DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME			
CLASS		INDEX NUMBER	

PHYSICS

9749/01

Paper 1 Multiple Choice

September 2020

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 **20** 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	=	$-\frac{Gm}{r}$
temperature	T/K	=	T/°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	=	$v_0 \cos \omega t$
		=	$\pm \omega \sqrt{x_0^2 - x^2}$
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	=	$\frac{Q}{4\pi\varepsilon_0 r}$
alternating current / voltage	x	=	$x_0 \sin \omega t$
magnetic flux density due to a long straight wire	B	=	$\frac{\mu_o I}{2\pi d}$
magnetic flux denxity due to a flat circular coil	B	=	$\frac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	B	=	$\mu_o nI$
radioactive decay	x	=	$x_0 \exp(-\lambda t)$
decay constant	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

1 The relation between the energy E of a photon and its wavelength λ is

$$E = \frac{K}{\lambda}$$

where K is a constant.

When E is measured in electronvolts and λ in nanometres, what is the numerical value of K?

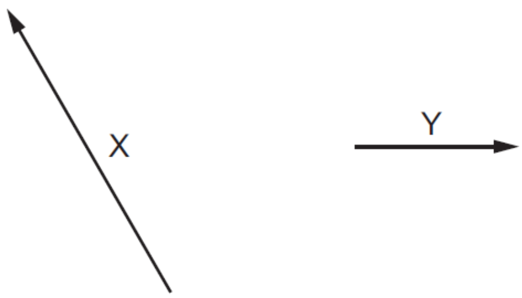
A 3.18×10^{-53}

B 3.18×10^{-35}

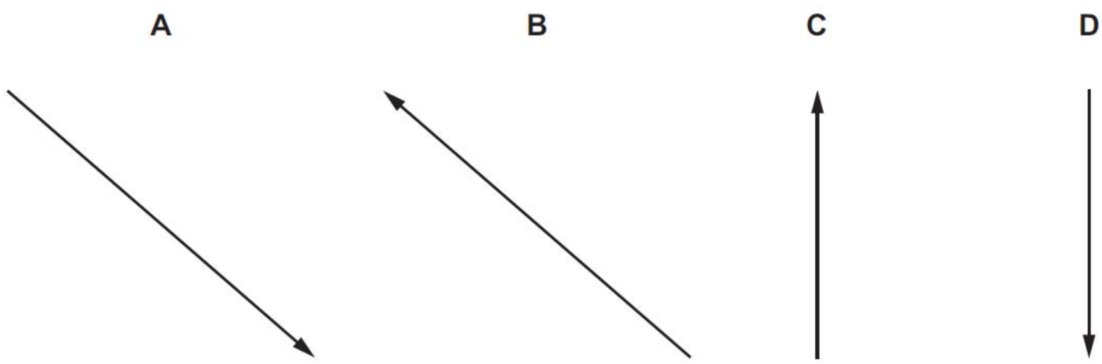
C 1.24×10^{-1}

D 1.24×10^{3}

2 The diagram shows two vectors X and Y, drawn to scale.



If X = Y – Z, which diagram best represents the vector Z?



3 A metal ball is dropped from rest over a bed of sand. It hits the sand bed one second later and makes an impression of maximum depth 8.0 mm in the sand.

Air resistance is negligible.

On hitting the sand, what is the average deceleration of the ball?

A 6.0×10^2 m s^{-2}

B 1.2×10^3 m s^{-2}

C 6.0×10^3 m s^{-2}

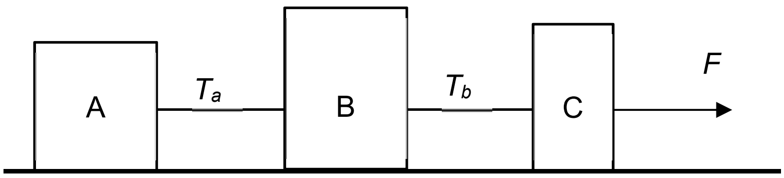
D 1.2×10^4 m s^{-2}

4 An elevator is moving downwards with an acceleration of 5.8 m s^{-2}. A ball, held 2.0 m above the floor of the elevator and at rest with respect to the elevator, is released.

How long does it take for the ball to reach the floor of the elevator?

A 0.51 s **B** 0.64 s **C** 0.83 s **D** 1.00 s

5 A force F is applied to pull three objects A, B and C across a frictionless horizontal surface. The three objects are connected by the strings as shown in the figure. The tensions in the strings between A and B is T_a and that between B and C is T_b.



A part of object B is chipped off such that the mass of object B is smaller. The force F remains unchanged and continues to pull the three objects. What are the changes to the tensions T_a and T_b in the strings?

A T_a increases and T_b decreases.

B T_a increases and T_b increases.

C T_a decreases and T_b decreases.

D T_a decreases and T_b increases.

6 Under which of the following conditions can a ladder standing on a frictionless horizontal floor and leaning against a rough vertical wall be in equilibrium?

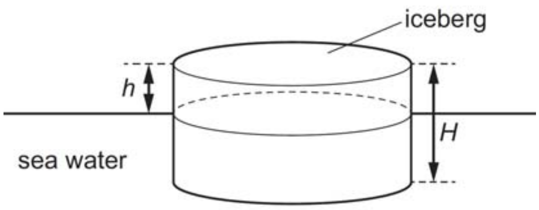
A The normal force exerted by the floor on the ladder equals the normal force the wall exerts on the ladder.

B The weight of the ladder is equal in magnitude to the frictional force the wall exerts on the ladder.

C Sum of the normal force exerted by the floor on the ladder and the frictional force the wall exerts on the ladder equals the weight of the ladder.

D A ladder in this situation cannot be in equilibrium.

7 A cylindrical iceberg of height H floats in sea water. The top of the iceberg is at height h above the surface of the water.

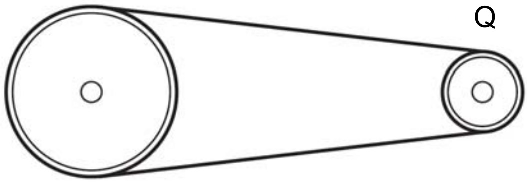


The density of ice is ρ_i and the density of sea water is ρ_w.

What is the height h of the iceberg above the sea water?

A $\left(1-\frac{\rho_i}{\rho_w}\right)H$ **B** $\left(\frac{\rho_i}{\rho_w}-1\right)H$ **C** $\frac{\rho_w}{\rho_i}H$ **D** $\frac{\rho_i}{\rho_w}H$

8 The diagram shows two pulley wheels connected by a belt.



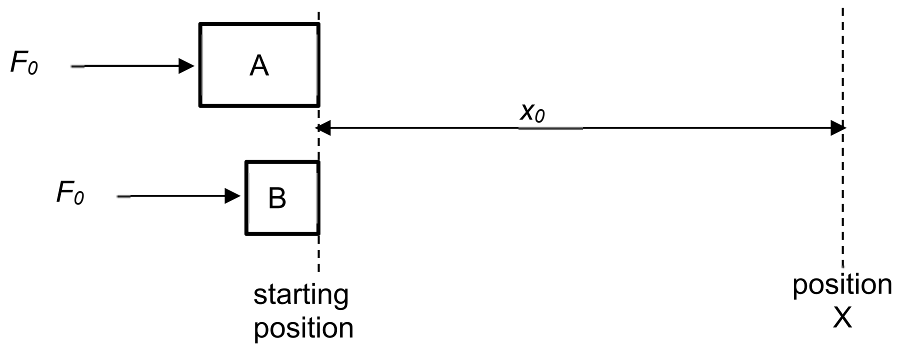
Wheel Q is driven by a motor and rotates clockwise at a constant rate. Wheel Q puts tension in the top portion of the belt, which in turn drives the wheel P. The lower portion of the belt is slack and has no tension. The weight of the belt and frictional forces are negligible.

The diameter of P is 150 mm. The diameter of Q is 100 mm. The torque applied to Q is 3.0 N m.

What is the tension in the belt and the torque on wheel P?

	tension in top of belt / N	torque on wheel P / N m
A	20	2.0
B	40	2.0
C	20	3.0
D	60	4.5

9 Carts A and B are initially at rest on a frictionless, horizontal surface. A constant force F_0 is applied to each cart as it travels from its starting position as shown in the figure. The mass of cart A is more than the mass of cart B.



Consider the kinetic energy E, and momentum p, of the carts at position X, a distance x_0 from the starting position. Subscripts A and B denote cart A and B respectively.

Which of the following is correct?

A $E_A < E_B$ and $p_A < p_B$

B $E_A < E_B$ and $p_A = p_B$

C $E_A = E_B$ and $p_A = p_B$

D $E_A = E_B$ and $p_A > p_B$

10 Trains supply coal to a power station. The table shows quantities describing the operation of the power station.

	symbol	unit
power station average output	P	W
number of trains per day	N	
mass of coal on a train	M	kg
energy from 1 kg of coal	E	J
number of seconds in one day	S	

Which expression gives the efficiency of the power station?

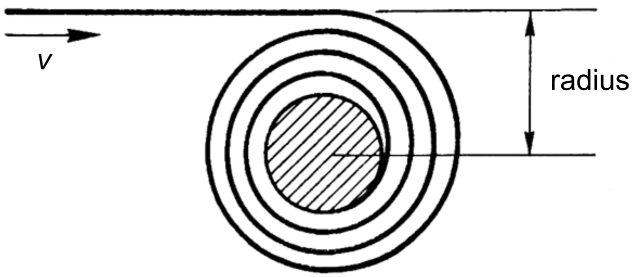
A $\frac{PS}{NME}$

B $\frac{PSN}{ME}$

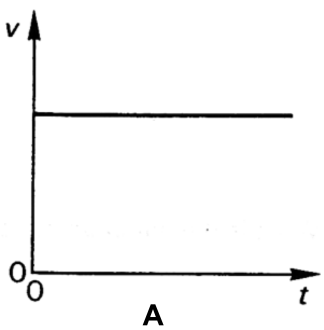
C $\frac{NME}{PS}$

D $\frac{NM}{PSE}$

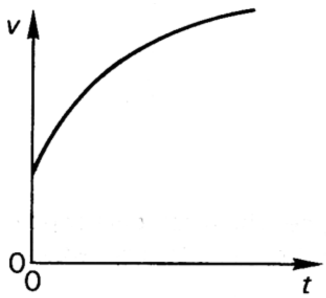
11 A straight length of tape winds on to a roll rotating about a fixed axis with constant angular velocity, the radius of the roll increasing at a steady rate.



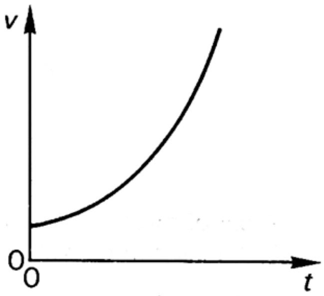
Which one of the graphs below correctly shows how the speed v at which the tape moves towards the roll varies with time?



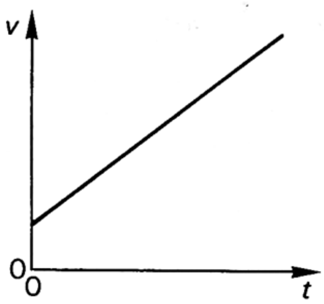
A



B



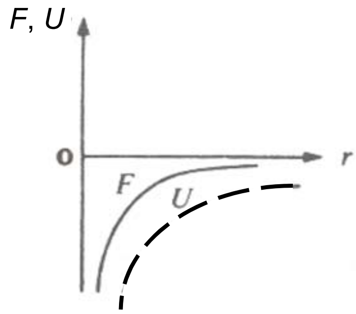
C



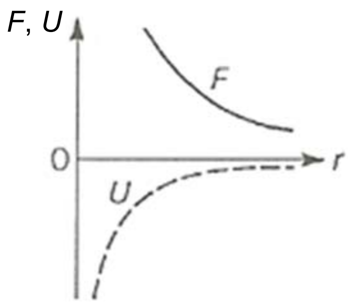
D

12 Which one of the following diagrams shows the variation of gravitational force F on a point mass and gravitational potential energy U of the mass at a distance r from another point mass?

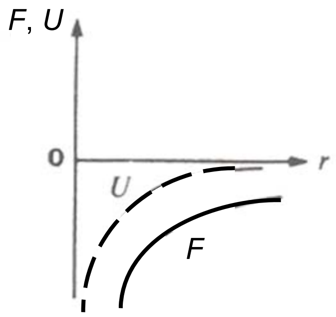
A



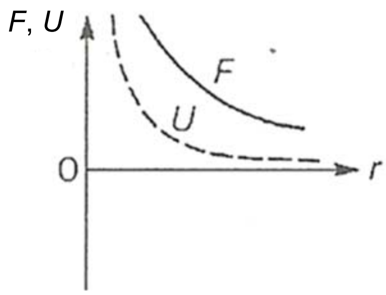
B



C



D



13 Two planets of masses M_1 and M_2 are a distance d apart. There is a point, lying on the line joining the planets, with zero gravitational field strength.

What is the distance of this point from M_1?

A $d\left(\frac{M_2}{M_1}\right)$

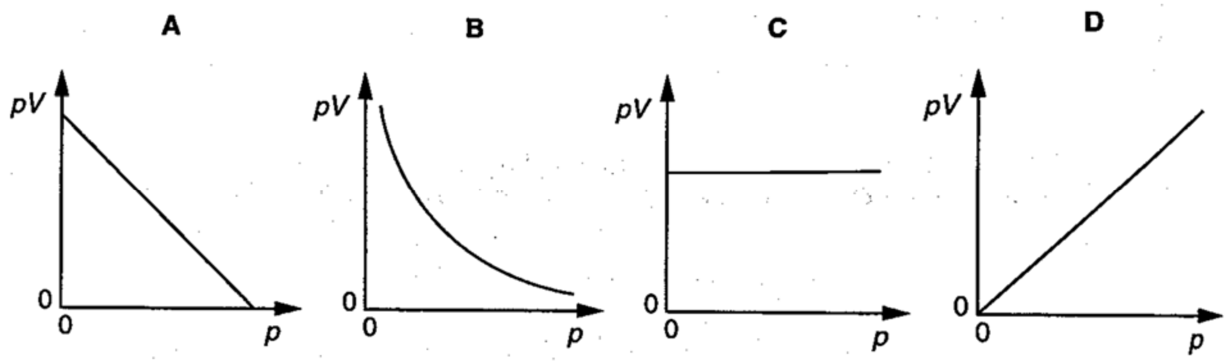
B $d\sqrt{\left(\frac{M_1}{M_2}\right)}$

C $d\sqrt{\left(\frac{M_1}{M_1+M_2}\right)}$

D $d\left(\frac{\sqrt{M_1}}{\sqrt{M_1}+\sqrt{M_2}}\right)$

14 In an experiment to investigate the relationship between the volume V of a fixed mass of an ideal gas and its pressure p, a graph of pV against p is plotted.

Which graph shows the correct relationship at constant temperature?



15 Latent heat of vaporization is the energy required to

A separate the molecules of the liquid.

B force back the atmosphere to make space for the vapour.

C separate the molecules and to force back the atmosphere.

D separate the molecules and to increase their average molecular speed to that in the gas phase.

16 The displacement x at time t of a molecule undergoing simple harmonic motion in a sound wave is given by

$$x = x_0 \sin 2\pi ft$$

where x_0 = 0.32 mm and f = 10 000 Hz.

What is the maximum acceleration of the molecule?

A 2.01×10^1 m s^{-2}

B 2.01×10^4 m s^{-2}

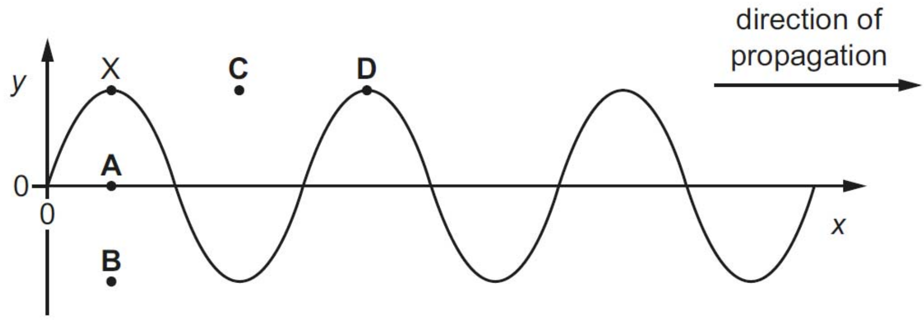
C 1.26×10^6 m s^{-2}

D 1.26×10^9 m s^{-2}

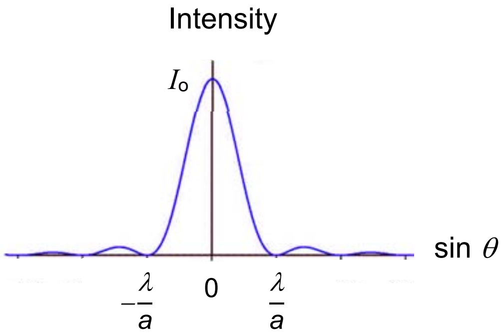
17 The variation with distance *x* of the displacement *y* of a transverse wave on a rope is shown at time $t = 0$. The wave has a frequency of 0.5 Hz.

A point X on the rope is marked. The diagram shows the original position of X and four new positions.

What is the position of X at time $t = 1.0$ s?

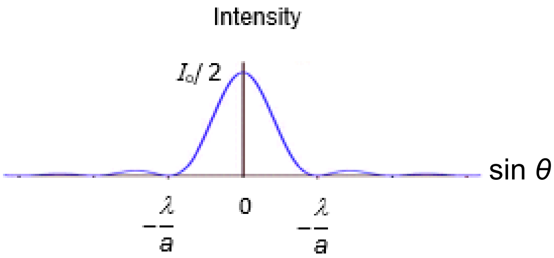


18 Light of wavelength λ incident on an adjustable single slit produces on a screen the diffraction pattern as shown when the slit width is *a*.

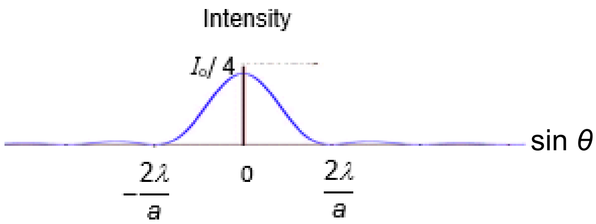


Which of the following diagrams best represents the diffraction pattern when the width of the slit is reduced to $\frac{a}{2}$?

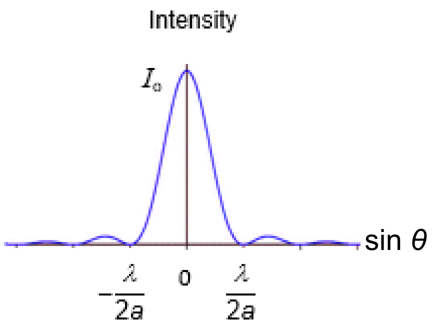
A



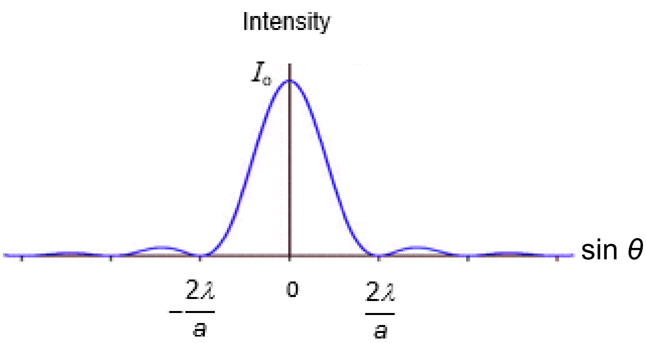
B



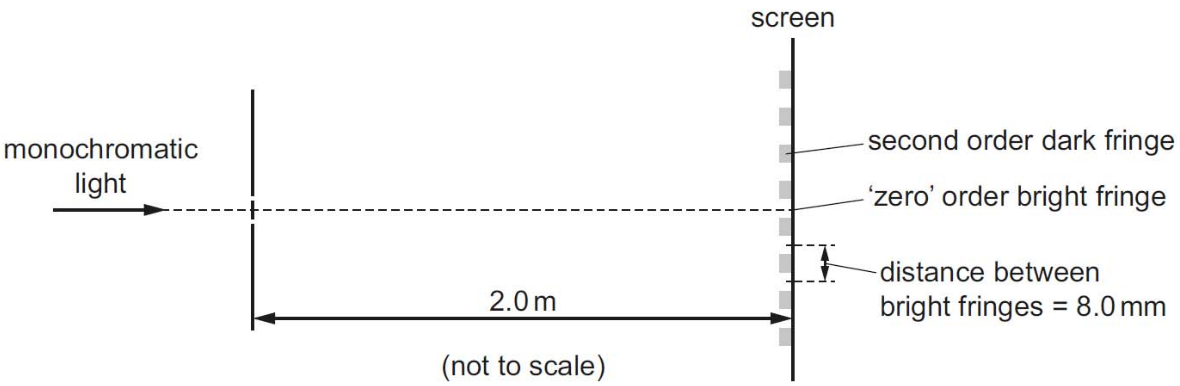
C



D



19 Monochromatic light is incident on a pair of narrow slits a distance of 0.10 mm apart. A series of bright and dark fringes are observed on a screen a distance of 2.0 m away. The distance between adjacent bright fringes is 8.0 mm.



What is the path difference between the light waves from the two slits that meet at the second order dark fringe?

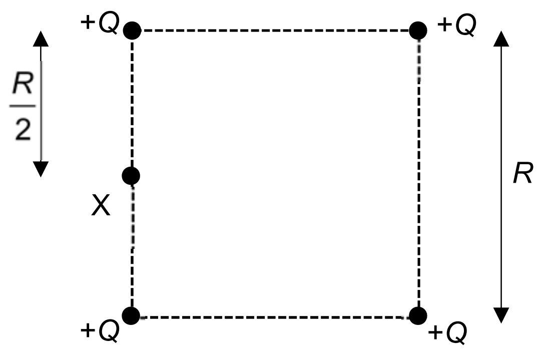
A 200 nm **B** 400 nm **C** 600 nm **D** 800 nm

20 Monochromatic light is incident on a diffraction grating and a diffraction pattern in observed.

Which row shows possible effects of replacing the grating with one that has twice as many lines per millimetre?

	number of orders of diffraction visible	angle between first and second order of diffraction
A	decreases	decreases
B	decreases	increases
C	increases	decreases
D	increases	increases

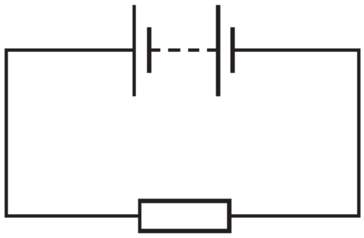
21 Four identical point charges are arranged at the corners of a square of length R as shown below.



What is the magnitude of the electric field strength E and the electric potential V at point X?

	E	V
A	$\frac{12}{5}\ \frac{Q}{\pi\varepsilon_0 R^2}$	$\frac{2}{5}\ \frac{Q}{\pi\varepsilon_0 R}$
B	$\frac{12}{5}\ \frac{Q}{\pi\varepsilon_0 R^2}$	$\left(1+\frac{1}{\sqrt{5}}\right)\ \frac{Q}{\pi\varepsilon_0 R}$
C	$\frac{4}{\sqrt{5}^3}\ \frac{Q}{\pi\varepsilon_0 R^2}$	$\frac{2}{5}\ \frac{Q}{\pi\varepsilon_0 R}$
D	$\frac{4}{\sqrt{5}^3}\ \frac{Q}{\pi\varepsilon_0 R^2}$	$\left(1+\frac{1}{\sqrt{5}}\right)\ \frac{Q}{\pi\varepsilon_0 R}$

22 In the circuit below, the battery converts an amount E of chemical energy to electrical energy when charge Q passes through the resistor in time t.



Which expressions give the e.m.f. of the battery and the current in the resistor?

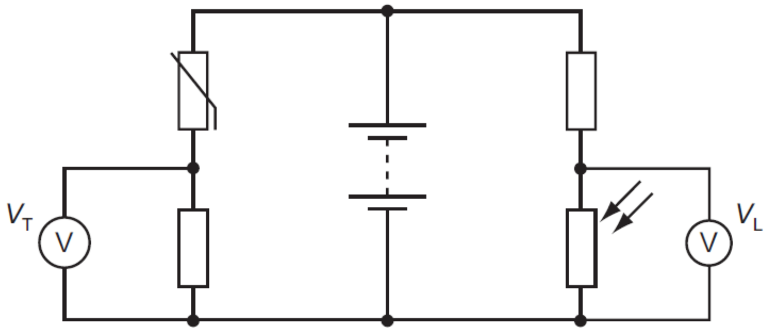
	e.m.f.	current
A	EQ	Q/t
B	EQ	Qt
C	E/Q	Q/t
D	E/Q	Qt

23 When the current in a wire is 5.0 A, the average drift speed of the conduction electrons in the wire is 7.4×10^{-4} m s^{-1}.

Which row gives a possible cross-sectional area and number of conduction electrons per unit volume for this wire?

	cross-sectional area / m^2	number of conduction electrons per unit volume / m^{-3}
A	7.2×10^{-7}	1.2×10^{28}
B	7.2×10^{-7}	5.9×10^{28}
C	2.3×10^{-6}	7.3×10^{26}
D	2.3×10^{-6}	3.7×10^{27}

24 In the circuit below, the reading V_T on the voltmeter changes from high to low as the temperature of the thermistor changes. The reading V_L on the voltmeter changes from high to low as the level of light on the light-dependent resistor (LDR) changes.

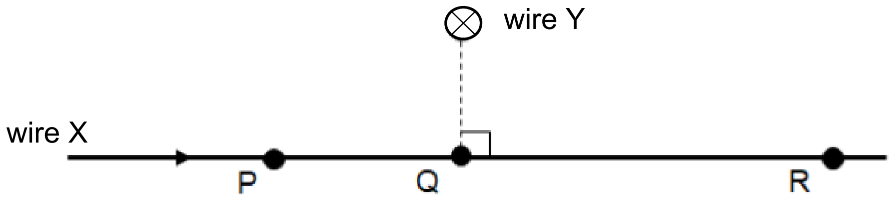


The readings on V_T and V_L are both high.

What are the conditions of temperature and light level?

	temperature	light level
A	low	low
B	low	high
C	high	low
D	high	high

25 Two long straight current-carrying wires, X and Y, are placed perpendicular to each other as shown in the diagram. Current flows from left to right in wire X and into the page in wire Y. P, Q and R are three points on wire X.



Which of the following statements is true?

A The magnetic force at point P acts in the opposite direction to that at point R.

B The magnitude of the magnetic force at point R is the smallest among all three points.

C The magnitude of the magnetic force at point Q is the largest among all three points.

D There is no magnetic force acting on wire X at all three points, P, Q and R, as the two wires are placed perpendicular to each other.

26 A flat circular coil of diameter 30 mm has 500 turns and is situated so that the plane of the coil is perpendicular to a uniform magnetic field of flux density 20 mT. The flux density is reduced to zero and then increased to 20 mT in the opposite direction at a constant rate. The time taken for the whole operation is 60 ms.

What is the average value of the e.m.f. induced in the coil?

A 0 **B** 0.12 V **C** 0.24 V **D** 0.94 V

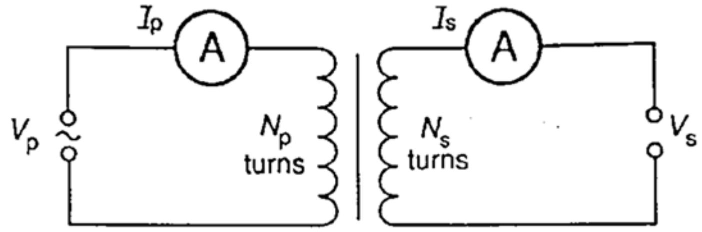
27 A mains electricity supply has a root-mean-square voltage of 240 V and a peak voltage of 340 V. When connected to this supply, a heater dissipates energy at a rate of 1000 W.

The heater is then connected to a 340 V d.c. supply and its resistance remains the same.

At what rate does the heater now dissipate energy?

A 1000 W **B** 1400 W **C** 2000 W **D** 2800 W

28 In a laboratory experiment to test a transformer, a student used the circuit shown in the diagram to take measurements.



Two of the original entries in the student's results table are missing as shown:

V_p / V	I_p / mA	N_p turns	V_s / V	I_s / mA	N_s turns
240	2.0	?	?	50	50

Assuming the transformer was 100% efficient, what are the missing results?

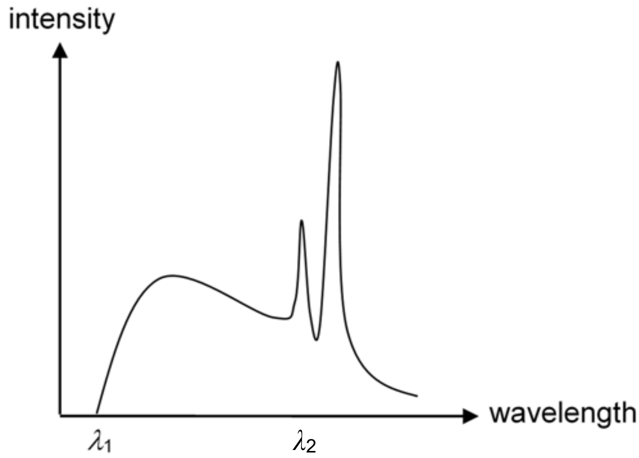
	N_p turns	V_s / V
A	50	9.6
B	450	1.0
C	1250	9.6
D	1250	240

29 When monochromatic light of wavelength 440 nm is incident on a metal surface, electrons are emitted. No electrons are emitted from the surface when the wavelength of the incident light is greater than 550 nm.

What is the minimum de Broglie wavelength of an emitted electron?

A 3.6×10^{-10} m **B** 7.2×10^{-10} m **C** 8.1×10^{-10} m **D** 1.6×10^{-9} m

30 The graph below shows the variation of X-ray intensity with wavelength emitted from an X-ray tube.



What are the factors that will affect λ_1 and λ_2?

	λ_1	λ_2
A	target metal	target metal
B	target metal	accelerating voltage
C	accelerating voltage	target metal
D	accelerating voltage	accelerating voltage

End of Paper

Paper 1

1	D
2	A
3	C
4	D
5	A
6	D
7	A
8	D
9	D
10	A

11	D
12	A
13	D
14	C
15	C
16	C
17	B
18	B
19	C
20	B

21	D
22	C
23	B
24	C
25	A
26	C
27	C
28	C
29	D
30	C

DUNMAN HIGH SCHOOL
Preliminary Examinations
Year 6
Higher 2

CANDIDATE NAME

CLASS

INDEX NUMBER

PHYSICS

9749/02

Paper 2 Structured Questions

September 2020

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	**11**
2	**12**
3	**11**
4	**13**
5	**10**
6	**23**
Total	**80**

This document consists of **20** 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	=	$\frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$
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	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

For Examiner's Use

1 A sphere is projected with an initial velocity u from the bottom of a smooth ramp which is inclined at an angle θ to the horizontal as shown in Fig. 1.1.

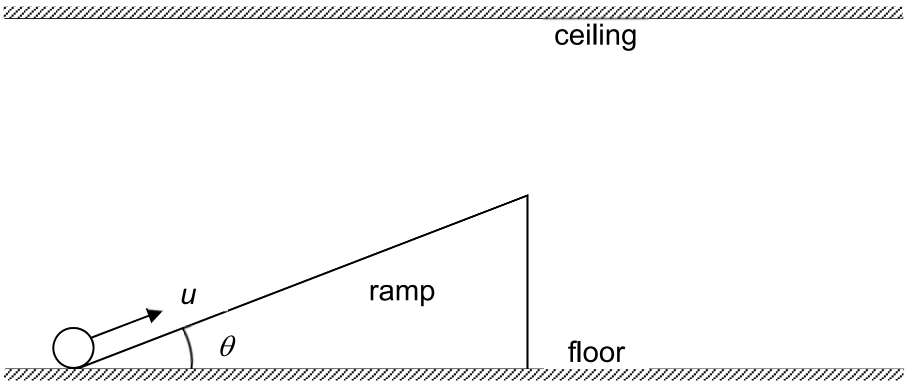


Fig. 1.1 (not to scale)

(a) Define *acceleration*.

....

.... [1]

(b) When u = 9.0 m s^{-1} and θ = 26°, the sphere leaves the ramp after 0.70 s.

(i) Show that the speed of the sphere as it leaves the ramp is 6.0 m s^{-1}.

[2]

(ii) Determine the height of the ramp.

height = ... m [2]

For Examiner's Use

(c) After the sphere leaves the ramp, it continues to travel upwards until it hits the ceiling at an angle of 5.0° to the horizontal as shown in Fig. 1.2.

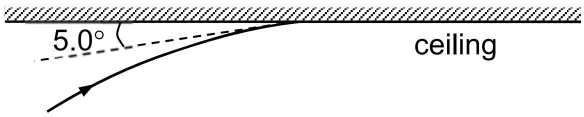


Fig. 1.2 (not to scale)

(i) Calculate the vertical component of velocity of the sphere just before hitting the ceiling.

vertical component of velocity = ... m s^{-1} [2]

(ii) Calculate the vertical displacement of the sphere from the instant it leaves the ramp to the instant it hits the ceiling.

vertical displacement = ... m [2]

(iii) Explain how momentum is conserved in the collision with the ceiling.

....

....

....

.... [2]

For Examiner's Use

2 A theme-park ride consists of two cages. They are moving in a circular path at constant speed v about a horizontal axis. Fig. 2.1 shows the ride at one instant when cage A is vertically above cage B.

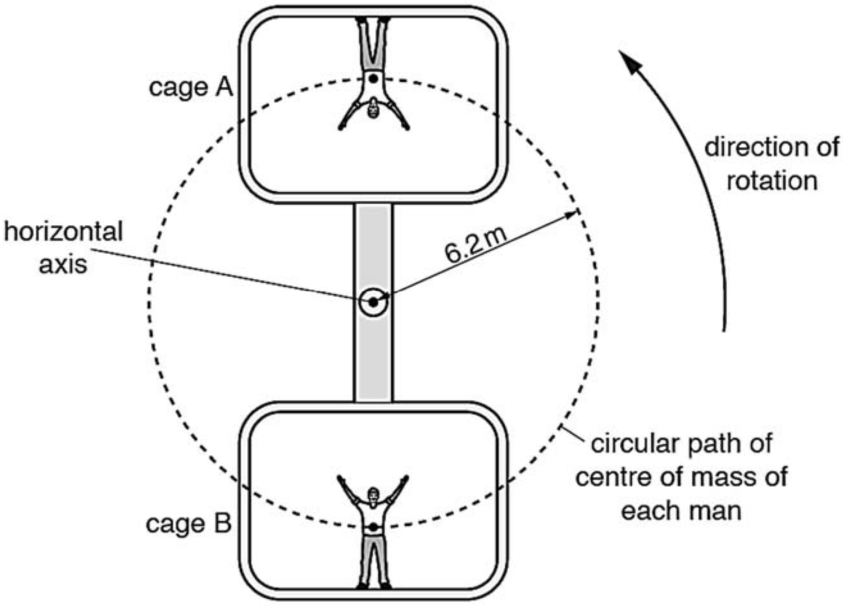


Fig. 2.1 (not to scale)

(a) A man is riding in each cage. The mass of each man is 75 kg. The centre of mass of each man is 6.2 m from the horizontal axis. The period of one rotation is 4.1 s.

(i) Determine the speed v of the centre of mass of each man.

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

(ii) Calculate the magnitude of the acceleration of the centre of mass of each man.

acceleration = ... m s^{-2} [2]

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(b) Fig. 2.2 shows the forces acting on the man in cage B at the instant the cages are in the positions shown. It shows the man in cage A at that same instant.

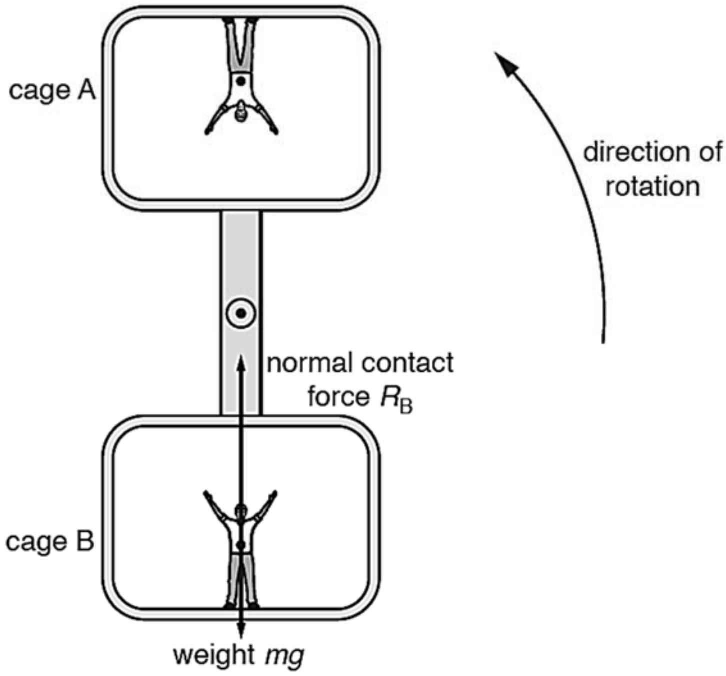

Fig. 2.2 (not to scale)

(i) On Fig. 2.2, mark labelled arrows to represent the magnitude and direction of the forces acting on the man in cage A. [2]

(ii) Calculate the magnitude of the normal contact force R_A on the man in cage A at this instant.

R_A = ... N [2]

(c) **(i)** Explain why a minimum value for the speed is needed for the man in cage A to maintain contact with the floor of his cage.

....

....

....

.... [2]

(ii) Calculate this minimum speed.

minimum speed = ... m s^{-1} [2]

3 **(a)** The mass M of a spherical planet may be assumed to be a point mass at the centre of the planet.

(i) A stone, of mass m travelling at speed v, is in a circular orbit of radius r about the planet, as illustrated in Fig. 3.1

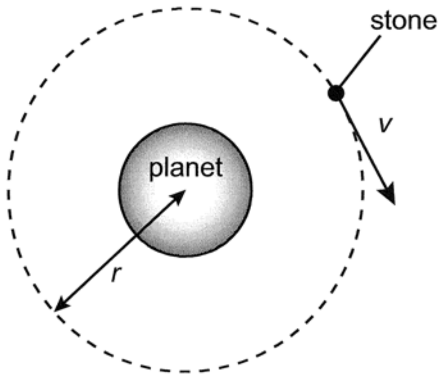

Fig. 3.1

Derive an expression, in term of r, M and the gravitational constant G, for the speed v. Explain your working.

[3]

(ii) A second stone, initially with negligible velocity at infinity, travels towards the planet. The stone does not hit the surface of the planet.

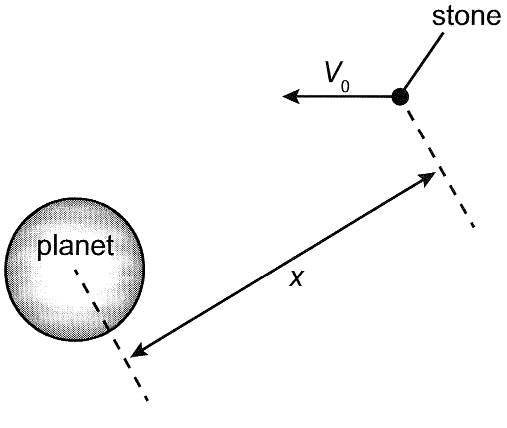

Fig. 3.2 (not to scale)

When the stone is at a distance x from the centre of the planet, its speed is V_0, as shown in Fig. 3.2.

For Examiner's Use

Determine V_0 in terms of the gravitational constant G, the mass M of the planet, and x. Explain your working.

You may assume that gravitational attraction on the stone is due only to the planet.

[3]

(iii) Use your answer in **(ii)** and your expression in **(i)** to explain whether this stone could enter a circular orbit about the planet.

....

....

....

.... [2]

(b) A charged point mass is situated in a vacuum. A proton travels directly towards the mass, as illustrated in Fig. 3.3.

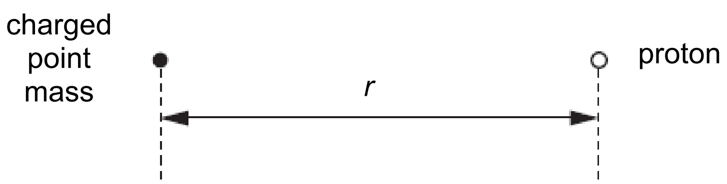

Fig. 3.3

When the separation of the mass and the proton is r, the electric potential energy of the system is U_P.

The variation with distance r of the electric potential energy U_P is shown in Fig. 3.4.

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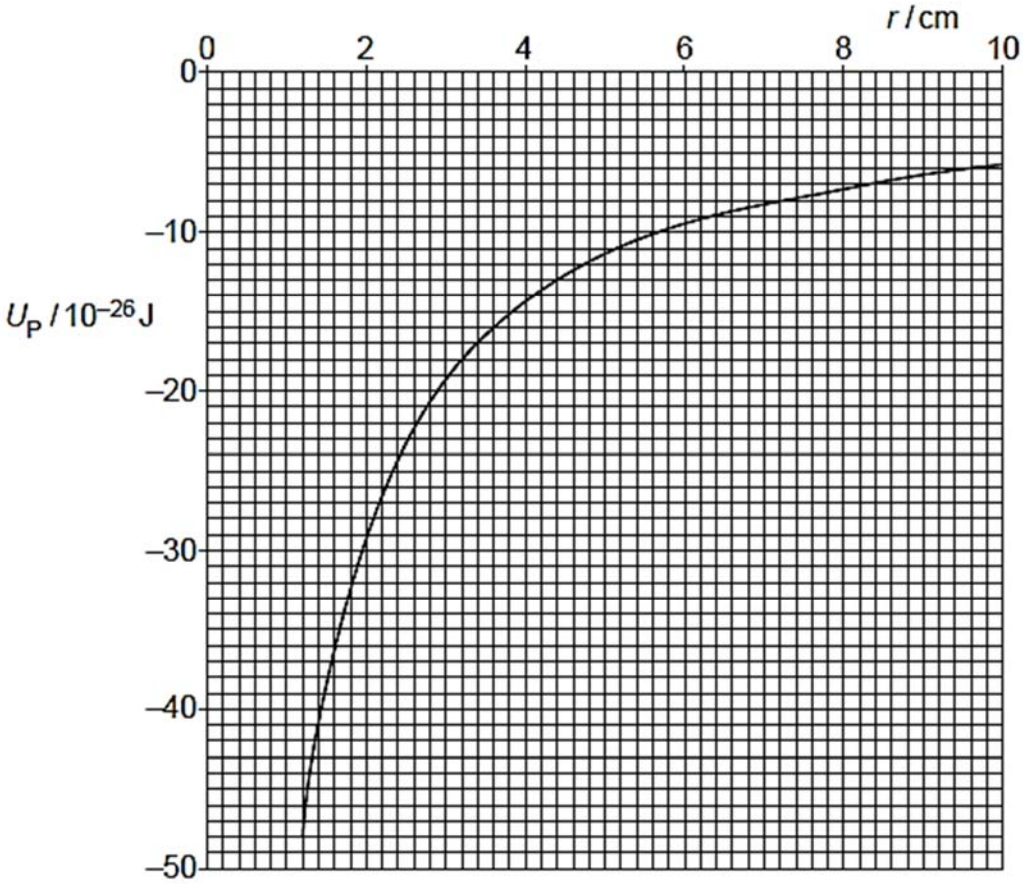


Fig. 3.4

Determine the electric field strength at a distance of 4.0 cm from the charged point mass.

field strength = …………………………….. V m^{-1} [3]

For Examiner's Use

4 **(a)** A load of mass 2.3 kg oscillates vertically with simple harmonic motion on the free end of a spring of force constant 63 N m^{-1}. The amplitude of the oscillation is 0.28 m and the period T of the oscillation is given by the expression

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

where m is the mass of the load and k is the force constant.

(i) Calculate the angular frequency ω of the oscillation.

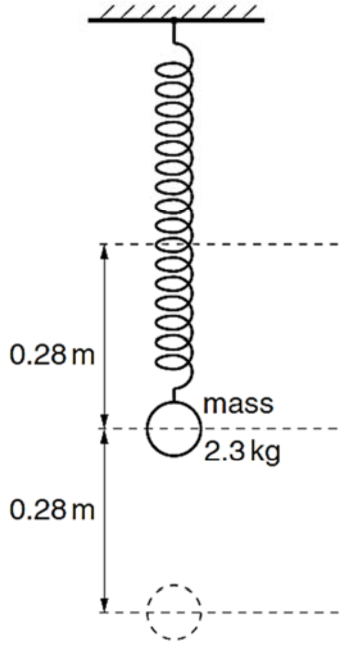
ω = ... rad s^{-1} [2]

(ii) Determine the maximum kinetic energy E of the oscillating mass.

E = ... J [2]

(b) The potential energy of the oscillating system in **(a)** is partly gravitational potential energy and partly elastic potential energy.

Complete the following table to show the values of the various different forms of energy at the top, the middle and the bottom of the oscillation of the mass.



	kinetic energy / J	gravitational potential energy / J	elastic potential energy / J	total energy / J
top			–3.85	
middle		reference zero	reference zero	
bottom				

[5]

(c) A car component of mass 0.0460 kg rattles at a resonant frequency of 35.5 Hz.

Fig. 4.1 shows how the amplitude of the oscillation varies with frequency.

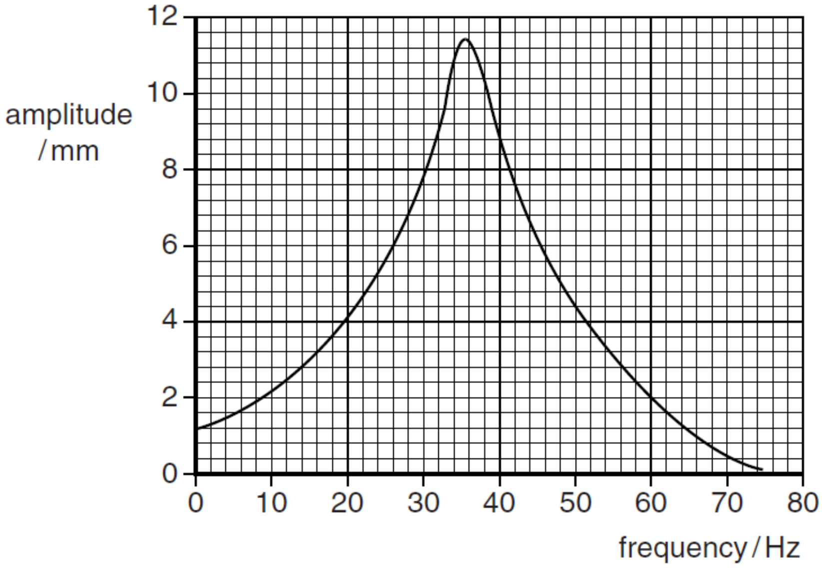


Fig. 4.1

For Examiner's Use

(i) Calculate the magnitude of the maximum acceleration of the component when oscillating at the resonant frequency.

magnitude of maximum acceleration = ... m s^{-2} [2]

(ii) On Fig. 4.1, draw a line to show the effect of supporting the component on a rubber mounting.

[2]

5 The variation with temperature of the resistance R_T of a thermistor is shown in Fig. 5.1.

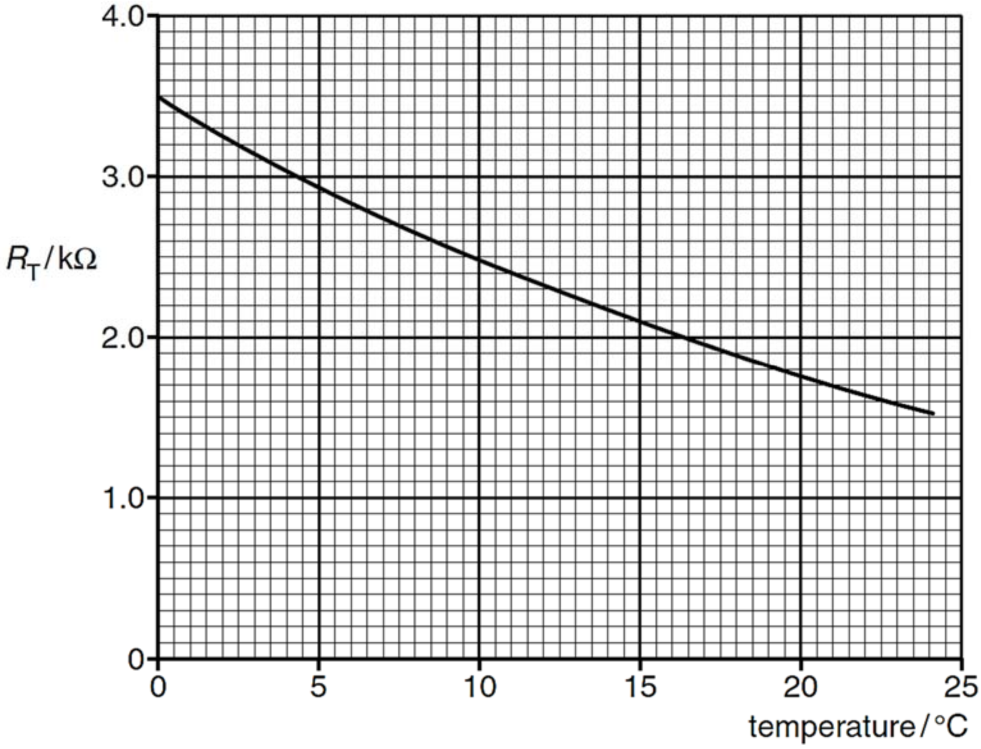


Fig. 5.1

The thermistor is connected into the circuit of Fig. 5.2.

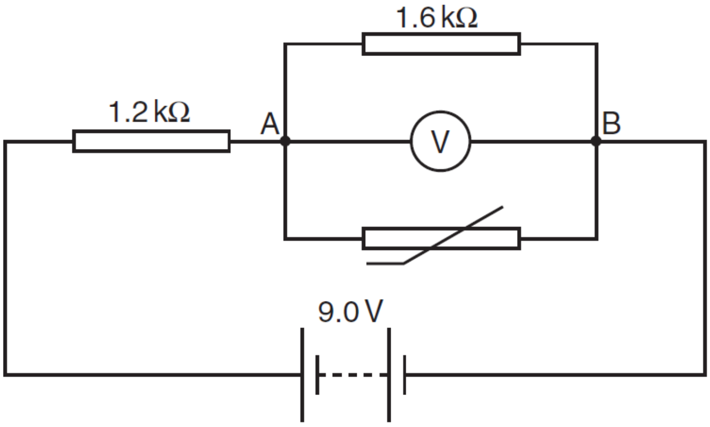


Fig. 5.2

The battery has e.m.f. 9.0 V and negligible internal resistance. The voltmeter has infinite resistance.

(a) For the thermistor at 22.5 °C, calculate

(i) the total resistance between points A and B on Fig. 5.2,

resistance = ... Ω [2]

(ii) the reading on the voltmeter.

voltmeter reading = ...V [2]

(b) The temperature of the thermistor is changed. The voltmeter now reads 4.0 V.

Determine

(i) the total resistance between points A and B on Fig. 5.2,

resistance = ... Ω [2]

(ii) the temperature of the thermistor.

temperature = ...°C [2]

(c) A student suggests that the voltmeter, reading up to 10 V, could be calibrated to measure temperature.

Suggest two disadvantages of using the circuit of Fig. 5.2 with this voltmeter for the measurement of temperature in the range 0 °C to 25 °C.

1. ....

....

2. ....

....
[2]

6 A light bulb manufacturer makes 240 V, 60 W bulbs, like the one shown in Fig. 6.1.

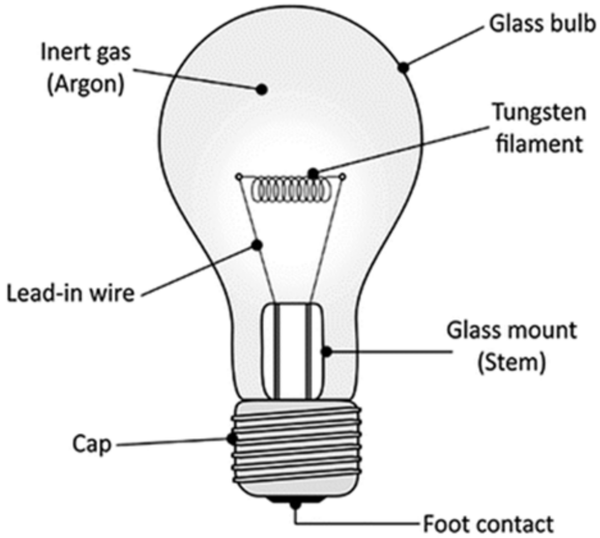


Fig. 6.1

The filament of the bulb is at a temperature of 2600 °C and the bulb lasts for 1000 hours before the filament breaks.

There are two schools of thought concerning these bulbs. One group of people want the manufacturer to raise the temperature at which the filament operates, so that for the same power, more light is emitted. The other group of people thinks that the manufacturer makes too much profit on the bulbs by making them so that they break after 1000 hours. They want the manufacturer to make bulbs that last 2000 hours. The manufacturer can happily satisfy both of these requirements – but only by manufacturing two other bulbs alongside the original bulb.

The material used for making the filament of the bulb is made of tungsten which has a resistivity of $7.9 \times 10^{-7}\ \Omega$ m at 2600 °C.

The manufacturer is going to make 3 bulbs using different length and diameters of tungsten filament as shown in Fig. 6.2. The filament B is used to manufacture the standard bulb operating at 2600 °C.

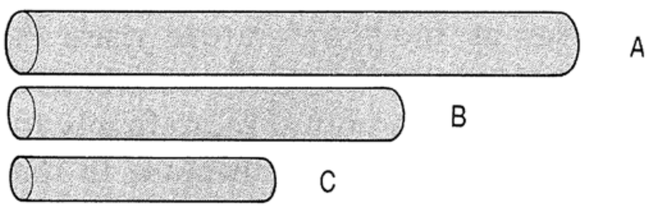


Fig. 6.2

The manufactured bulbs will have the same resistance.

(a) **(i)** What is meant by the *resistance* of the bulb?

……………………………………………………………………………………………

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

(ii) Calculate the resistance of the 240 V, 60 W bulb.

resistance = ………………………Ω [2]

(b) If the length of the filament wire in bulb B is 0.14 m, calculate the diameter of tungsten wire needed to manufacture this bulb.

diameter = ………………………mm [2]

(c) Explain how it is possible for the filaments in Fig 6.2, to have the same resistance.

……………………………………………………………………………………………

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

(d) State which filament will be used to manufacture

(i) the bulb with higher temperature than 2600 ^{o}C

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

(ii) the bulb that can last 2000 hours

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

(e) Fig 6.3 compares the characteristics of the different filaments.

	A	B	C
resistance/ Ω			
diameter/ mm	0.0129		0.0113
length/ m		0.14	
surface area/ m^2			
power lost per unit area/ W m^{-2}			

Fig. 6.3

Complete the missing values in Fig. 6.3. [3]

(f) The variation with temperature of the power lost per unit area of the filament is shown in Fig. 6.4.

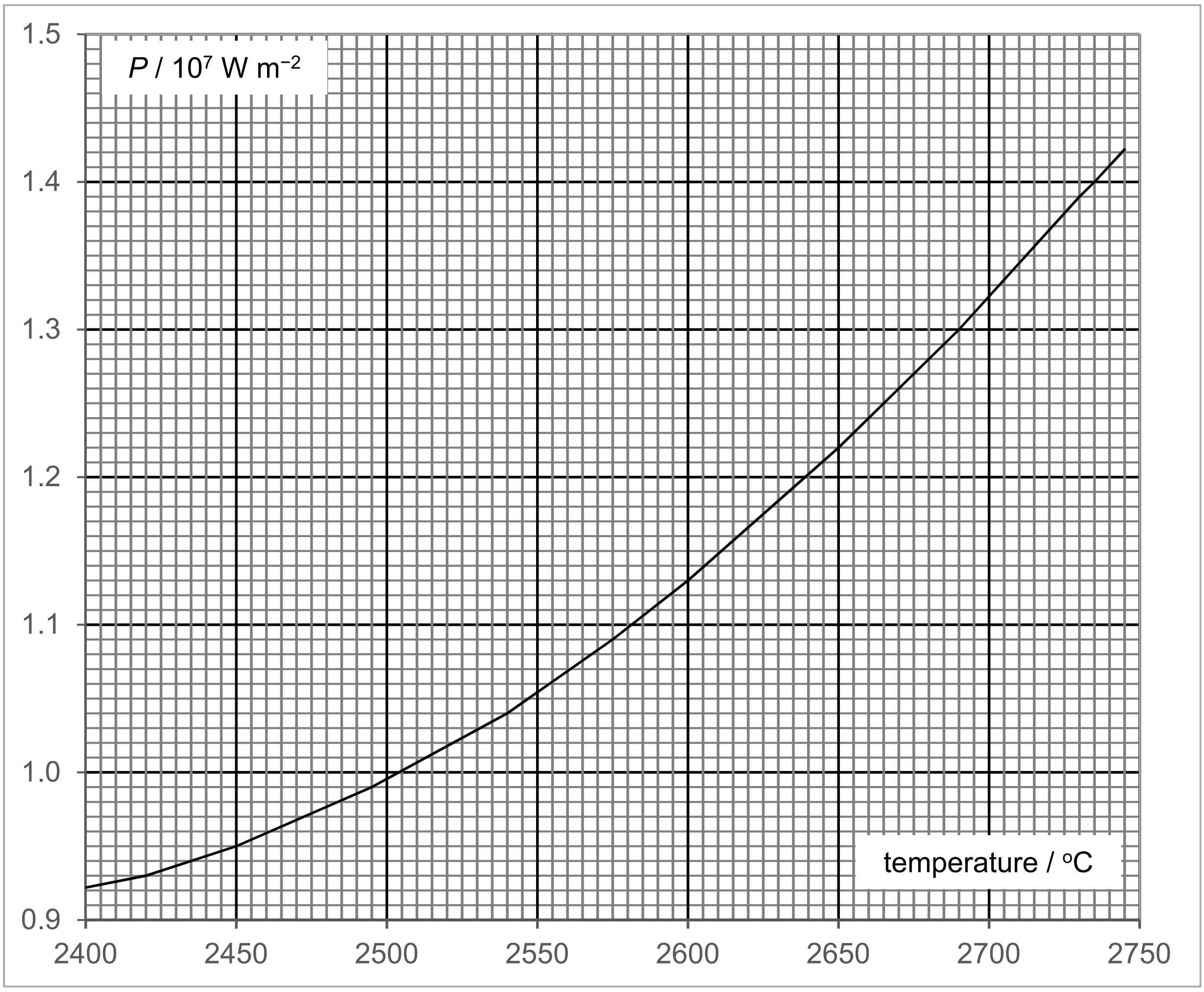


Fig. 6.4

Using your values from Fig. 6.3, determine the temperature at which each filament operates.

filament A temperature = …………………………. °C [1]

filament B temperature = ………………………….. °C [1]

filament C temperature = …………………………. °C [1]

(g) The bulb at the highest temperature gives out 12% of power as light but it only lasts 500 hours. The bulb at the lowest temperature gives out 9.0% of its power as light. The cost of manufacturing each bulb is \$0.50 and each kilowatt-hour electricity costs \$0.172.

When used for a duration of 2000 hours,

(i) determine which bulb has a higher running cost,

bulb with ………………………………………… has a higher running cost [3]

(ii) calculate the ratio $\dfrac{\text{cost of a unit of light energy from the lowest temperature bulb}}{\text{cost of a unit of light energy from the highest temperature bulb}}$.

ratio = ………………………….. [4]

(iii) Suggest two other types of lightbulbs that are commonly available in the market other than the filament incandescent lightbulbs.

…………………………………………………………………………………………………..

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

(iv) State the key advantage of the type of lightbulbs suggested in **(iii)**.

…………………………………………………………………………………………………..

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

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

September 2020

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 **one** question only.

You are advised to spend one and a half hours on Section A and half an hour on Section B.

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.

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1	7
2	11
3	11
4	8
5	8
6	8
7	7
8	20
9	20
Total	80

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

Data

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resistors in series,	R	=	$R_1 + R_2 + \ldots$
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radioactive decay,	x	=	$x_0 \exp(-\lambda t)$
decay constant,	λ	=	$\frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 **(a)** The distance from the Earth to the Sun is 0.15 Tm. Calculate the time in minutes for light to travel from the Sun to the Earth.

time = ... min [1]

(b) A mass *m* placed on the end of a spring that is hanging vertically, as shown in Fig. 1.1.

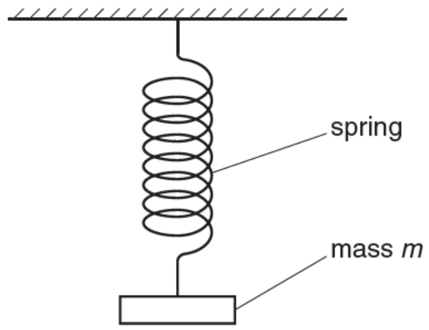

Fig 1.1

The mass is made to oscillate vertically. The period of the oscillations of the mass is *T*. The period *T* is given by

$$T = C\sqrt{\frac{m}{k}}$$

where *C* is a constant and *k* is the spring constant.

Show that *C* has no units. [1]

(c) An experiment is performed to determine the value of *C*. The data from the experiment are shown in Fig. 1.2.

Quantity	Value with its corresponding SI unit	uncertainty
T	0.242	± 1%
m	0.300	± 2%
k	239	± 3%

Fig. 1.2

(i) Use data from Fig. 1.2 to calculate *C* with its uncertainty.

C = ………………………… ± ………………………… [3]

(ii) The quantities used to determine *C* should be measured with accuracy and precision. Explain the difference between accuracy and precision.

accuracy: ……………………………………………………………………………………

……………………………………………………………………………………………

precision: ……………………………………………………………………………………

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

For Examiner's Use

2 Two blocks, A and B, are on a horizontal frictionless surface. The blocks are joined together by a spring, as shown in Fig. 2.1.

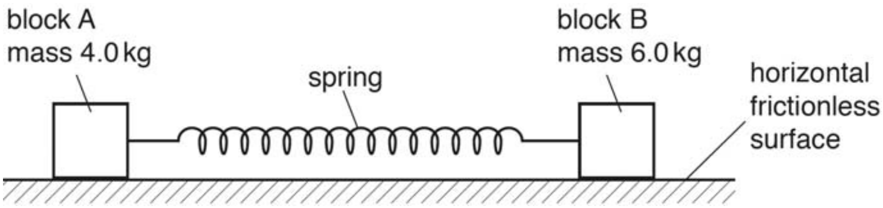

Fig. 2.1

Block A has mass 4.0 kg and block B has mass 6.0 kg.

The variation of the tension F with the extension x of the spring is shown in Fig. 2.2.

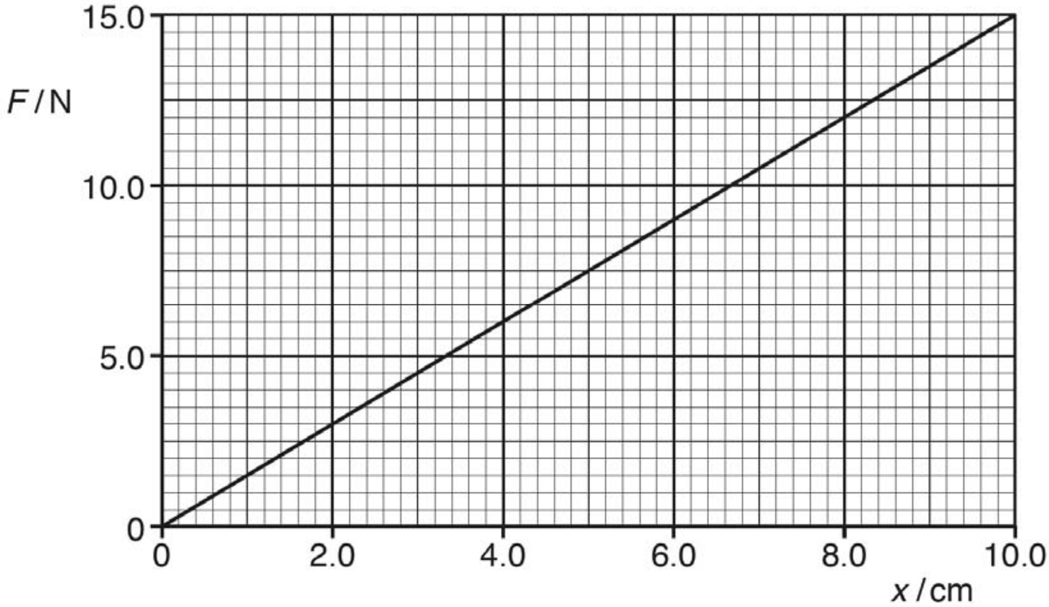

Fig. 2.2

The two blocks are held apart so that the spring has an extension of 8.0 cm.

(a) Use Fig. 2.2 to explain whether the spring obeys Hooke's law for this range of extensions.

....

....[1]

(b) Show that the elastic potential energy of the spring at an extension of 8.0 cm is 0.48 J.

[1]

(c) The blocks are released from rest at the same instant. When the extension of the spring becomes zero, block A has speed v_A and block B has speed v_B. It may be assumed that the mass of the spring is negligible.

For the instant when the extension of the spring becomes zero,

(i) determine the ratio of $\frac{\text{kinetic energy of block A}}{\text{kinetic energy of block B}}$,

ratio = ... [3]

(ii) Hence or otherwise, determine the speed v_A of block A.

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

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(d) The blocks are released at time $t = 0$.

On Fig. 2.3, sketch a graph to show how the speed of block A varies with time t until the extension of the spring becomes zero.

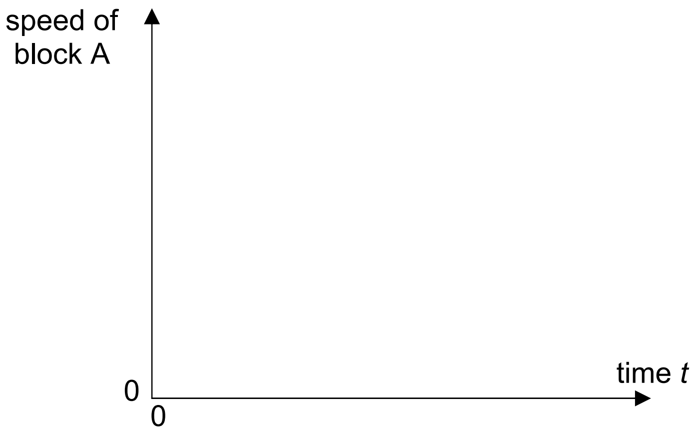

Fig. 2.3

[2]

(e) State and explain whether the two blocks of different masses oscillate with the same frequency of vibration.

....

....

....[2]

For Examiner's Use

3 **(a)** A pendulum bob is fixed onto the ceiling of a toy train by a string. The train is accelerated to the right with an acceleration a of 2.5 m s^{-2}, as shown in Fig. 3.1. The string makes an angle θ with the vertical.

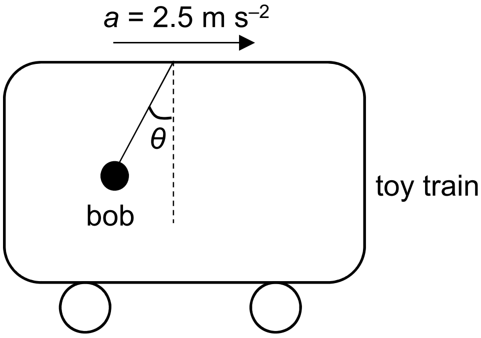

Fig. 3.1

Determine the angle θ.

θ = ... ° [2]

(b) Another train has a helium balloon attached to the floor of the train by a string as shown in Fig 3.2.

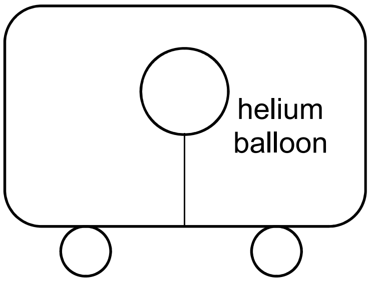

Fig. 3.2

The toy train is then accelerated to the right.
Sketch in Fig. 3.3 and explain the resultant position of the helium balloon when the toy train is accelerating to the right.

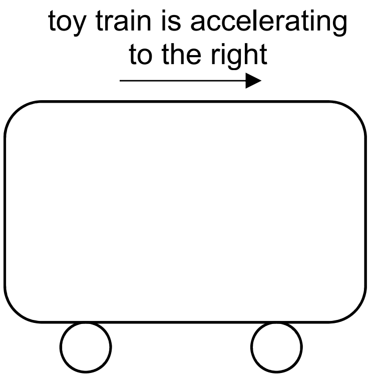

Fig. 3.3

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

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

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

(c) Sand falls vertically on to a horizontal conveyor belt at a rate of 60 kg s^{-1} as shown in Fig. 3.4.

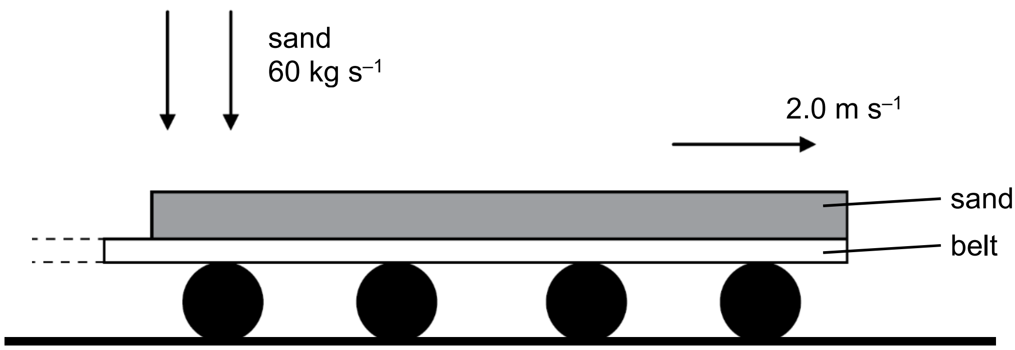

Fig. 3.4

The conveyor belt that is driven by an engine, moves with speed of 2.0 m s^{-1}.

The sand hits the conveyor belt with zero horizontal speed.

(i) Name the type of the force *F* that accelerates the sand to the speed of the conveyor belt.

....[1]

(ii) Determine the magnitude of the force *F*.

F = ………………………… N [2]

(iii) Calculate the power *P* required to move the conveyor belt at the constant speed.

P = ………………………… W [1]

(iv) Determine the rate of change of kinetic energy *K* of the sand.

K = ………………………… W [1]

(v) Explain why the values of *P* and *K* are not equal.

....

....[1]

For Examiner's Use

4 **(a)** A cube of length L contains N molecules of an ideal gas. Each molecule has a component c_x of velocity normal to one side S of the cube, as shown in Fig. 4.1.

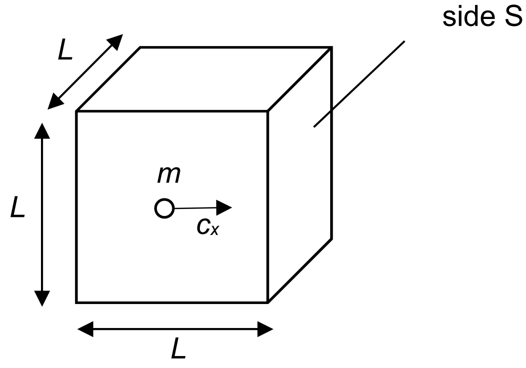

Fig. 4.1

The pressure p of the gas due to the component c_x of velocity is given by the expression

$$p = \frac{Nm\langle c_x^2 \rangle}{V}$$

where V is the volume of the gas and m is the mass of a molecule.

Explain how the expression leads to the relation

$$p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$$

where $\langle c^2 \rangle$ is the mean square speed of the molecules.

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

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

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

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

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

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

For Examiner's Use

(b) In a diesel engine a fixed amount of gas can be considered to undergo a cycle of four stages. The cycle is shown in Fig. 4.2.

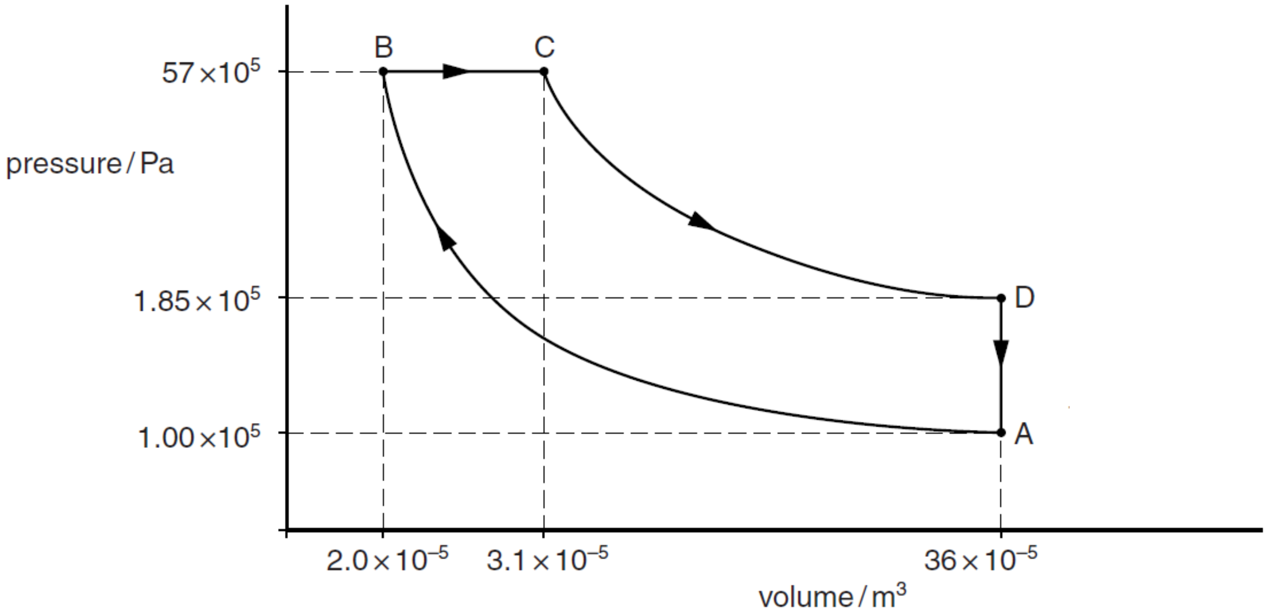

Fig. 4.2

The four stages are

A → B a compression with a rise in pressure and temperature from an initial temperature of 300 K,

B → C an expansion at constant pressure while fuel is being burnt,

C → D a further expansion with a drop in both temperature and pressure,

D → A a return to the starting point.

Some numerical values of pressure and volume are given on Fig. 4.2. The values are for an idealised engine.

Using Fig. 4.2, determine the work done by the gas during the stage B → C.

work done = ... J [2]

(c) Complete the following table for the four stages of the cycle given in **(b)**.

stage of cycle	heat supplied **to the gas** / J	work done **on the gas** / J	**increase** in the internal energy of the system / J
A → B	0	235	
B → C	246		
C → D	0	−333	
D → A			

[3]

5 **(a)** An arrangement for producing stationary waves in air in a tube that is closed at one end is shown in Fig. 5.1.

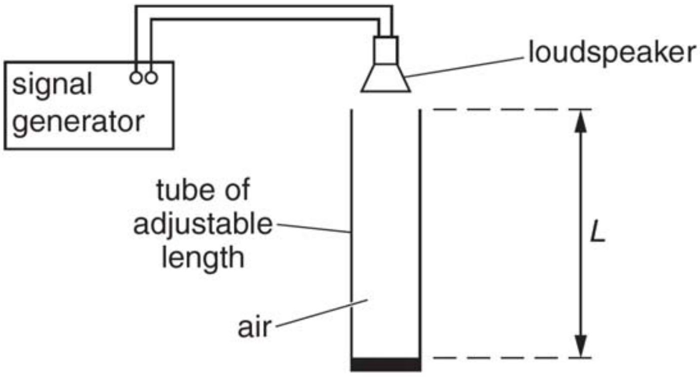

Fig. 5.1

A loudspeaker produces sound waves of wavelength 0.680 m in the tube.
For some values of length L of the tube, stationary waves are formed.

(i) Explain how stationary waves are formed in the tube.

....

....

....[2]

(ii) The length L is adjusted between 0.200 m and 1.00 m.
Calculate one value of L for which stationary waves are formed. Ignore end corrections.

L = ………………………… m [1]

(b) A horizontal string is stretched between two fixed points X and Y. The string is made to vibrate vertically so that a stationary wave is formed. At one instant $t = t_1$, each particle of the string is at its maximum displacement, as shown in Fig. 5.2.

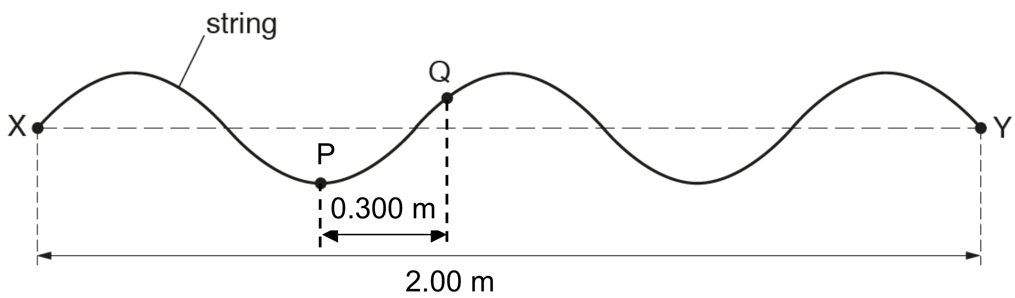

Fig. 5.2

P and Q are two particles of the string. The string vibrates with a frequency of 50 Hz. Distance XY is 2.00 m and horizontal distance between P and Q is 0.300 m.

(i) State the number of antinodes in the stationary wave.

number = ………………………… [1]

(ii) Determine the phase difference between the vibrations of particle P and Q.

phase difference = ………………………… [1]

(iii) On Fig. 5.2, sketch the position of the string between X and Y at times

1. t_1 + 10 ms (label this line M)

2. t_1 + 25 ms (label this line N)

[3]

6 In the circuit shown in Fig. 6.1, cell A has a constant e.m.f. of 2.0 V and negligible internal resistance. Wire XY is 100 cm long with a resistance of 5.0 Ω. Cell B has an e.m.f. of 1.5 V and an internal resistance of 0.80 Ω.

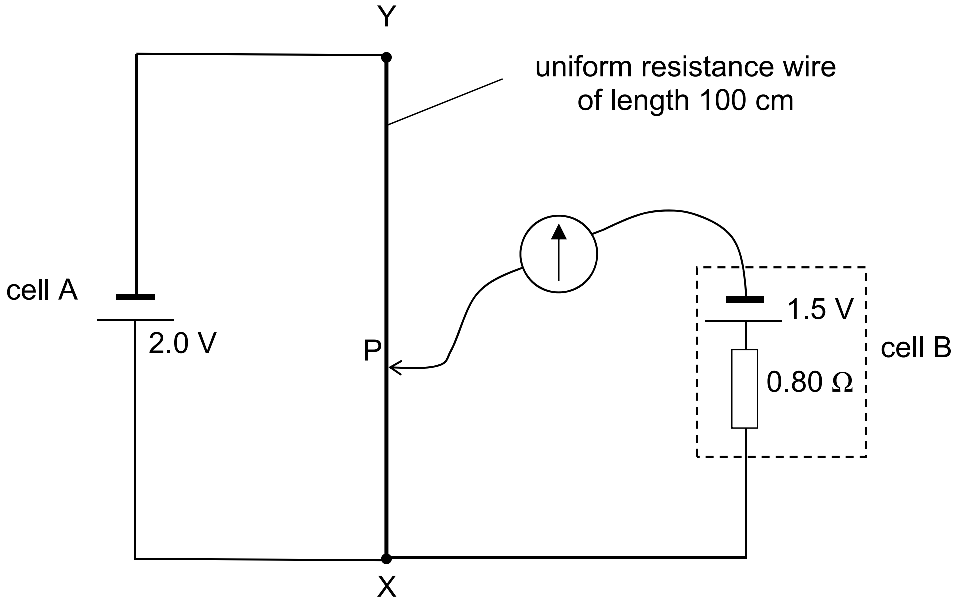

Fig. 6.1

Calculate the length XP to produce zero current in the galvanometer

(a) in the circuit as shown in Fig. 6.1,

XP = ………………………… cm [2]

(b) when a 1.0 Ω resistor is placed in series with cell A,

XP = ………………………… cm [3]

(c) when the 1.0 Ω resistor in **(b)** is removed from A and placed in parallel with cell B.

XP = ……………………………………… cm [3]

For Examiner's Use

7 A metal disc is swinging freely between the poles of an electromagnet, as shown in Fig. 7.1.

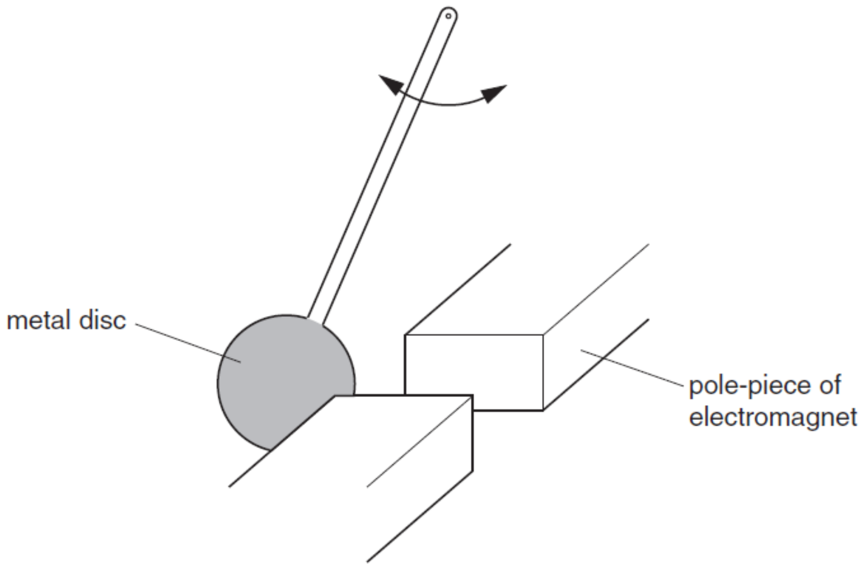

Fig. 7.1

When the electromagnet is switched on, the disc comes to rest after a few oscillations.

(a) (i) State Faraday's law of electromagnetic induction and use the law to explain why an e.m.f. is induced in the disc.

....

....

....

....[2]

(ii) Explain why eddy currents are induced in the metal disc.

....

....

....

....[2]

For Examiner's Use

(b) Use energy principles to explain why the disc comes to rest after a few oscillations.

....

....

....

....

....

....[3]

For Examiner's Use

Section B

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

8 Force-fields may be represented using lines that have direction.

(a) State

(i) what is meant by *field of force*,

....

....[1]

(ii) how, using lines of force, changes in the strength of a force-field are represented.

....

....

....[2]

(b) Conventionally, arrows on field lines define the direction of a force acting on an object.

State the property of the object that experiences a force in this direction for

(i) a gravitational field,

....[1]

(ii) an electric field,

....[1]

(iii) a magnetic field,

....[1]

(c) A proton, travelling in a vacuum at a constant velocity of 4.5×10^6 m s^{-1}. It enters a region of uniform magnetic field of flux density 1.2 T. The direction of the magnetic field is out of the plane of the paper. Initially the proton is travelling at a right-angle to the magnetic field, as shown in Fig. 8.1.

(i) Calculate the radius of the path of the proton in the magnetic field.

radius = ……………………… m [2]

(ii) On Fig. 8.1 draw the path of the proton through, and beyond, the region of magnetic field.

Fig 8.1

[4]

(d) A uniform electric field is now created in the same region as the magnetic field in Fig. 8.1, so that the proton passes undeviated through the region of the two fields.

(i) On Fig. 8.1 mark, with an arrow labelled E, the direction of the electric field. [1]

(ii) Calculate the magnitude of the electric field strength.

field strength = ……………………… V m^{-1} [2]

(e) Suggest why gravitational forces on the proton have not been considered in the calculations in part **(c)** and **(d)**.

……

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

(f) The proton in **(d)** is replaced by other particles. The electric and magnetic fields remain unchanged.

Without any further calculation, state and explain the deviation, if any, of the following particles in the region of the fields.

(i) an electron entering the region with twice the velocity.

……

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

(ii) an alpha particle (helium nucleus) entering the region with the same velocity.

……

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

9 **(a)** Explain what is meant by a *photon*.

………

………[2]

(b) An X-ray photon of wavelength 6.50 × 10^{-12} m is incident on an isolated stationary electron, as illustrated in Fig. 9.1.

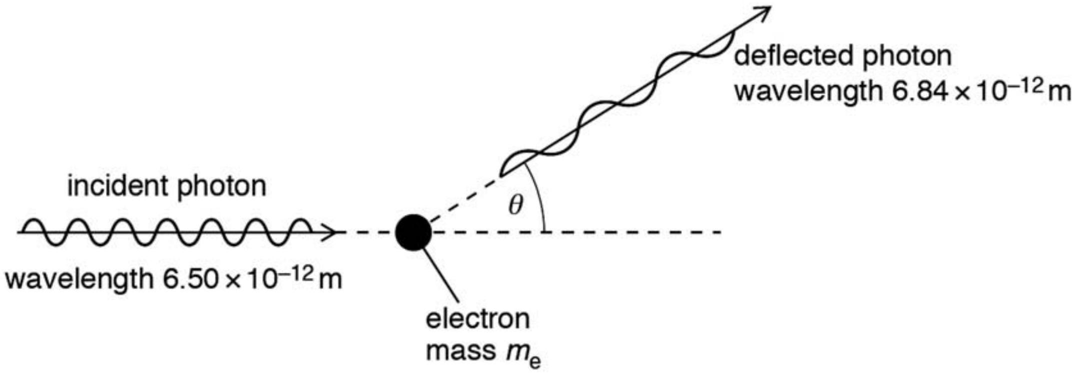

Fig. 9.1

The photon is deflected elastically by the electron of mass m_e. The wavelength of the deflected photon is 6.84 × 10^{-12} m.

(i) On Fig. 9.1, draw an arrow to indicate a possible initial direction of motion of the electron after the photon has been deflected. [1]

(ii) Calculate

1. the change in energy of the deflected photon.

change in photon energy = ……………………… J [2]

2. the speed of the electron after the photon has been deflected.

speed = ……………………… m s^{-1} [2]

(iii) The electron is deflected at an angle of 70° to the horizontal.

Calculate the angle *θ* through which the photon is deflected.

θ = ……………………… ° [3]

(c) The deflected photon in Fig. 9.1 falls on a metal surface of work function 180 keV. Photoelectrons are emitted.

(i) Calculate the maximum kinetic energy of the photoelectrons.

maximum kinetic energy = ……………………… J [2]

(ii) Calculate the stopping potential of the photoelectrons

stopping potential = ……………………… kV [2]

(iii) Explain why the kinetic energy of the photoelectrons is described as maximum.

…………………………………………………………………………………………………

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

(d) The electron in **(b)(ii)2** collided with an atom with the 5 lowest energy levels shown in Fig. 9.2.

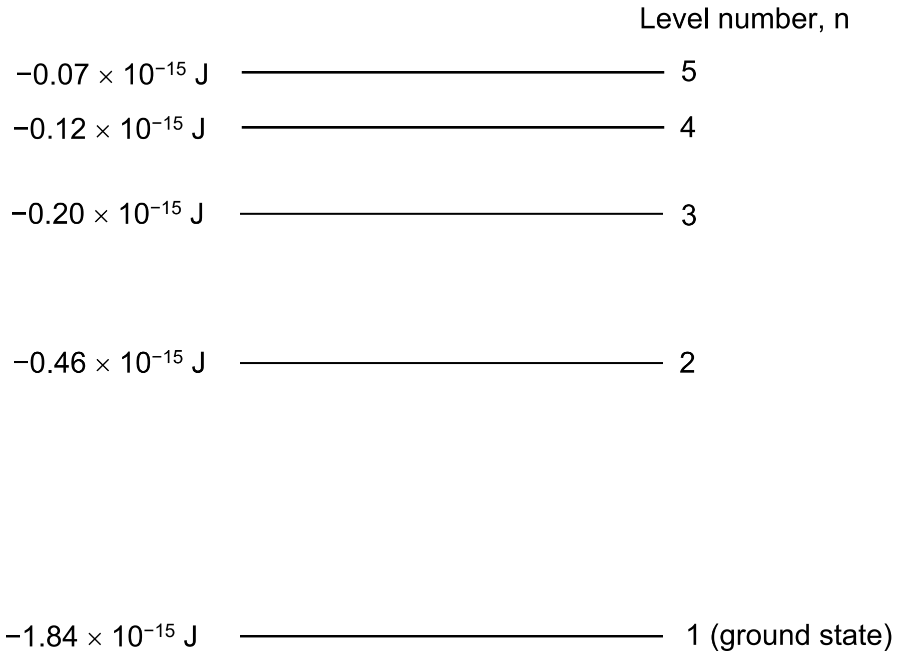

Fig. 9.2

The atom is initially at ground state. As a result of the collision, the atom transits to an excited state.

(i) Calculate the remaining energy of the recoiling electron after the collision.

energy = ……………………… J [3]

(ii) State and explain whether the atom will transit to higher energy level if a photon of identical energy is incident on the atom.

……………………………………………………………………………………………......

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

END OF PAPER

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For Examiner's Use

Dunman High School 2020 Year 6 Prelim Exam H2 Physics Answers

Paper 1

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

Paper 2

1

(a) Acceleration is defined as the rate of change of velocity with respect to time. B1 [1]

Comments: "per unit time" is NOT accepted

(b) (i) $v = u + (-g \sin \theta)\, t$ M1

$= 9.0 + (-9.81 \times \sin 26^{o})(0.70)$ M1

$= 5.99$

$= 6.0 \text{ m s}^{-1}$ A0 [2]

(ii) Gain in GPE = Lose in KE

$mgh = ½\, mu^2 - ½\, mv^2$ (h is the height of ramp)

$gh = ½\, u^2 - ½\, v^2$

$(9.81)\, h = ½\,(9.0)^2 - ½\,(6.0)^2$ M1

$h = 2.3$ m A1 [2]

Comments: Quite a number of candidates treat this part as projectile motion without realizing that weight is NOT the ONLY force that acts on the body. (b)(i) is a "show" question and full working needs to be shown, such as formula and full substitutions of values.

(c) (i) $\tan 5.0^{\circ} = v_y / v_x$

$= v_y / (6.0 \cos 26^{\circ})$ M1

$v_y = 0.47 \text{ m s}^{-1}$ A1 [2]

(ii) $v_y^2 = u_y^2 + 2a_y s_y$

$0.47^2 = (6.0 \sin 26^{o})^2 + 2(-9.81)s_y$ M1

$s_y = 0.34$ m A1 [2]

Comments: Error-carry-forward saved the day for a number of candidates.

(iii) sphere + ceiling (part of Earth) as system
ceiling gains upward momentum of equal magnitude as the downward momentum change of sphere (due to weight & force by ceiling) B1
ceiling gains rightward momentum of equal magnitude as the leftward momentum change of sphere (due to friction) B1 [2]

Comments: Candidates need to answer in <u>*details*</u> *to* <u>*context*</u>*. Some merely says sphere transfer momentum to ceiling without saying equal magnitude and opposite direction. To gain full credit, the direction of momentum change for each object need to be stated for the context.*

[11]

2

(a) (i) $v = 2\pi r/T$, (= 2π × 6.2/4.1) [1]
= 9.5 (m s^{-1}) (9.50) [1] [2]
(ii) acceleration = v^2/r (= 9.502/6.2) [1]
= 14.6 (m s^{-2}) [1] [2]
(b) (i) mg <u>unaltered</u> (beyond arms but not beyond bottom of cage) $mv^2/r > mg$ [1]
contact force downward <u>smaller</u> than weight [1] [2]
(ii) $R + mg = ma$, $R = m(a - g)$ [1]
= 75 (14.6 – 9.81) = 360 (N) [1] [2]
(c) (i) $R = ma - mg$, <u>$R > 0$ is required</u> to remain contact [1]
so $a > g$, i.e. $v > \sqrt{rg}$, the minimum speed for a contact force to be required [1] [2]
(ii) minimum speed when $v^2/r = g$
$v^2/6.2 = 9.81$ [1]
v = 7.8 (m s^{-1}) [1] [2]
[12]

Comments: The magnitude of centripetal force acting on the man is constant, so in (b) (i) the length of normal contact force at A should be drawn shorter than the length of weight, so that the length of the vector sum is similar to that when the man is at B. In (c) (ii), some used the expression vω for the centripetal acceleration and calculated the value of v incorrectly as g/ω = 9.81/1.53 = 6.4 m s^{-1}.

3 (a) (i) gravitational force provides centripetal force B1
$GMm / r^2 = mv^2 / r$ B1
$v = \sqrt{\frac{GM}{r}}$ A1

Comments: For a "show" question, should start with a statement. Also the word "provides" needs to be written for full credit.

(ii) gain in kinetic energy = loss in gravitational potential energy B1

$\frac{1}{2} mV_0^2 - 0 = 0 - (-GMm / x)$ C1

$V_0 = \sqrt{\frac{2GM}{x}}$ A1

Comments: When question ask "Explain your working", full spelling is needed, e.g. "gravitational potential energy" rather than just "GPE". Leniency in marking saved the day for many candidates in this prelim but please spell in full in A level for qualitative or "show" questions. Besides that, a lot of candidates did not put negative sign for gravitational potential energy. Again, Leniency in marking saved the day for them.

(iii) for $x = r$, V_0 is greater than v M1

Stone could not enter orbit A1

Comments: A lot of candidates did not realise that when V_0 is greater than v, the centripetal force required is greater than the gravitational force provided, and hence gravitational force is insufficient to provide for centripetal force, thus no circular motion. Leniency in marking saved the day for many candidates.

(b) tangent drawn at (4.0, 14.5) B1

gradient = 3.3×10^{-24} to 3.9×10^{-24} A1

field strength = $(3.6 \times 10^{-24}) / (1.6 \times 10^{-19})$

$= 2.3 \times 10^{-5}$ V m^{-1} A1

Comments: Some students gave the force instead of the field strength as the answer.

4 (a) (i) $T = 2\pi\sqrt{(2.3 / 63)} = 1.20$ s C1

$\omega = 2\pi / T = 2\pi / 1.20 = 5.23$ rad s^{-1} A1

OR directly from $\omega = \sqrt{(k / m)}$

(ii) correct substitution C1

giving $E = \frac{1}{2} \times 2.3 \times 5.23^2 \times 0.28^2 = 2.47$ J A1

Comments: This part was answered well.

(b)

	kinetic energy / J	gravitational potential energy / J	elastic potential energy / J	total energy / J
top	**0**	**6.32**	–3.85	**2.47**
middle	**2.47**	reference zero	reference zero	**2.47**
bottom	**0**	**– 6.32**	**8.79**	**2.47**

kinetic energy column correct B1

mgh = 2.3 × 9.81 × 0.28 = 6.32 J B1

giving + 6.32 at top and – 6.32 at bottom B1

total energy constant at 6.32 – 3.85 = 2.47 J B1

so e.p.e. at bottom = 8.79 J B1

Comments: No error-carried-forward for this part of the question. Total energy can be calculated using the first row after obtaining 6.32 J for GPE.
Some students gave the EPE at the bottom to be +3.85 J.

(c) (i) at the resonant frequency $\omega = 2\pi f = 2\pi \times 35.5 = 223$ rad s^{-1} C1
use of $A = 0.0114$ m in equation $a = \omega^2 A$
$= (223)^2 (0.0114) = 567$ m s^{-2} A1

Comments: Students should use f = 35.5 Hz as given in the question and not to read from graph.

(ii) same starting point and lower graph peak B1
maximum amplitude (at same or lower frequency)
within original shape B1

5

(a) **(i)** at 22.5 °C, $R_T = 1600\,\Omega$ or $1.6\,k\Omega$ C1
total resistance = 800 Ω A1 [2]

(ii) *either* use of potential divider formula $V = (0.8/2.0) \times 9$ = 3.6 V *or* current = 9 / 2000 (4.5 mA) $V = (9/2000) \times 800$ = 3.6 V C1 A1 [2]

(b) **(i)** total resistance = 4/5 × 1200 C1
= 960 Ω A1 [2]

(ii) for parallel combination, $1/960 = 1/1600 + 1/R_T$
$R_T = 2400\,\Omega$ / $2.4\,k\Omega$ C1
temperature = 11 °C A1 [2]

(c) e.g. only small part of scale used / small sensitivity B1
non-linear B1 [2]
(*any two sensible suggestions, 1 each, max 2*)
(e.g. from 0 °C to 25 °C, the voltmeter reading varies from about 4.3 V to 3.6 V so only small part of the voltmeter scale is used / small sensitivity in V per °C change)

[10]

Comments: Most answered this question well. In part (b) (ii), lack of care saw a few misread the temperature from Fig. 5.1.

6 **(a)** **(i)** Resistance of the bulb is defined as the ratio $\frac{V}{I}$ where V is the potential difference across the bulb and I is the current flowing in it. [B1]

Comments: It is best to provide the expression for resistance, rather than simply answering that it is the ratio of potential difference to current. Resistance is not potential difference per unit current.

(ii) $P = \frac{V^2}{R}$

$60 = \frac{(240)^2}{R}$ [C1]

$R = 960\ \Omega$ [A1]

(b) $R = \frac{\rho L}{A} = \frac{\rho L}{\left(\frac{\pi d^2}{4}\right)}$

$960 = \frac{(7.9\times10^{-7})(0.14)}{\left(\frac{\pi d^2}{4}\right)}$ [C1]

$d = 1.2 \times 10^{-5}$ m = 0.012 mm [A1]

(c) The ratio of length to cross-section area is the same for all the filaments. [B1]

(d) **(i)** Filament C is used to make the bulb with higher temperature. [A1]

(ii) Filament A is used to make the bulb that can last 2000 hours. [A1]

(e) Missing values in italics, from 3rd to 5th row, one mark for each correct row.[A3]

	A	B	C
resistance/ Ω	*960*	*960*	*960*
diameter/ mm	0.0129	*0.012*	0.0113
length/ m	*0.159*	0.14	*0.122*
surface area/ m^2	*6.4×10^{-6}*	*5.3×10^{-6}*	*4.3×10^{-6}*
power lost per unit area/ W m^{-2}	*0.93×10^7*	*1.13×10^7*	*1.39×10^7*

Comments: Surface area refers to the curved area and the cross-sectional areas of the wire.

(f) From the graph,

filament A temperature = 2420 °C [A1]

filament B temperature = 2600 °C [A1]

filament C temperature = 2730 °C [A1]

Comments: There were some careless reading from the graph. It is expected that readings should be to half the smallest division, similar to practical.

(g) **(i)** For lowest temperature bulb,

running cost = cost of using bulb + cost of replacing bulb
= (0.060 kW)(2000 h)($0.172 kWh^{-1}) + $0.50
= $21.14 [B1]

For highest temperature bulb ,

running cost = cost of using bulb + cost of replacing bulb
= (0.060 kW)(2000 h)($0.172 kWh^{-1}) + $2.00
= $22.64 [B1]

Hence bulb with highest temperature has a higher running cost. [A1]

(ii) light energy from lowest temperature bulb for 2000 hours
= (0.090)(60) (2000 × 3600) = 3.9×10^7 J [B1]

light energy from highest temperature bulb for 2000 hours
= (0.12)(60)(2000 × 3600) = 5.2×10^7 J [B1]

$$\frac{\text{cost of a unit of light energy from lowest temperature bulb}}{\text{cost of a unit of light energy from highest temperature bulb}} = \frac{21.14/3.9}{22.64/5.2}$$ [M1]

$= 1.2$ [A1]

Comments: This part is poorly done. Many students do not know how to use the given electricity cost \$0.172 kWh^{-1} in their calculation.

(iii) (Compact) fluorescent lightbulbs and LEDs [B1]

(iv) Higher energy efficiency/ longer lifespan [B1]

Comments: saves energy or uses less energy/power or brighter light are not acceptable as they are too generic and need to be elaborated further.

[23]

Paper 3

1 **(a)** time $= \frac{\text{distance}}{\text{speed}} = \frac{0.15 \times 10^{12}}{3.00 \times 10^{8}}$

$= 8.3$ min A1

Comments: never leave answer in fraction form.

(b) units of k = N m^{-1} = kg s^{-2}, units of T = s, units of m = kg

$C = T\sqrt{\frac{k}{m}}$

units of $C = \text{s}\sqrt{\frac{\text{kg s}^{-2}}{\text{kg}}} = 1$ A1

Hence C has no units. A0

Comments: Presentation of answer is important as it is a 'show' type of question. Often mistakes were made by equating quantity with unit e.g. k = kg s^{-2}

(c) **(i)** $C = T\sqrt{\frac{k}{m}} = 0.242\sqrt{\frac{239}{0.300}} = 6.83$ A1

(ii) $\frac{\Delta C}{C} = \frac{\Delta T}{T} + \left(\frac{1}{2}\right)\frac{\Delta k}{k} + \left(\frac{1}{2}\right)\frac{\Delta m}{m}$

$= \frac{1}{100} + \left(\frac{1}{2}\right)\frac{3}{100} + \left(\frac{1}{2}\right)\frac{2}{100}$

$= 0.035$ C1

$\Delta C = 0.2$

$C = (6.8 \pm 0.2)$ A1

(iii) accuracy: determined by the closeness of the value(s)/ measurement(s) to the true value B1

precision: determined by the range of values/measurements B1

2 **(a)** Straight line graph through origin, so A1

extension is proportional to applied force, it obeys Hooke's law

(b) area under graph = ½ Fx = ½ (12.0)(8.0 × 10^{-2}) A1

= 0.48 J

Comments: Students must write down the appropriate algebraic equation and then show the full substitution of numerical values.

(c) **(i)** conservation of momentum, $4.0\ v_A = 6.0\ v_B$ M1

ratio = $\dfrac{0.50\times 4.0\times v_A^2}{0.50\times 6.0\times v_B^2} = \dfrac{0.50\times 4.0}{0.50\times 6.0}\left(\dfrac{6.0}{4.0}\right)^2$ C1

= 1.5 A1

Comments: The force was not constant and the acceleration was not uniform. It was wrong to use kinematics equations (v = u + at or etc) to work out the answer. No credit for such an approach.

(ii) 0.48 = (KE of A) + (KE of B)

$0.48 = \dfrac{5}{3}$ (KE of A) $= \dfrac{5}{3}\left(\dfrac{1}{2}\times 4.0\times v_A^2\right)$ C1

$v_A = 0.38$ m s^{-1} A1

(d) curve starts from origin and has decreasing gradient B1

final gradient of graph is zero B1

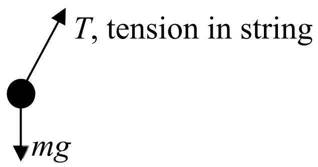
Comments: The graph is the first quarter of a sine graph. Few students understood and showed clearly that when the extension of the spring becomes zero the force on block A will become zero so that the gradient of the graph (rate of change of velocity) becomes zero momentarily. The graph should stop once gradient has reached zero.

(e) Momentum of A and momentum of B are always equal in magnitude but opposite in directions (conservation of momentum) M1

So the two masses must oscillate with the same frequency. A1

3 **(a)** $T\sin\theta = ma$

$T\cos\theta = mg$ C1



$\tan\theta = \dfrac{a}{g}$

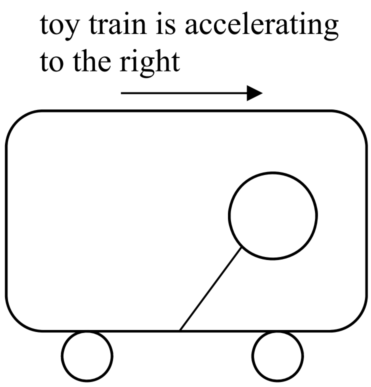
$\theta = 14°$ A1

(**b**) more air is packed at the back in the accelerating train B1

Therefore higher pressure at back than at front of train B1

Force due to pressure difference pushes the helium balloon forward. B1

Helium (lighter than air) balloon leans forward to region of lower pressure.



(c) **(i)** Friction A1

(ii) $F = \frac{\Delta(mv)}{\Delta t} = 60 \times 2.0$ C1

$= 120$ N A1

(iii) $P = Fv = 120 \times 2.0 = 240\,\text{W}$ A1

(iv) $K = \frac{1}{2}\frac{mv^2}{\Delta t} = \frac{1}{2} \times 60 \times 2^2 = 120\,\text{W}$ A1

(v) Friction between sand and belt
Kinetic energy is lost/ dissipated as <u>internal energy/ Heat in the sand and conveyor belt</u>. A1

4 **(a)** Molecule has component of velocity in three directions

$c^2 = c_x^2 + c_y^2 + c_z^2$ B1

Averaging: $\langle c^2 \rangle = \langle c_x^2 \rangle + \langle c_y^2 \rangle + \langle c_z^2 \rangle$ B1

Due to <u>random motion</u>: $\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$ B1

$\langle c^2 \rangle = 3\langle c_x^2 \rangle$

$\langle c_x^2 \rangle = \frac{1}{3}\langle c^2 \rangle$

$P = \frac{Nm\langle c_x^2 \rangle}{V} = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$ A0

(b) work done = $p\Delta V = 5.7 \times 10^6$ Pa × $(3.1 - 2.0) \times 10^{-5}$ m^3 1

= 62.7 J 1

(c)

section of cycle	heat supplied to the gas / J	work done on the gas / J	increase in the internal energy of the system / J
A → B	0	235	**235** A1
B → C	246	**– 63** B1	**183** B2 (sum of 246 and –63)
C → D	0	– 333	**– 333** A2
D → A	**–85** C2	**0** C1	−(235 + 183 –333) = **– 85** C2

A1 & A2 (1), B1 & B2 (1), C1 & C2 (1), no ECF

Comments: In (a), many mixed up $\langle c_x^2 \rangle$ and $\langle c_x \rangle^2$, as well as the expressions $\langle c_x^2 \rangle = \langle c_y^2 \rangle = \langle c_z^2 \rangle$ and $c_x = c_y = c_z$. In (b), some gave negative value for the work done by the gas. Most answered part (c) well, though a few were careless in additions and subtractions when using $\Delta U = Q + W$ and $\Delta U_{cyclic\ process} = 0$.

5 **(a)** **(i)** Waves from loudspeaker travel down tube and are reflected at closed end B1

Two waves travelling in opposite directions with same frequency and wavelength overlap B1

(ii) 0.51 m or 0.85 m A1

(b) **(i)** number = 5 A1

(ii) phase difference = 180° or π rad (must have unit) A1

(iii) $T = \frac{1}{50}$ = 20 ms C1

1. reflection of curve about the line XY and labelled M A1

2. horizontal line between X and Y and labelled N A1

Comments: Many students are unable to obtain the correct phase difference or draw N correctly.

6 **(a)** p.d. per unit length = V_{XY} / 100 = 2.0/100 = 0.020 V cm^{-1} C1

XP = 1.50/0.020 = 75 cm A1

(b) V_{XY} = (5.0/6.0) (2.0 V) = 5/3 V C1

p.d. per unit length = V_{XY} / 100 = (5/3)/100 = 0.017 V cm^{-1} C1

XP = 1.50/0.017 = 90 cm A1

(c) terminal p.d. of cell B = 1.50 – (1.50/1.80)(0.80) or $\left[1.0/(1.0+0.80)\right](1.5)$ C1

= 0.833 V C1

XP = 0.833/0.020 = 41.7 cm A1

Comments: Some found this question challenging. The difficulties they experienced were in calculating voltage per unit of length of wire XY and identifying the p.d. across XP.

7 **(a)** **(i)** (induced) e.m.f proportional/equal to rate of change of flux (linkage) B1
(allow 'induced voltage, induced p.d.)
flux is cut as the disc moves M1
hence inducing an e.m.f A0

(ii) field in disc is not uniform/rate of cutting not same/speed of disc not same (over whole disc) B1
so different e.m.f.'s in different parts of disc M1
lead to eddy currents A0

(b) eddy currents dissipate thermal energy in disc B1
energy derived from oscillation of disc B1
energy of disc depends on amplitude of oscillations B1

Comments: Answers to this question, especially parts (a) (ii) and (b), were generally poor. A number quoted Faraday's law of EM induction incorrectly. Another issue was the inappropriate use of correct language here, as the phrase cutting of magnetic flux linkage was used instead of cutting of magnetic flux. In part (b), many did not mention eddy currents dissipating thermal energy in disc, and the dependence on the amplitude of oscillations of the total energy of disc.

8 **(a)** **(i)** A region of space where a force is experienced and is represented by lines of forces. B1

Comments: Some candidates are not awarded marks if their answers are specific to "charge' or "mass" but question asked for force-field in general.

(ii) Field strength was related to the closeness of the lines of force. B1
The field strength is greater if the lines of force are closer to each other. B1

Comments: This part is well done.

(b) **(i)** Mass B1
(ii) Positive charge B1
(iii) North Pole B1

Comments: Majority of the candidate did not read the question carefully and did not realise that the force must be in the same direction as the field as stated in the question.

(c) **(i)** Magnetic force provides centripetal force
$Bqv = mv^2 / r$
$r = (1.67 \times 10^{-27} \times 4.5 \times 10^{6}) / (1.2 \times 1.6 \times 10^{-19})$ C1
$r = 0.039$ m
$= 3.9$ cm A1

Comments: This part is well done

(ii) circular path with the correct radius C1
clockwise C1
exit field at an angle below horizontal and pointing to the right C1
straight line tangential outside field C1

Comments: Candidates need to use <u>compass</u> to draw circle and <u>ruler</u> to draw straight line to earn the full credit.

(d) **(i)** arrow pointing up the page B1

Comments: Candidates need to use <u>ruler</u> to draw straight line to earn the full credit.

(ii) $Bqv = Eq$ C1
$E = 1.2 \times 4.5 \times 10^6$
$= 5.4 \times 10^6$ V m^{-1} A1

Comments: A small number of candidates used $E = Q/(4\pi\varepsilon_0 r^2)$ which is only applicable if field is produced by a point charge.

(e) gravitational force <u>very</u> small compared with magnetic force and/or electric force B1

Comments: Must do comparison. Also must compare quantities with same unit, e.g. compare gravitational force with electric force rather than compared mass with charge.

(f) **(i)** magnetic force > electric force M1
So deflects upwards A1

(ii) $Bqv = q E$, forces are independent of mass and charge 'cancels' M1
So no deviation A1

Comments: For (f)(ii), some candidates did not realize that both magnetic force and electric force doubles so they are still equal in magnitude. Leniency in marking saved the day for them.

9 **(a)** packet of energy of electromagnetic radiation B1
energy = hf B1

Comments: A lot of candidates have missing keywords such as "electromagnetic radiation" and "Energy = hf". Another common mistake is that a number of candidates wrote "electromagnetic waves" which is not suitable in this context where photon is a particle and not a wave.

(b) (i) arrow below axis and pointing to right B1

(ii) 1 change in energy of photon = $\frac{hc}{\lambda_f} - \frac{hc}{\lambda_i}$ M1

$$= (6.63\times10^{-34}\times3.0\times10^{8})\left(\frac{1}{6.84\times10^{-12}} - \frac{1}{6.50\times10^{-12}}\right)$$

$= -1.52\times10^{-15}$ J (accept +ve value) A1

(ii) 2 gain in kinetic energy of electron = loss in energy of photon

$\frac{1}{2} m v^2 = 1.52\times10^{-15}$

$\frac{1}{2} (9.11 \times 10^{-31}) v^2 = 1.52\times10^{-15}$ C1

$v = 5.78\times10^{7}$ m s^{-1} A1

(iii) conservation of momentum in either x or y direction C1

$$\left(\frac{6.63\times10^{-34}}{6.50\times10^{-12}}\right) = \left(\frac{6.63\times10^{-34}}{6.84\times10^{-12}}\right)\cos\theta + (9.11\times10^{-31})(5.78\times10^{7})\cos70°$$

OR

$$\left(\frac{6.63\times10^{-34}}{6.84\times10^{-12}}\right)\sin\theta = (9.11\times10^{-31})(5.78\times10^{7})\sin70°$$ C1

Solving: θ = 30.7° A1

Comments: Conservation of momentum is needed to be awarded marks

(c) (i) hf = Φ + KE_{max}

$$\frac{6.63\times10^{-34}(3\times10^{8})}{6.84\times10^{-12}} = (180\times10^{3}\times1.6\times10^{-19}) + KE_{max}$$ M1

$KE_{max} = 2.79 \times 10^{-16}$ J A1

Comments: This part is well done

(ii) $KE_{max} = eV_S$

$2.79 \times 10^{-16} = (1.6 \times 10^{-19})\ V_S$ M1

V_S = 1.74 kV A1

Comments: This part is well done

(iii) These electrons are emitted from the surface where least energy is required for emission (hence the remaining kinetic energy is maximum)

A1

Comments: This part is marked leniently. Candidates should improve on their answers even though they are awarded credit.

(d) **(i)** Energy needed to transit to level 2 = $-0.46 \times 10^{-15} - (-1.84 \times 10^{-15})$ C1

$= 1.38 \times 10^{-15}$ C1

Remaining energy = $1.52 \times 10^{-15} - 1.38 \times 10^{-15} = 0.14 \times 10^{-15}$ J

$= 1.4 \times 10^{-16}$ J A1

(ii) The atom will not transit to higher energy level A1
because the energy of the photon is not equal to the
difference between any two energy levels M1

Comments: This part is well done

<u>Paper 4</u>

Qns			Skills Assessed and Marking Instructions	M
1	**a**	**(i)**	Value of *x* to nearest mm with unit in the range 9.0 – 11.0 cm.	1
		(ii)	Percentage uncertainty in *x* based on absolute uncertainty of 2 – 4 mm. If repeated readings have been taken, then the uncertainty can be half the range (but not zero) if the working is clearly shown. Correct method of calculation to obtain percentage uncertainty. Percentage uncertainty in 1 or 2 s.f.	1
	b	**(i)**	Value of raw *L* to nearest mm with unit in the range 20.0 – 30.0 cm.	1
		(ii)	Correct calculation of $\sqrt{L}$ with correct unit.	1
		(iii)	Justification for s.f. in $\sqrt{L}$ <u>linked to s.f. in *L*</u>.	1
	c	**(ii)**	Second value of *L* with unit. Second value of $\sqrt{L}$ > first value of $\sqrt{L}$	1 1
	d	**(i)**	Two values of *k* calculated correctly with correct unit.	1
		(ii)	Draw conclusion based on the calculated values of *k* (calculate the percentage difference between two values of *k*). Candidate must test against a specified criterion (the criteria can be equal or greater than percentage uncertainty calculated *(a)(ii)*).	1 1
	e		Values of *T* in the range 1.0 – 2.0 s. The number of oscillations *n* taken such that *nT* > 15 s.	1
	f		Correct calculation of *g* using second value of k. *g* with correct consistent unit	1 1

Qns			Skills Assessed and Marking Instructions	M
2	a		Value of raw *d* and raw *t* to the nearest mm with unit.	1
	b		Correct calculation of *V* with unit.	1
	c		Value of *n* with no unit. Evidence of repeats.	1 1
	d		Value of *k* calculated correctly with correct consistent unit, e.g. m^{-3}.	1
	e		Correct unit and calculation of *M*, in the range 2.0 – 8.0 g.	1
	f		Weight of coins + lids = upthrust $(nM + m)g = \rho Vg$ Repeat step (a) to (c) • measure *d* and *t*. • Calculate *V* • Put coins into the lid until the lid sinks and record n For ten different lids of the same mass. Plot a straight line graph of *n* against *V* with gradient $\frac{\rho}{M}$ and y-intercept $= -\frac{m}{M}$ $M = \frac{\rho}{gradient}$ and *m* = (– y-intercept) (*M*) Method to ensure the coins and lids are dry before conducting each set of experiment. Use a lever system to ensure each coin has same *M* and same *m* for each lid. Or other sensible details	1 1 1 1

Qns			Skills Assessed and Marking Instructions		M
3	b		Room temperature in the range 25 to 36 °C, to the nearest 1 °C.		1
	c	(ii)	Value of *V* with unit V Value of *I* with unit mA. *I* not more than 20 mA.		1 1
	d		• Award 2 marks if student has successfully collected 6 or more sets of data (*V, I*) without assistance/intervention. 5 sets one mark. 4 or fewer sets zero mark. • Deduct 1 mark if minor help from supervisor, deduct 2 if major help. • Deduct 1 mark if range of $I \leq 10$ mA	d1	2

			Each column heading must contain a quantity and a unit where appropriate. Ignore units in the body of the table. There must be some distinguishing mark between the quantity and the unit i.e. solidus is expected, I/mA. Allow ln(I), ln(I/mA) but not ln$I$/mA.	d2	1
			Consistency of raw readings for I *(2 dp)* and *V (3 dp)*.	d3	1
			For each calculated value of *ln* I, the number of d.p in calculated value should be equal to the number of s.f. in the raw readings.	d4	1
			Correctly calculated values of *ln* (I).	d5	1
	e		Linearising equation and deriving expressions that equate e.g. gradient to $\frac{e}{kT}$ and *y*-intercept to ln(I_0)	e1	1
			Graph: Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points occupy at least half the graph grid in both *x* and *y* directions. Scales must be labeled with the quantity which is being plotted.	e2	1
			All observations must be correctly plotted. Work to an accuracy of half a small square. Diameter of the plotted point must be less than half the small square.	e3	1
			Line of best fit – judge by scatter of points about the candidate's line. There must be a fair scatter of points either side of the line. Allow <u>only one anomalous</u> point if clearly indicated (i.e. labelled or circled) by the student. Thickness of line must be less than half the small square.	e4	1
			Gradient – the hypotenuse of the Δ must be greater than half the length of the drawn line. Read-offs must be accurate to half a small square. Check for $\Delta y/\Delta x$ (i.e. do not allow $\Delta x/\Delta y$).	e5	1
			y-intercept – must be read off to nearest half a small square or determined from $y=mx+c$ using a point on the line.	e6	1
			Values of *e* calculated correctly. Value of *e* must be in the range of 10^{-19} to 10^{-20}	e7	1
			Value of I_0 calculated correctly.	e8	1
			Correct units correct for both *e* and I_0.	e9	1
	f		T = 373.15 K Value of I calculated correctly.		1 1

4

<u>Defining the problem</u>

A1: identify independent (length *r*) and dependent (frequency *f* of turntable) <u>and</u> keeping mass *m* constant [1]

Comments: using the same cube as the variable to keep constant is not acceptable as the reason for using the same cube i.e. to keep m constant need to be mentioned.

Method of data collection

B1: labelled diagram showing power supply connected to motor (two leads) within turntable; circuit must be workable [1]

B2: method to change frequency of rotation of turntable e.g. adjust output of variable power supply or adjust variable resistor [1]

B3: increase frequency until the cube moves (relative to the turntable) [1]

B4: method to determine the period of rotation of turntable e.g. stopwatch, light gate attached to a timer/data-logger or stroboscope [1]

Comments: Marks will not be awarded if light gate with data logger are not correctly set up for use.

Method of Analysis

C1: plot a graph of *f* against 1 / *r* (allow log *f* against log *r*) [1]
relationship valid if a straight line produced passing through the origin
(for log *f* vs log *r*, straight line of gradient –1)

C2: K = gradient x $4\pi^2 m$ (for log *f* vs log *r*, $K = 10^{\text{y-intercept}} \times 4\pi^2 m$) [1]

Comments: Statement about validity of relationship is often left out or wrongly written.

Safety

D1: to protect against flying cube e.g. use safety screen [1]

Comments: use of googles to protect eyes is not good enough and as the face can also be hurt by flying cube.

Additional details: (max 4)

E1: time of oscillations >= 15.0 s and repeated time measurements and correct determination of period of rotation of turntable or fiducial marker to aid in counting the number of oscillations [1]

Comments: It is important that the time of oscillation be at least 15 s to minimise the random error due to human reaction time, and thus decide on the number of oscillations required.

E2: *f* = 1 / *T* or detailed use of stroboscope AND repeat experiment for each *r* and average *f* [1]

E3: use balance to measure mass of cube [1]

E4: use a spirit level to check that turntable is horizontal or clean cube/surface [1]

E5: use a ruler to measure *r* [1]

E6: method to ensure that r is measured to the centre of the cube e.g. put a mark on the cube or align front or back of cube by a set distance [1]

E7: method to determine the centre of the turntable [1]

E8: wait for turntable to rotate steadily before increasing frequency or gradual/incremental/slowly increase in frequency [1]

Independent variable: distance *r* of the mass from the centre of turntable
Dependent variable: frequency *f* of the turntable
Variable to be kept constant: mass *m* of the cube.

Labeled diagram:

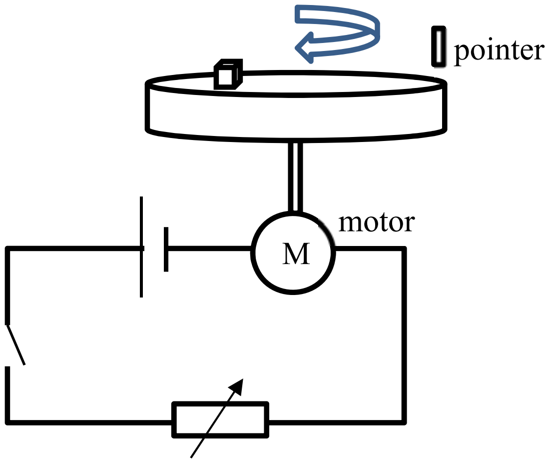


Fig. B

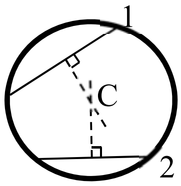


Fig. A

Procedures:

1. Put a mark on the centre of the cube using a marker.
2. Determine the centre of the turntable. This can be done by drawing 2 chords on the turntable. At the mid-point of each chord, draw a perpendicular line using a set-square. This is shown by the dotted lines in Fig. A. The intersection of the dotted lines gives the centre C of the turntable.
3. Set up the apparatus as shown in Fig. B.
4. Use a ruler to measure the distance *r*, from the centre of the cube to the centre of the turntable.
5. When the switch is closed, the cell supplies current to the motor which causes the turntable to rotate. Gradually increase the frequency of rotation by adjusting the variable resistor until the cube moves relative to the turntable.
6. A fiducial marker is used to aid in counting the number of rotations *N* of the pointer on the turntable. Measure the time taken *t* to complete *N* rotations using a stopwatch. The frequency *f* of the turntable can be found using $f = 1 / T = N / t$.
7. Repeat steps 4 to 7 to obtain at least 10 sets of readings for *r* and *f*, until *r* is about the full radius of the turntable.

<u>How to improve accuracy</u>:
1. Ensure that the total time taken to measure the rotations is ≥ 20 s and repeat the measurements.
2. The average *f* is obtained for each value of *r*.
3. Use a spirit level to check that the turntable is horizontal.
4. The mass *m* of the cube is measured using a weighing balance.

<u>Data analysis:</u>
$f = K / 4\pi^2 mr$
Plot a graph of *f* vs 1 / *r*
The relationship is valid if a straight line graph passing through the origin is obtained.
K = gradient x $4\pi^2 m$

<u>Safety Precautions:</u>
1. Use a safety screen or wear googles so that the flying cube does not accidentally hit the eyes.