………………………………………… J [2]

(iii) Hence, explain why the reaction is not possible.

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [1]

(d) **(i)** The arrival of particles at a Geiger tube from a radioactive substance is said to be random. Describe what '*random*' means in this context.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(ii) A student stated that 'radioactive materials with a short half-life always have a high activity'. Discuss whether the student's statement is valid.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [2]

(iii) Some radioactive nuclides have very long half-lives. For example, Uranium-238 has a half-life of 4.5×10^9 years. Outline an experimental method to determine the half-life of the Uranium-238 nuclide.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

…………………………………………………………………………………………………… [4]

END OF PAPER

Dunman High School Year 6 Prelim Exam 2017 H2 Physics Answers

Paper 1 (/30 marks)

1. B	2. B	3. C	4. C	5. D	6. C	7. C	8. B	9. D	10. D
11. C	12. D	13. B	14. C	15. D	16. D	17. D	18. D	19. C	20. C
21. C	22. A	23. A	24. A	25. D	26. A	27. B	28. B	29. B	30. B

Paper 2 (/80 marks)

1 (a) (i) Weight of monkey and (frictional) force by rope on monkey
Or Weight of monkey and tension of rope on monkey A1

(ii) Monkey climbs up so force by monkey on rope > 20g B1
(Frictionless pulley) tension in the rope is the same on the monkey and on the bananas M1
Bananas move up. A1

(iii) Start at rest with same upwards acceleration, distance is a constant. A1

(b) Bananas slow down at the same rate as that of monkey (same magnitude of force on monkey and bananas). M1
Bananas also come to a complete stop at the same time as that of monkey. A1

2 (a) $E_k = ½ mv^2 = ½ \times 0.40 \times 0.30^2 = 1.8 \times 10^{-2}$ J A1

(b) loss in KE = gain in EPE
$1.8 \times 10^{-2} = ½ \times F \times 0.080$
$F_{MAX} = 0.45$ N A1

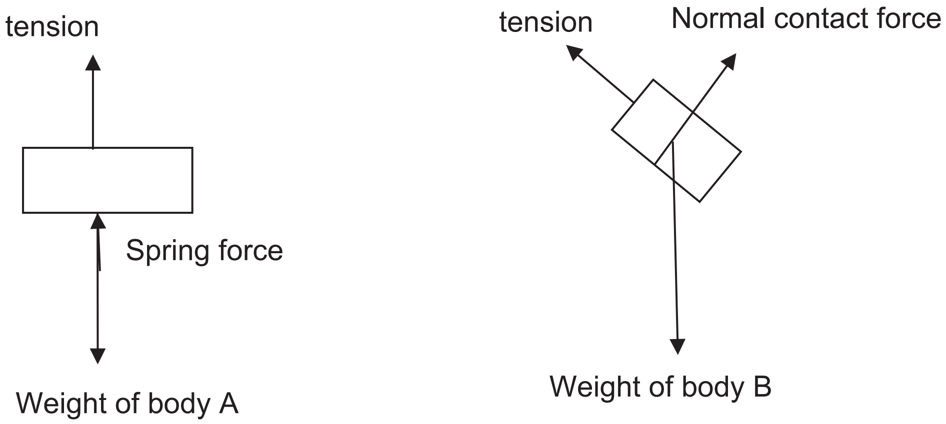
(c) $a = F/m = 0.45 / 0.40 = 1.1$ m s^{-2} A1

(d) Resultant force is not zero (F_{MAX} acting on block), so not in equilibrium. A1

(e) spring constant increases (by 2 times) M1
maximum compression reduces (is now 5.7 cm) A1

(f) Curved line from origin, B1
With decreasing gradient (no plateau) B1

3 (a)



For the two free bodies each:
Correct label of all forces B1
Correct magnitude shown in the length drawn for all forces B1 Total: 4 marks

(b) Restoring Force, $F_{restoring}$ = $-kx$ = $-200x$ M1

Consider body A and body B as one system,

$F_{net} = F_{restoring} = -200x = (m_A + m_B)a$ M1

$a = -200x/(m_A + m_B) = -200x/(6.5 + 9.5) = -12.5x$ A0

(c)

$$v = \omega\sqrt{x_0^2 - x^2}$$
$$v = \sqrt{12.5}\sqrt{0.020^2 - 0.010^2}$$
$$= 0.0612 \text{ ms}^{-1}$$ A1

4 (a) (i) transverse wave has vibrations perpendicular/normal to direction of energy travel B1
longitudinal wave has vibrations parallel to the direction of energy travel B1
accept answers in terms of a diagram

(ii) polarised with all vibrations in a single axis / direction
(normal to direction of energy travel) B1
non-polarised with vibrations in all directions B1
a diagram here must have at least three doubled headed arrows.

(iii) progressive: all particles have same amplitude
stationary: maximum (antinode) to minimum/zero amplitude (node) B1
progressive: adjacent particles are not in phase
stationary: wave particles are in phase (between adjacent nodes) B1
progressive: transfer energy
stationary: do not transfer energy B1
(max 2 marks)

(b) (i)

	red / °	green / °
0	0	0
1	23.6	19.0
2	53	40.5
3	–	77.2

all correct 2 marks
1 wrong, 1 mark.
More than 1 wrong, 0 mark

(b) (ii) One side correct (GRGRG) B1
Same on both sides B1

(iii) Fuzzy pattern instead of sharp B1
Any two from: B2
Red bands wider than green bands
Red bands wider apart than green bands
Some yellow bands where they overlap
Equally spaced maxima/minima/fringes

5(a) (i) $Q = It = (6.0)(200) = 1200\text{ C}$ B1

(ii) $N = Q/e = 1200/(1.60\times10^{-19}) = 7.5\times10^{21}$ B1

(b)

Let the voltmeter resistance be R_V.

When the sliding contact P was at Y, potential divider rule gives:

$$\left(\frac{R_V}{R_V+1000}\right)(12\text{ V}) = 11\text{ V}$$ B1

$\Rightarrow R_V = 11\text{ k}\Omega$ A1

OR

Current through XY $= 1/1000$ A. B1

$$R_V = \frac{11}{1/1000} = 11\text{ k}\Omega$$ A1

(c) (i)

$I_V = 3\text{ V}/11\text{ k}\Omega$

$= 0.27\text{ mA}$ A1

(ii) Position of slider has to be such that $\frac{PY}{XY} = \frac{3\text{ V}}{12\text{ V}} = \frac{1}{4}$ C1

Sliding contact would have been moved down 3/4 of its length from X. B1

(iii) resistance of lamp = $V^2/P = (3.0)^2/0.60 = 15\ \Omega$

effective resistance across AB, $R_{AB} = \dfrac{15 \times 250}{15 + 250} = \underline{14.2\ \Omega}$ B1

p.d. across AB, $V_{AB} = (12)\left(\dfrac{R_{AB}}{R_{AB} + 750}\right) = \underline{0.222\ \text{V}}$ B1

power delivered to the lamp $= \dfrac{{V_{AB}}^2}{15\ \Omega} = \underline{0.0033\ \text{W}}$ M1

[OR

current from power supply, $I = \dfrac{12}{(750 + R_{AB})} = 0.0157$ A,

current through lamp, $I_{lamp} = I\left(\dfrac{250}{250 + 15}\right) = 0.0157\left(\dfrac{250}{250 + 15}\right) = \underline{0.0148\ \text{A}}$, B1

power delivered to the lamp $= I_{lamp}V_{AB}$ or ${I_{lamp}}^2(15) = \underline{0.0033\ \text{W}}$ M1]

This is only 0.55% of 0.6 W. Since this is much lower than 0.6 W, its brightness is very low. A1

6 (a) (i)

$$Bqv = \frac{mv^2}{r}$$

$$r = \frac{mv}{eB} = \frac{(9.11x10^{-31})(1.55x10^{6})}{(1.6x10^{-19})(0.45x10^{-3})}$$ M1

$= 1.96\text{x } 10^{-2}$ m A1

$$T = \frac{2\pi r}{v}$$

$$= \frac{2\pi(1.96x10^{-2})}{(1.55x10^{6})}$$

$= 7.95 \text{ x } 10^{-8}$ s A1

(ii) Distance traveled $= (1.55 \text{ x } 10^{6})\cos 30^0 (7.95 \text{ x } 10^{-8})$ M1

$= 0.107$ m A1

(b) The north pole of the magnet indicates the direction of the Earth's magnetic field which points at an angle of 5^0 below the horizontal.

Vertical component of Earth's magnetic field, *B* downwards

$= 0.17x10^{-3}\sin 5^o$

$= 1.48 \text{ x } 10^{-5}\ T$ C1

To orientate the magnet horizontally, the magnetic field due to the wire must neutralise the downward field due to the Earth.

$$B = \frac{\mu_o I}{2\pi r} = \frac{4\pi x 10^{-7} I}{2\pi(5.0x10^{-2})} = 1.48 \text{ x } 10^{-5}\ T \quad = 3.7 \text{ A} \qquad \text{M1}$$

in the north-south direction A1

7 (a) No. of electrons leaving 9th dynode = 6^9 = 1.01 x 10^7 ------------------[B1]

Rate at which photoelectrons are collected at 9th dynode to produce 6.3 μA,

$$\left(\frac{dn}{dt}\right)_{collected} = \frac{6.3\times10^{-6}}{1.6\times10^{-19}} = 3.9375\times10^{13}\ s^{-1}$$ ---------------------------[B1]

Rate at which photoelectrons are ejected from cathode,

$$\left(\frac{dn}{dt}\right)_{ejected} = \frac{3.9375\times10^{13}}{1.01\times10^{7}} = 3.9\times10^{6}\ s^{-1}\ \text{(shown)}$$ ------------------[B1]

(b) Rate at which photons are incident on cathode,

$\frac{N_{photon}}{t}$ = 3 x Rate at which photoelectrons are ejected C1

= 3 (3.9 x 10^6)

= 1.17 x 10^7 s^{-1}

$$P = \frac{N_{photon} h \,c/\lambda}{t} = \frac{1.17 \text{ x } 10^7 \times 6.63 \text{ x } 10^{-34} \times 3.0 \text{ x } 10^8}{400 \text{ x } 10^{-9}} \qquad \text{M1}$$

$= 5.82 \text{ x } 10^{-12}$ W A1

8 (a)

The resistance R of a conductor is defined as the **ratio** $\frac{V}{I}$ where V is the potential difference across the conductor and I is the current flowing through it. -----------------[B1]

Resistivity is a relationship between the dimensions of a specimen of a material and its resistance that is constant at constant temperature and determined by ρ = $\frac{RA}{L}$ where *R* is resistance, *A* is cross-sectional area and *L* is length. ----------------------------[B1]

Resistance is a property of the sample (depends on the dimensions of the sample) whereas resistivity relates to the material. --[B1]

(b) lattice vibrations increases ----------------- [M1]
Resulting in lower drift velocity of the charge carriers (electrons) ---------------------[A1]

(c) (i) 3.27 x 10^{-8} Ωm -----[A1]
(ii) 8.12 x 10^{-8} Ωm -----[A1]

(d) (i) The 2 wires are in series, thus effective resistance adds up.
Resistance

$$= R_{gold,120\deg} + R_{tungsten,120\deg}$$

$$= \frac{(3.27\times10^{-8})(0.050)}{\pi(\frac{0.240\times10^{-3}}{2})^2} + \frac{(8.12\times10^{-8})(0.050)}{\pi(\frac{0.140\times10^{-3}}{2})^2}$$ ----[M2, A1]

$$= 0.03614 + 0.26374 = 0.300\Omega$$

(d)(ii) The 2 wires are in parallel,

$$R = (1/R_{gold,120\deg} + 1/R_{tungsten,120\deg})^{-1}$$

$$= (\frac{1}{0.03614} + \frac{1}{0.26374})^{-1} = 0.0318\Omega$$ -----[M1,A1]

(e) Material X is more suitable, as it has a larger resistivity. Thus for the same resistance in the heating element, a shorter length of X is required compared to Y.
OR
Material X is a more suitable material. It has a much smaller temperature coefficient of resistivity α than material Y. The resistance of X and hence the power output will be relatively more constant compared to Y during heating. ---[B1]

(f) (i) best fit line drawn and anomalous point identified correctly. -----[B1]

(ii) linearising equation and deriving expressions that equate gradient and y-intercept [C1]
gradient calculated correctly. Read offs must be accurate to half a small square. [C1]
ρ_0 = (0.4 to 0.6) Ω m [A1]
α = -(0.04 to 0.06) °C^{-1} [A1]

(iii) A negative temperature coefficient of resistivity indicates that the resistivity of Germanium decreases with increasing temperature. [M1]
Germanium is a semiconductor. [A1]

Paper 3 (/80 marks)

1 (a) (i) Weight of liquid overflowed = density of liquid x volume of liquid overflowed x g
= ρ V_s g C1
= 8.0 x 0.40 x 9.81 = 31.4 N = 31 N A1

(ii) Upthrust (force by liquid on sphere) = 31N
Based on Newton's Third Law, |Force by sphere on liquid| = |Upthrust| = 31N

By considering the liquid as a free body, reading on the scale is W'
W' = Original weight of fluid – weight of liquid overflowed
+ force by sphere on liquid C1
$= W - \rho V_s g + \rho V_s g$
= W = 100 N A1

(b) (i) $T + m_s g = U$ C1
$T = \rho V_s g - m_s g$
= 31.4 – 0.5(9.81) = 26.48 N = 26 N (↓) A1

(ii) By considering the [sphere + liquid] as a free body, the new reading on the scale is W''
W'' = Original weight of liquid – weight of liquid overflowed
+ weight of sphere C1
$= W - \rho V_s g + m_s g$
= 100 – 31.4 + 0.5(9.81) = 73.5 = 74 N A1

2 (a) Work done per unit mass in bringing a small test mass from infinity to that point B1
(b) Forces are attractive and potential is zero at infinity M1
Work got out in moving to that point A1

(c) (i) $\frac{GMm}{r^2} = mrw^2$
$\rightarrow r^3 \propto T^2$
$\frac{r^3}{(1.50\times10^{11})^3} = \frac{29.5^2}{1^2}$ C1
$r = 1.43 \text{ X } 10^{12}$ m A1

(ii) Gravitational forces by other planets on Earth or Saturn are negligible compared to that by Sun. B1
Or Saturn and Earth are considered as point masses

(d) $\frac{GMm}{r^2} = mrw^2$
$\frac{(6.67\times10^{-11})(1.99\times10^{30})}{r^2} = r\left(\frac{2\pi}{23.4\times24\times60\times60}\right)^2$ C1
$r = 2.40 \text{ X } 10^{10}$ m A1

(e) Changing satellite to a lower orbit, the gain in KE is less than the loss in PE
Or Total Energy (TE) decreases M1
So negative work done on satellite A1

3 (a) *pV/T* = constant
T = (6.5 x 10^6 x 30 x 300) / (1.1 x 10^5 x 540)

= 985 K -------------------[C1]
= 712 °C -------------------[A1]

(b)(i) The increase in the internal energy of a system is equal to the sum of the heat supplied to the system and the external work done on the system. [B1]

(ii) *q* is zero. --[B1]
W is positive and *U* increases. --[B1]
U increases is rise in KE of atoms since gas is ideal. ----------------------[M1]
Mean KE increases, hence T increases. ------------------------------------[A1]
(allow only one of the last 2 marks if states "U increases so T rises")

4 (a) (i) solid has fixed volume / fixed shape/ incompressible. ----------------[B1]
(ii) gas fills any space into which it is put / compressible. ---------------[B1]

(b) atoms have collisions with the walls, hence momentum of atom changes. ----[B1]
so impulse (on wall) / force on wall --[B1]
random motion / many collisions (per unit time) gives rise to force / pressure. ----[B1]

(c) (i) 12.5 J -------------------------------[A1]

(ii) energy is needed to push back atmosphere /do work against atmosphere ---[M1]
So total energy required is greater --[A1]

5 (a) (i) 1. $V \propto \frac{1}{r} \Rightarrow (900)R = (450)(300) \Rightarrow R = 150 \text{ mm}$ B1

2.

$900 = \frac{1}{4\pi\varepsilon_0}\frac{Q}{(150 \text{ mm})}$ C1

$\Rightarrow Q = 1.5 \times 10^{-8} \text{ C}$ A1

(b) less than 900 V B1
mutual repulsion displaces the charges toward the outer sides of the spheres
effective separation of the charges increases B1

(c)(i)

potential at X or Y = potential due to P + potential due to Q C1

$V_X = \frac{900 \times 150}{450} + 900 = 1200 \text{ V}$ B1

$V_Y = \frac{900 \times 150}{750} + 900 \quad 1080 \text{ V}$ B1

(ii) yes B1
there is an electric potential gradient B1

6 (a) Peak value is the amplitude of the a.c. signal. B1

Root mean square value of an alternating current is equivalent to the steady direct current which dissipates heat at the same average rate in a given resistor. B1

(b) $V_{rms} = \sqrt{<V^2>} = \sqrt{\frac{1}{2}(\frac{V_0^{\ 2}}{2})}$ C1

$= \frac{V_0}{2}$ C1

(c)(i)

$P_{loss} = I^2 R = \left(\frac{20.0 \times 10^6}{240 \times 10^3}\right)^2 \times 20.0 \times 10$ M1

$= 1.39 \times 10^6$ W A1

(ii) $P_{loss} = I^2 R = \left(\frac{20.0 \times 10^6}{16 \times 10^3}\right)^2 \times 20.0 \times 10 = 3.13 \times 10^7$ W M1

Money saved $= (3.13 \times 10^8 - 1.39 \times 10^6) \times 10^{-3} \times 24 \times 0.10$ M1

$= \$747000$ A1

7 (a) (i) when electrons/atoms are in their lowest energy/minimum energy/most stable (state) B1

(ii) excitation promotes an electron to a higher energy level. B1
ionization occurs when an electron receives enough energy to leave the atom. B1

(b) electrons occupy discrete energy levels / difference in energy levels are discrete. B1
energy of photon is proportional to frequency (E = hf) B1
atom/electron can be excited only when energy of photon exactly matches the difference in energy levels (1 to 1 interaction/ all energy of photon absorbed) B1

(c) 4 lines drawn. M1
Correct spacing. A1

8 (a) (i) 0.075s, 0.225s, 0.375s, 0.525s A1

(ii) $\omega = 2\pi / 0.30$ M1
$= 20.9$ rad s^{-1} A1

(iii) maximum potential energy $= \frac{1}{2}m\omega^2 y_0^{\ 2}$
$= \frac{1}{2} \times 0.130 \times 20.9^2 \times (1.5 \times 10^{-2})^2$ M1
$= 6.4 \times 10^{-3}$ J A1

(iv) Correct shape B1
Correct values of max P.E and amplitude B1

(b) Correct values of amplitude and resonant frequency B1
Correct shape B1

(c) (i)

$$E = -\frac{dN\phi}{dt} \quad \text{M1}$$

$$\frac{dN\phi}{dt} = 84 \text{ x } 10^{-3} \text{ V} \quad \text{A1} \quad \text{C1 for correct unit}$$

(ii) The induced e.m.f is directly proportional to the rate of change of magnetic flux linkage. B1

(ii) Lenz's law is a consequence of law of conservation of energy B1
Magnetic field created by induced current in coil repels permanent magnetic field B1
Work has to be done to move the magnet through the coil because it is repelled B1
This energy is converted to electrical energy dissipated in the coil's complete circuit B1

(d) 3 complete oscillations drawn B1
Period kept constant (slight increase acceptable) B1
Reasonably symmetrical and continuous steady decrease in amplitude B1

9 (a) *either*
(minimum) energy required / work done to separate the nucleons (in a nucleus) M1
to infinity A1
or
energy released when nucleons come together (to form a nucleus) (M1)
from infinity (A1)

(b) (i) (total) binding energy of thorium and helium (nuclei) greater than binding energy of uranium (nucleus) B1

(ii) $7.597 \times 234 + 7.075 \times 4 - 7.570 \times 238 = 4.338$ MeV B1

$4.338 \times 10^{6} \times 1.60 \times 10^{-19}$ J = $\underline{6.941 \times 10^{-13}\text{ J}}$ A1

(iii) Th nucleus / He nucleus / product nucleus has kinetic energy M1
energy of gamma photon must be less than energy released A1

(c) (i) $(9.0150 + 4.0040) \times 1.66 \times 10^{-27} \times (3.00 \times 10^{8})^{2} + 8.0 \times 10^{-13}$ J B1
$= \underline{1.946 \times 10^{-9}\text{ J}}$ A1

(ii) $13.0075 \times 1.66\times10^{-27} \times (3.00\times10^{8})^2 + 8.8\times10^{-12}$ B1

$= \underline{1.952\times10^{-9}\ \text{J}}$ A1

(iii) the total energy after the nuclear reaction is greater than that before the reaction (violation of conservation of energy) B1

(d) **(i)** in each second there is a fixed probability that a particle will arrive, [B1]
but time of arrival of a particle cannot be predicted [B1]

(ii) $A = \left(\dfrac{\ln 2}{t_{1/2}}\right)N$: activity proportional to the number of unstable/undecayed nuclei present B1
short half-life radioactive material having low number of unstable nuclei can have low activity B1

(iii) <u>determine the number of atoms *N*</u> in a pure sample from the measured mass of the sample (using weighing machine) B1

use a GM tube, with effective window area *S* at a distance *x* from source, connected to a rate meter to <u>measure the count rate *C*</u> B1

<u>calculate the activity</u> $A = (4\pi x^2/S)\,C$ B1

determine decay constant λ from $A = \lambda N$,
and then determine half-life $t_{1/2}$ using equation $t_{1/2} = (\ln 2)/\lambda$ B1