Name: ____________________________ (   )   Class: 20 / ______

ANDERSON SERANGOON JUNIOR COLLEGE

2020 JC2 Preliminary Examination

PHYSICS Higher 2 — 9749/01

Paper 1 Multiple Choice — **Tuesday 22 September 2020**

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Write your name and class on the Multiple Choice Answer Sheet.
Shade and write your NRIC/FIN.

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 Multiple Choice Answer Sheet.

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

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ 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	$\phi = -\dfrac{Gm}{r}$
temperature	$T/\text{K} = T/^\circ\text{C} + 273.15$
pressure of an ideal gas	$p = \dfrac{1}{3}\dfrac{Nm}{V}\langle c^2\rangle$
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	$V = \dfrac{Q}{4\pi\varepsilon_o r}$
alternating current/voltage	$x = x_0 \sin \omega t$
magnetic flux density due to a long straight wire	$B = \dfrac{\mu_o I}{2\pi d}$
magnetic flux density due to a flat circular coil	$B = \dfrac{\mu_o NI}{2r}$
magnetic flux density due to a long solenoid	$B = \mu_o nI$
radioactive decay	$x = x_0 \exp(-\lambda t)$
decay constant	$\lambda = \dfrac{\ln 2}{t_{\frac{1}{2}}}$

1 A student makes the following measurements to determine the density of a plastic ruler.

length = 31.2 ± 0.1 cm
cross−sectional area = 0.32 ± 0.02 cm^2
mass = 13.78 ± 0.01 g

Which statement is correct?

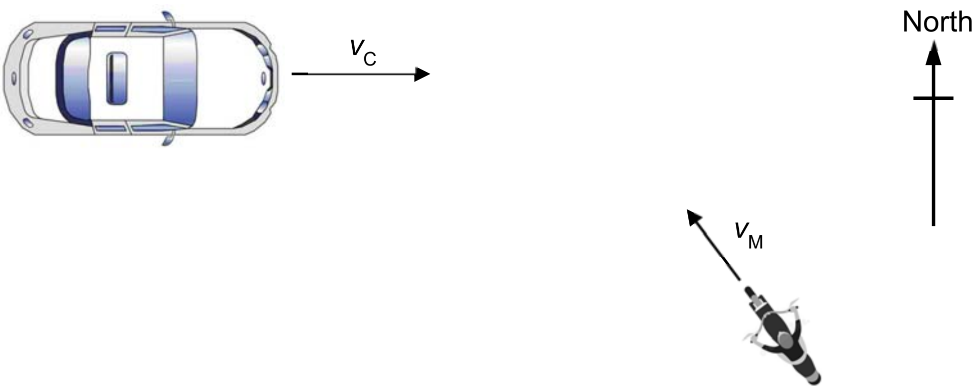
A The actual uncertainty of density is 0.03 g cm^{-3}.

B The fractional uncertainty of density is 0.031.

C The percentage uncertainty of density is 6.6 %.

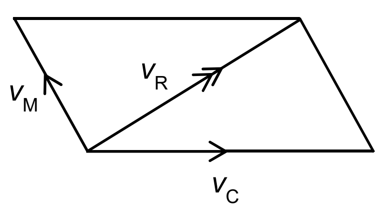
D The density of the plastic ruler is expressed as 1.38 ± 0.07 g cm^{-3}.

2 A passenger in a car travelling due East at speed v_C sees a motorcyclist travelling due North-West at speed v_M.

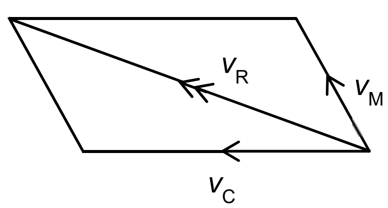


Which diagram shows the velocity v_R of the motorcyclist relative to the passenger on the car?

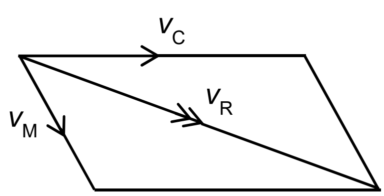
A



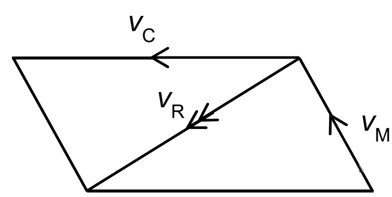
B



C

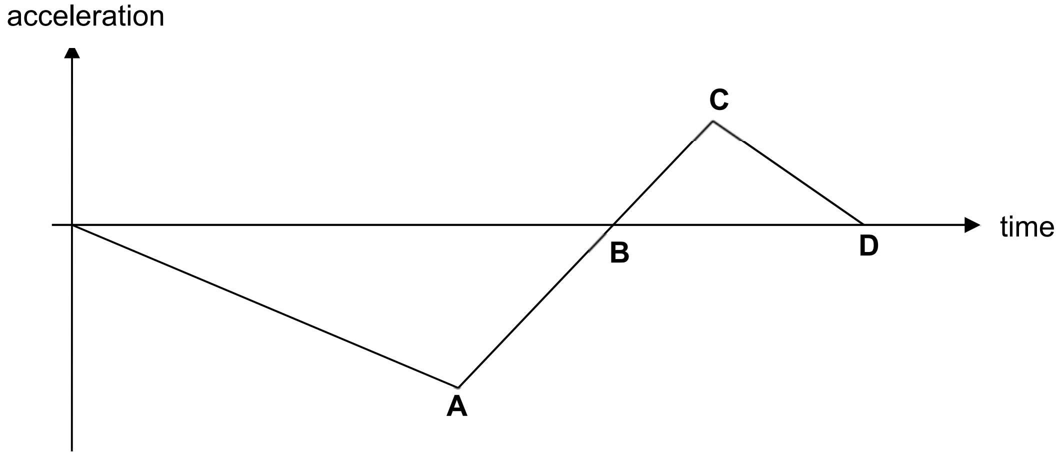


D

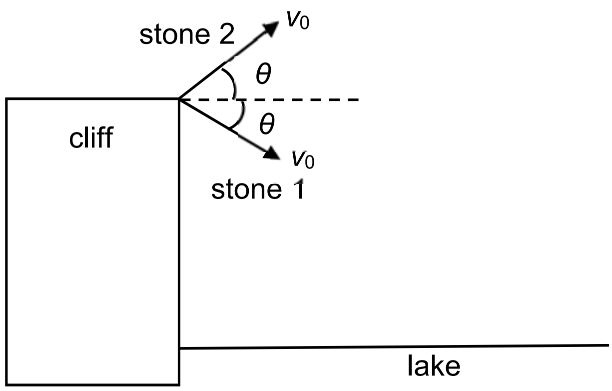


3 The acceleration−time graph of an object in a straight line is as shown. The object was initially at rest.

Which point on the graph does the object has the largest speed?



4 A student throws two stones from the top of a cliff overlooking a lake.



The stones have identical initial speed v_0. Stone 1 is thrown at an angle θ below the horizontal, while stone 2 is thrown at the same angle θ above the horizontal. Air resistance is assumed to be negligible.

Which of the following statements is true?

A Both stones strike the water with the same velocity.

B Stone 1 strikes the water with a greater speed than stone 2.

C Stone 2 strikes the water with a greater speed than stone 1.

D Both stones strike the water with the same speed but at a different angle above the water surface.

5 Two blocks move towards each other with speed v on a smooth surface.

The blocks collide inelastically. Which statement is correct?

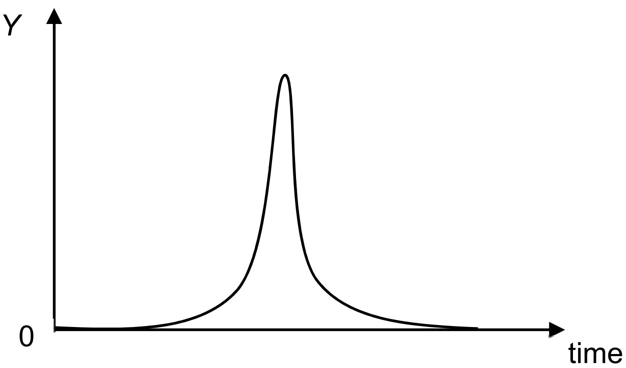
A The relative speed of separation is $2v$.

B The two blocks stick together after collision.

C The sum of momentum after collision is less than the sum of momentum before collision.

D The sum of momentum after collision is the same as the sum of momentum before collision.

6 The area under the graph represents the impulse during a collision.



What is the quantity Y?

A kinetic energy **B** resultant force **C** total momentum **D** acceleration

7 A ball which is less dense than water is held in the water by a string at the base of a tank. The string is cut and the ball rises to the surface of the water and eventually floats on the water. Fig. I shows when the ball is held by the string, Fig. II when the ball is rising and Fig. III when the ball is floating on the water.

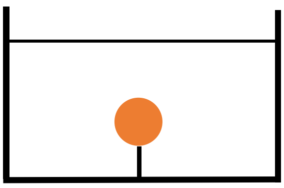


Fig. I

held by string

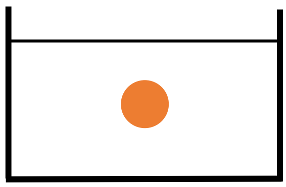


Fig. II

rising

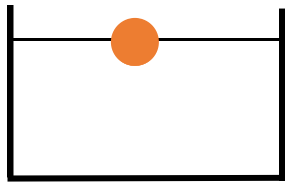


Fig. III

floating

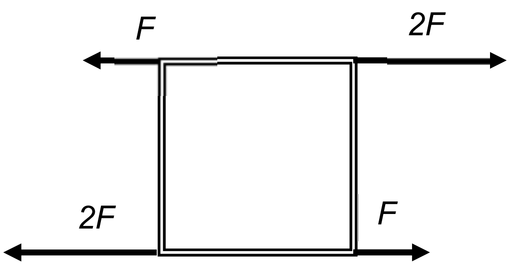
In which figure(s) is the upthrust and the resultant force acting on the ball the greatest?

	upthrust	resultant force
A	I	II
B	I	I & II
C	I & II	II
D	I & II	III

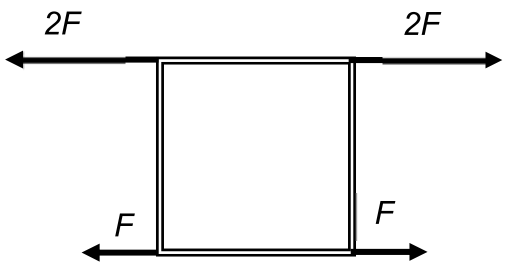
8 Four forces act on the corners of a rigid square, resting on a frictionless surface.

In which situation will the square be in equilibrium?

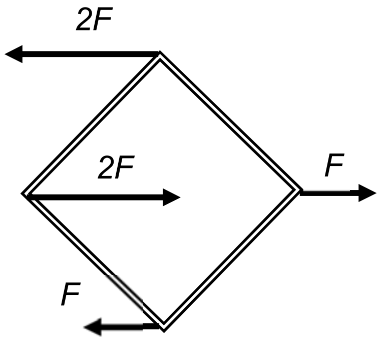
A



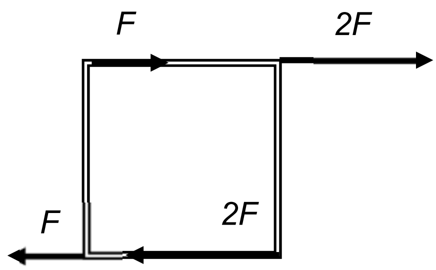
B



C



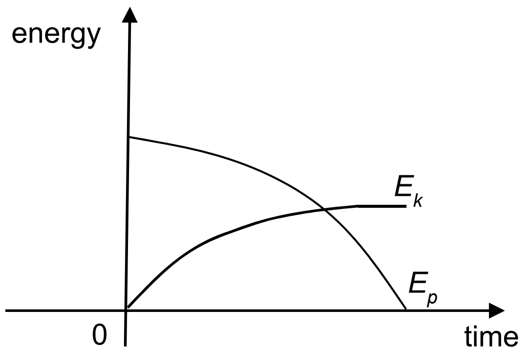
D



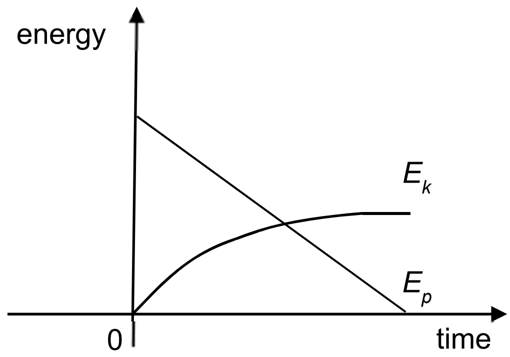
9 A steel ball is released from rest in a tall cylinder of oil.

Which graph shows variation with time of the gravitational potential energy, E_p and the kinetic energy, E_k of the ball?

A



B



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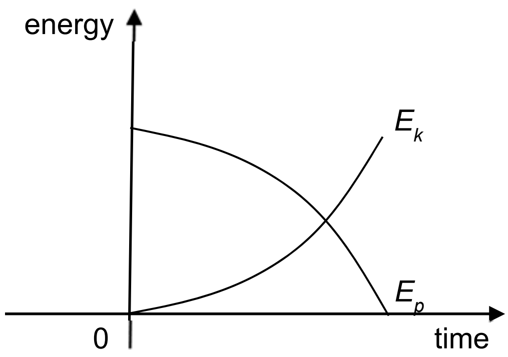

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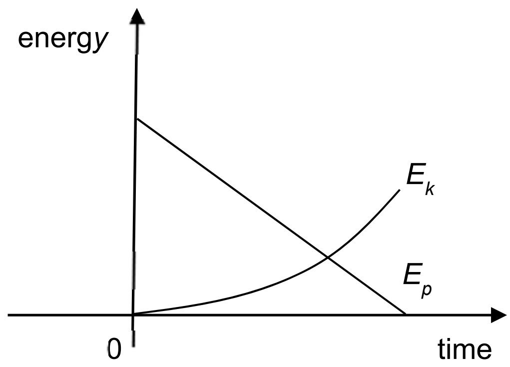


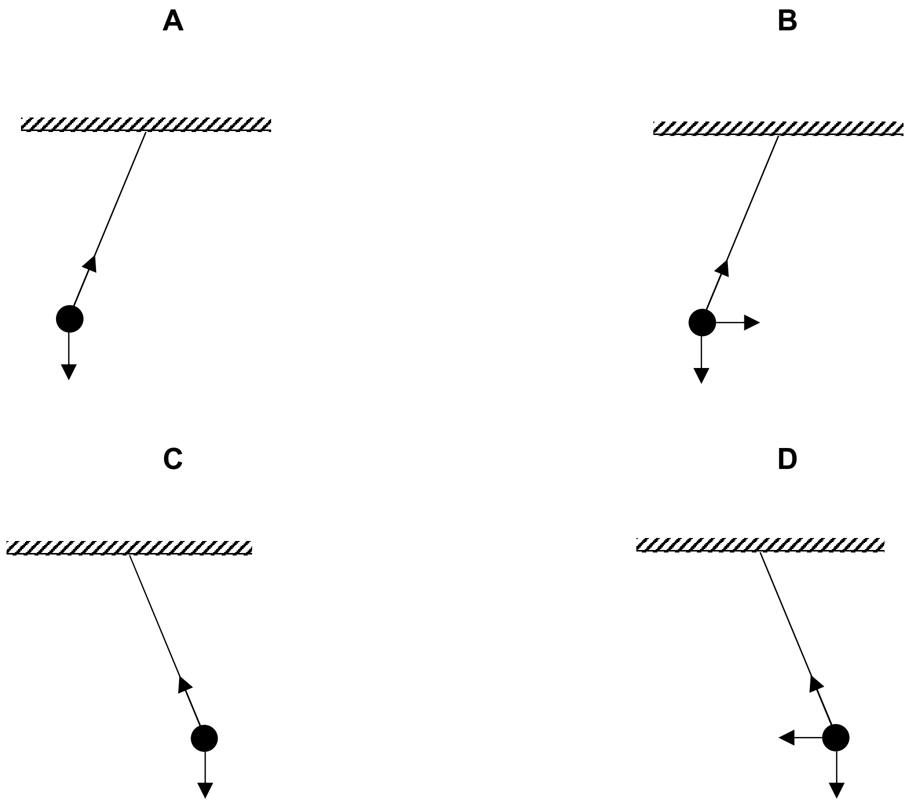
10 An old-fashioned 60 W lamp converts 95% of its energy supply into heat. A 4.0 W modern lamp has the same power output of light as the old-fashioned lamp.

What is the efficiency of the modern lamp?

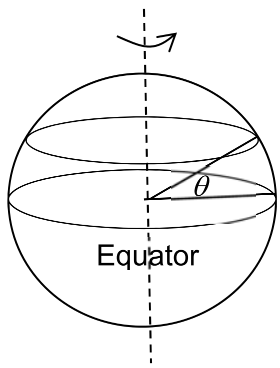
A 5.0% **B** 6.7% **C** 75% **D** 95%

11 A passenger is sitting in a railway carriage facing the direction in which the train is travelling. A pendulum hangs down in front of him from the carriage roof. The train travels along a circular arc bending to the left.

Which one of the following diagrams shows the position of the pendulum as seen by the passenger, and the directions of the forces acting on it?



12 The Earth has a radius of 6.38×10^6 m, and rotates on its axis once every 24 hours.



What is the linear speed of a person standing at a latitude θ of 30° on the surface of the Earth?

A 230 m s^{-1} **B** 400 m s^{-1} **C** 540 m s^{-1} **D** 8.4×10^5 m s^{-1}

13 Two satellites X and Y are orbiting at heights of 5R and 9R above the surface of the Earth respectively, where R is the radius of the Earth.

What is the $\dfrac{\text{linear speed of satellite X}}{\text{linear speed of satellite Y}}$?

A 1.29 **B** 1.34 **C** 1.67 **D** 1.80

14 A liquid is maintained at boiling point by means of an electric heater.

The constant rate at which the liquid boils is measured for two different powers of the heater as shown.

power of heater	rate of loss of mass of liquid
P_1	m_1
P_2	m_2

For each power of the heater, P_1 or P_2, the rate of heat loss to the environment is the same.

Which expression is the correct expression for rate of heat loss to the environment?

A $\dfrac{P_1 - P_2}{m_2 - m_1}$ **B** $P_1 - P_2$ **C** $\dfrac{P_1}{m_1}$ **D** $\dfrac{P_1 m_2 - P_2 m_1}{m_2 - m_1}$

15 In deriving the equation $p = \frac{1}{3}\rho < c^2 >$ in the simple kinetic theory of gases, where p is pressure, ρ is the density of the gas and $< c^2 >$ is the mean square speed of the gas particles, which of the following is not taken as a valid assumption?

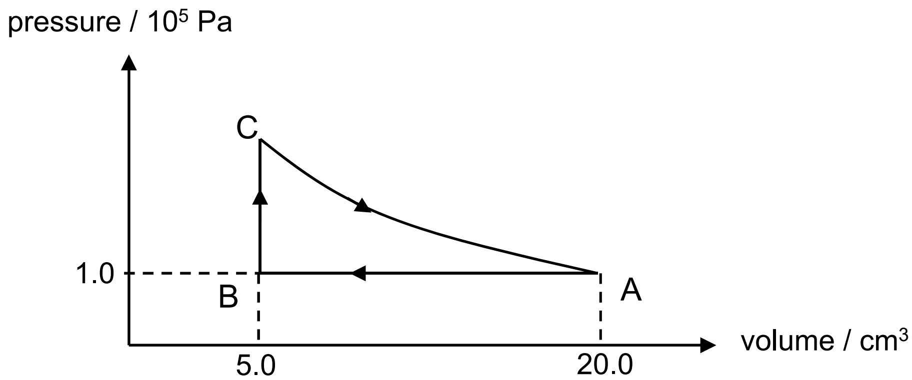
A The molecules are in continuous random motion.

B Attractive forces between the molecules are negligible.

C The average kinetic energy of a molecule is directly proportional to the temperature of the gas.

D Collisions with the walls of the container and with other molecules cause no change in the average kinetic energy of the molecules.

16 An ideal gas undergoes a cycle of changes A → B → C → A, as shown below.

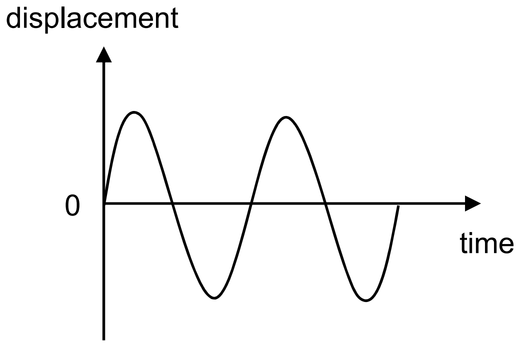


Work done by gas from C to A is 4.2 J.

What is the overall heat gain in process A → B → C → A?

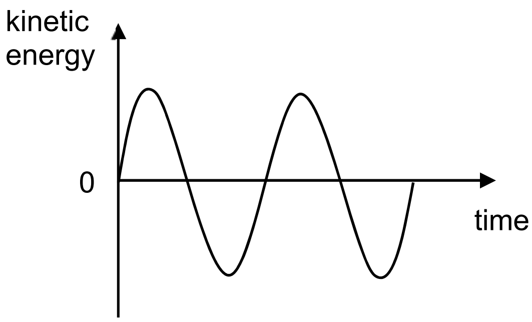
A –5.7 J **B** –2.7 J **C** 2.7 J **D** 5.7 J

17 The variation with time of displacement of an oscillating mass is shown in the graph below.

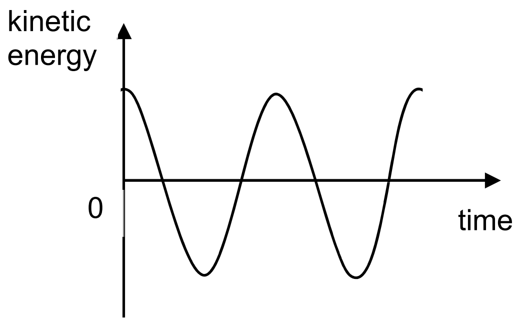


Which one of the following graphs best represents the variation with time of its kinetic energy?

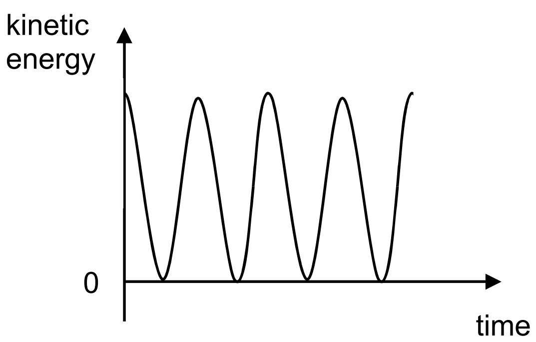
A



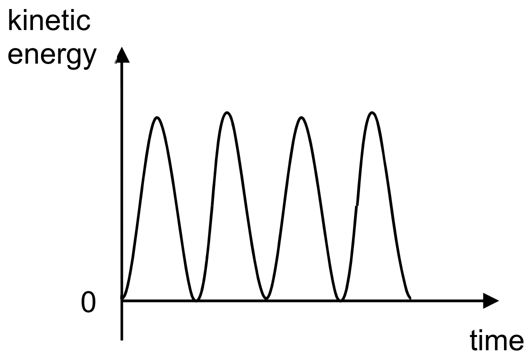
B



C



D



18 A beam of plane-polarised light of intensity I falls normally on a thin sheet of polaroid.

If the transmitted light beam has an intensity of $\frac{I}{4}$, what is the angle between the plane of polarisation of the incident beam and the polarising axis of the polaroid?

A 14° **B** 30° **C** 60° **D** 76°

19 A beam of monochromatic light is incident normally on a diffraction grating with N_1 number of lines per millimetre. The second order diffracted beam makes an angle of 45° with the grating.

The grating is then replaced by one with N_2 number of lines per millimetre. The third order diffracted beam is now observed at the same angle.

What is the ratio of $\dfrac{N_1}{N_2}$?

A 0.47 **B** 0.67 **C** 1.1 **D** 1.5

20 Green light is emitted by two point sources. The light passes through a narrow slit and is incident on a screen. The images of the two sources just failed to be resolved.

Which of the following changes will allow the images to be resolved?

A Replacing the narrow slit with a circular aperture of a smaller size

B Moving the two sources further from the slit

C Moving the screen nearer to the slit

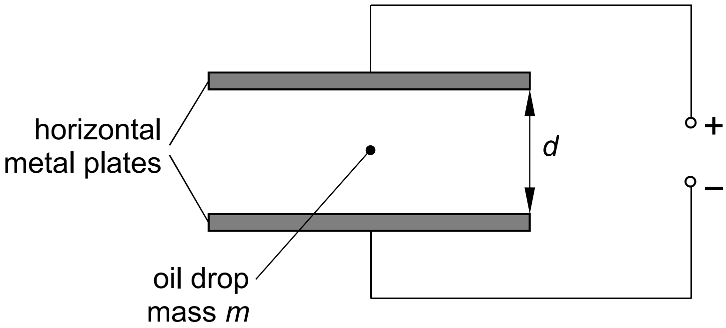
D Using violet light

21 A small charge q is placed in the electric field of a large charge Q.
Both charges experience a force F.

What is the electric field strength due to the charge q at the position of the charge Q?

A $\dfrac{F}{Qq}$ **B** $\dfrac{F}{Q}$ **C** FQq **D** $\dfrac{F}{q}$

22 A negatively charged oil drop of mass m is between two horizontal parallel metal plates at a distance d apart.



When the potential difference (p.d.) between the plates is V_1, the oil drop rises at a constant speed. When the p.d. is decreased to V_2, the oil drop falls at the same constant speed.

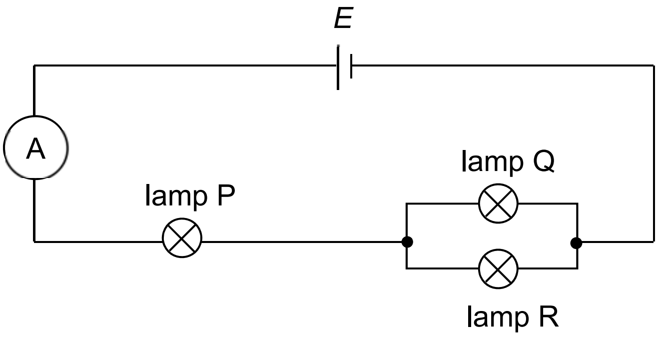
Air resistance acts on the oil drop when it is moving. The upthrust on the drop is negligible.

The acceleration of free fall is g.

What is the charge on the oil drop?

A $\dfrac{mdg}{V_1 - V_2}$ **B** $\dfrac{mdg}{V_1 + V_2}$ **C** $\dfrac{2mdg}{V_1 - V_2}$ **D** $\dfrac{2mdg}{V_1 + V_2}$

23 Three identical lamps P, Q and R are connected as shown in the diagram. Each lamp operates at normal brightness and the ammeter (of negligible resistance) registers a steady current.



The filament of lamp Q breaks. What happens to the ammeter reading and the brightness of the remaining lamps?

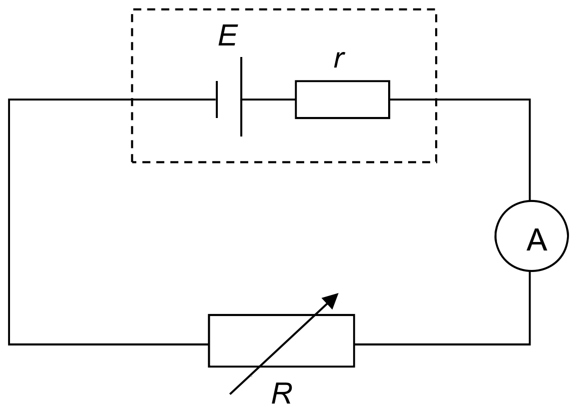
	ammeter reading	brightness of lamp P	brightness of lamp R
A	increases	increases	decreases
B	increases	decreases	increases
C	decreases	increases	decreases
D	decreases	decreases	increases

24 A battery of e.m.f. 10 V with an internal resistance of 2.0 Ω delivers a current through a load.

What is the maximum power delivered to the load?

A 5.0 W **B** 12.5 W **C** 25.0 W **D** 50.0 W

25 A battery of e.m.f. *E* and internal resistance *r* delivers a current I through a variable resistance *R*.



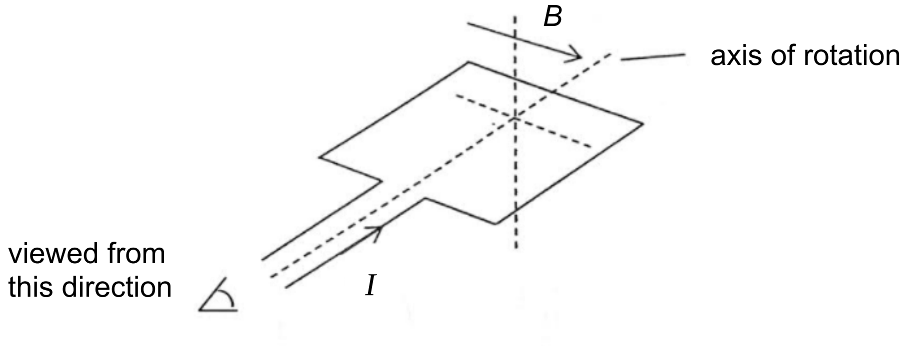
R is set at two different values and the corresponding currents I are measured using an ammeter of negligible resistance.

R / Ω	I / A
3.0	1.00
12.0	0.40

What is the value of the internal resistance *r* ?

A 1.3 Ω **B** 3.0 Ω **C** 6.0 Ω **D** 13.0 Ω

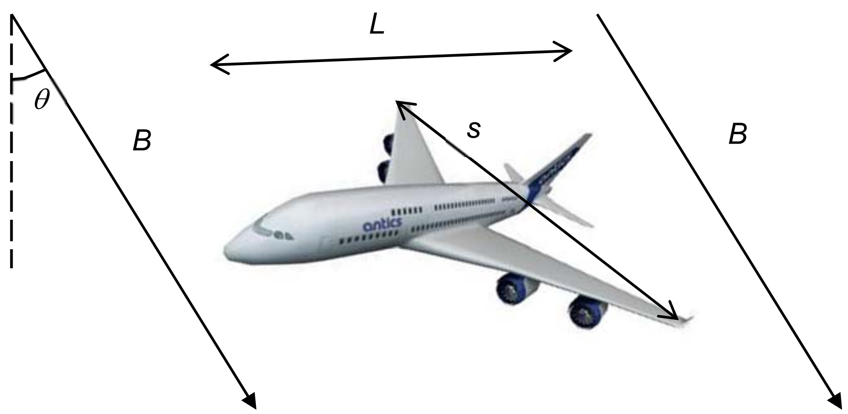
26 In an electric motor, current I passes through a rectangular coil of wire which is in a region of uniform magnetic field B.



Which of the following describes the rotation of the coil (viewed from the front along the axis of rotation as shown in the figure) through a quarter of a rotation?

	direction of rotation of coil	torque
A	clockwise	decreases
B	clockwise	constant
C	anticlockwise	decreases
D	anticlockwise	constant

27 The diagram represents an aircraft of length L, wingspan s, flying horizontally at speed v in a region where the Earth's magnetic field, of uniform flux density B, is inclined at an angle of θ to the vertical.



Which expression gives the magnitude of the e.m.f. generated between the wingtips by electromagnetic induction?

A $BLv \sin\theta$ **B** $BLv \cos\theta$ **C** $Bsv \sin\theta$ **D** $Bsv \cos\theta$

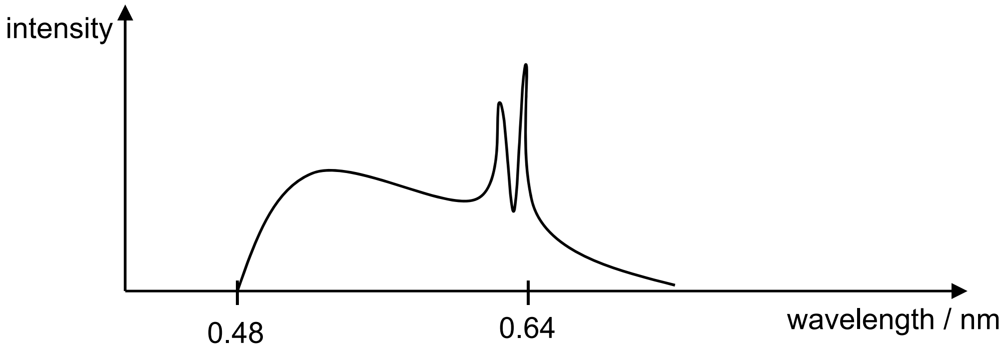
28 The secondary coil of a step-up transformer is connected to an external load with cables of resistance 80 Ω. The number of turns in the primary coil and secondary coil is 120 and 480 respectively. The r.m.s. voltage of the primary coil is 500 V. The mean power provided by the primary coil is 3600 W.

What is the power dissipated in the cables?

A 260 W **B** 4.1 kW **C** 50 kW **D** 66 kW

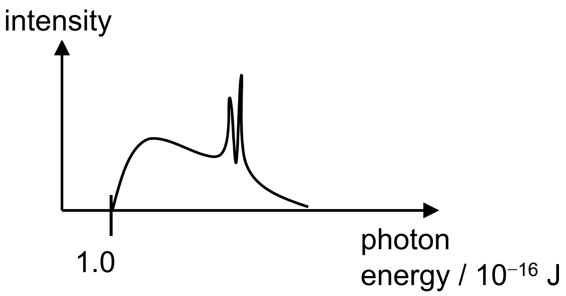
29 X-rays were produced via high speed electrons bombarding a target metal.

The variation with wavelength of the intensity of X-rays emitted is as shown below.

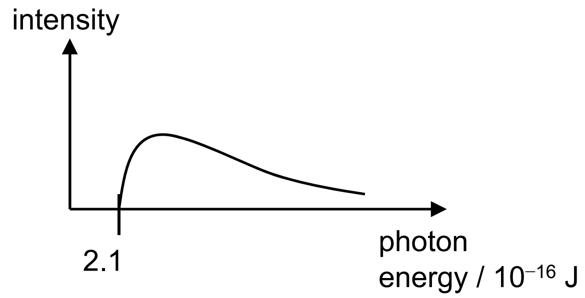


Which of the following diagrams shows the variation with photon energy of the intensity when the speed of the electrons is halved?

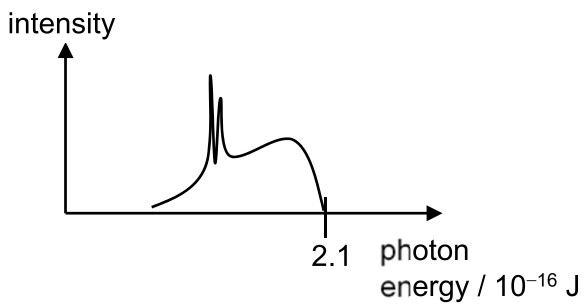
A



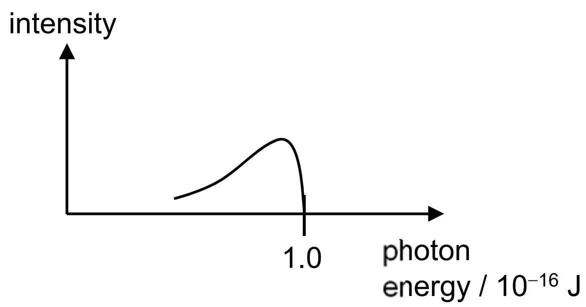
B



C



D



30 The uncertainty in position of a particle in space is 2.00×10^{-20} m and the uncertainty in its momentum is 4.00×10^{-14} N s.

What is the minimum percentage change in uncertainty of its momentum when the uncertainty in position is halved?

A –100 % **B** –66 % **C** 66 % **D** 100 %

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Name: ______________________________ (   )   Class: 20 / ______

ANDERSON SERANGOON JUNIOR COLLEGE

2020 JC2 Preliminary Examination

PHYSICS Higher 2 — 9749/02

Paper 2 Structured Questions — **Wednesday 2 September 2020**

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and class in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

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	
Paper 2 (80 marks)	
1	/ 10
2	/ 12
3	/ 9
4	/ 9
5	/ 10
6	/ 10
7	/ 20
Deduction	
Total	/ 80

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ 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	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/°\text{C} + 273.15$
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	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density 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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

[Turn Over

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

1 **(a)** Spring A of force constant 3.0 N m^{-1} and spring B of force constant 2.0 N m^{-1} are attached to a non-uniform plank CD of mass 0.15 kg as shown in Fig. 1.1. In order for the plank to remain horizontal, spring A is placed 12 cm away from X, the centre of gravity (c.g.) of plank CD whereas spring B is placed at a distance d away. Both springs are extended by 30 cm.

Take g to be 10 m s^{-2}.

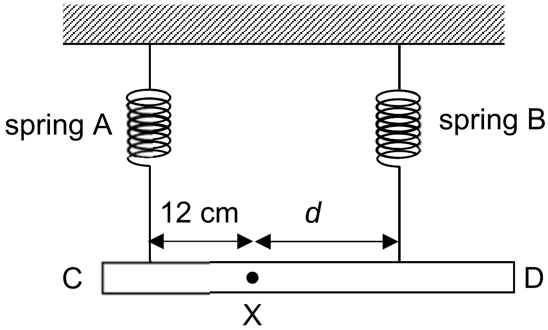

Fig. 1.1

(i) determine d,

d = ……………………………. cm [2]

(ii) determine the effective force constant of the two springs.

effective force constant = ………………………….. N m^{-1} [2]

(b) A block of mass 0.050 kg with negligible dimension is now placed on top of the plank at a distance of 8.0 cm away from X as shown in Fig. 1.2. The position of springs A and B are adjusted so that the plank CD remains horizontal.

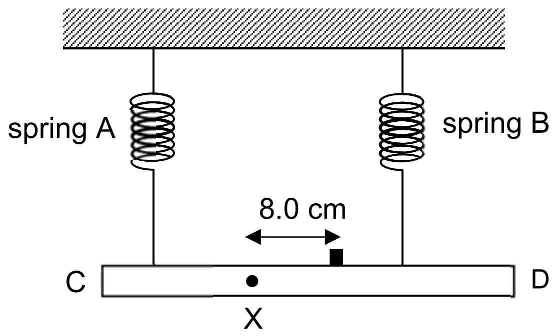

Fig. 1.2

(i) calculate the new extension of spring A and B,

extension = ………………………… m [2]

(ii) calculate the increase in elastic potential energy of the system in Fig 1.2 as compared to that in Fig. 1.1.

increase in elastic potential energy = ………………………… J [2]

(c) The plank CD and the block of mass are then removed from the springs as shown in Fig. 1.3.

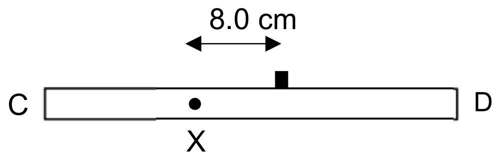

Fig. 1.3

Determine the distance of the effective c.g. of the plank and block from X.

distance = ……………… m [2]

[Total: 10]

Question 2 begins over the page

2 In a binary star system, two stars of equal mass 3.5×10^{30} kg orbit about their common centre of mass O, as shown in Fig. 2.1. O is equidistant from the centres of the two stars. The separation between the centres of the two stars is 2.0×10^{11} m.

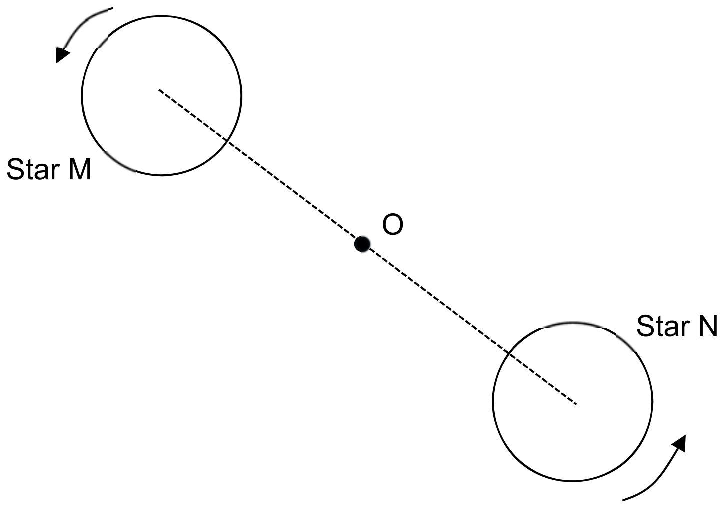

Fig. 2.1

(a) **(i)** Define gravitational potential at a point.

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

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

(ii) Calculate the gravitational potential at O.

gravitational potential = ……………………..…… J kg⁻¹ [2]

(iii) An asteroid passes through point O.

Determine the minimum speed of the asteroid at point O if it is to escape from the gravitational pull of the binary star system.

minimum speed = ……………………..…… m s⁻¹ [3]

(iv) On Fig. 2.2, sketch a graph showing the variation of gravitational potential from the surface of Star M to the surface of Star N, along the line joining the centres of the two stars.

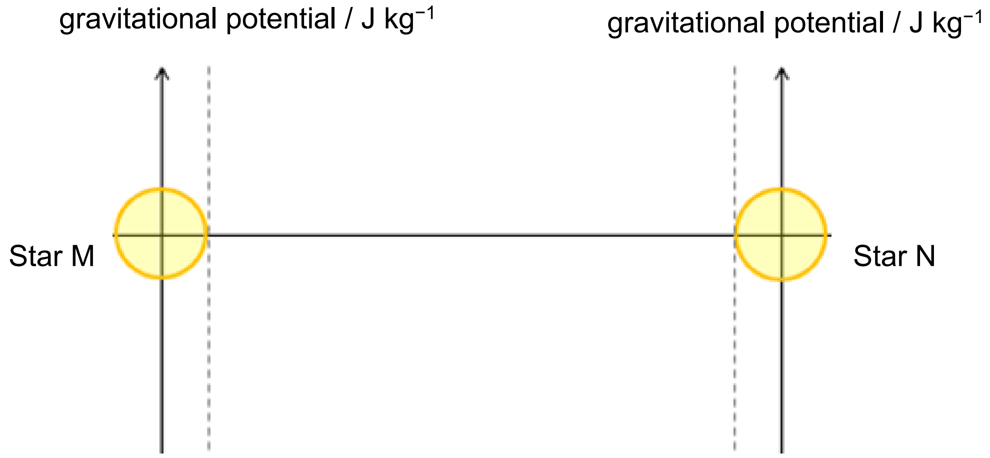

Fig. 2.2

[2]

(b) (i) Explain why the gravitational force acting on the stars do not cause them to move closer to each other.

………………………………………………………………………………………………

………………………………………………………………………………………………

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

(ii) Calculate the period of the stars.

period = ……………… years [3]

[Total: 12]

3 **(a)** State the *first law of thermodynamics*, indicating the direction of all energy changes.

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

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

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

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

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

(b) Use the first law of thermodynamics to explain why specific heat capacity of an ideal gas measured at constant volume is lower than the specific heat capacity when measured at constant pressure.

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

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

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

(c) State 2 reasons why temperature of a body is not a measure of the amount of internal energy in a body.

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

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

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

(d) **(i)** A car tyre has a fixed internal volume of 0.0360 m^3. The temperature and pressure of the air inside the car tyre is 25.0°C and 2.62 x 10^5 Pa initially. An additional 0.30 mol of air was pumped into the tyre at constant temperature of 25.0°C. Air can be considered as an ideal gas in this case.

(i) **1.** Show that the original amount of air particles in the car tyre is 3.8 mol.

[1]

2. Determine the final pressure of the gas inside the tyre.

pressure = ……………………………. Pa [2]

[Total: 9]

4 A long strip of springy steel is clamped at one end so that the strip is vertical. A mass of 65 g is attached to the free end of the strip, as shown in Fig. 4.1.

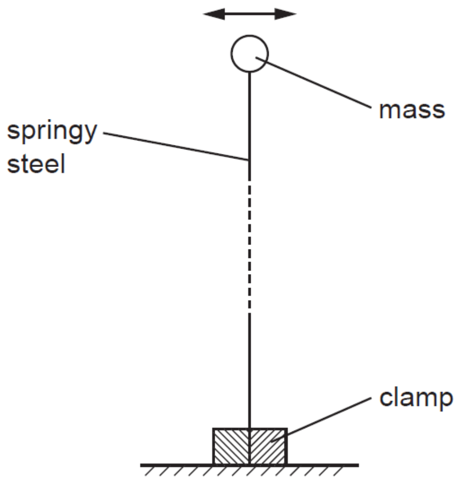

Fig. 4.1

The mass is pulled to one side and then released. The variation with time *t* of the horizontal displacement of the mass is shown in Fig. 4.2.

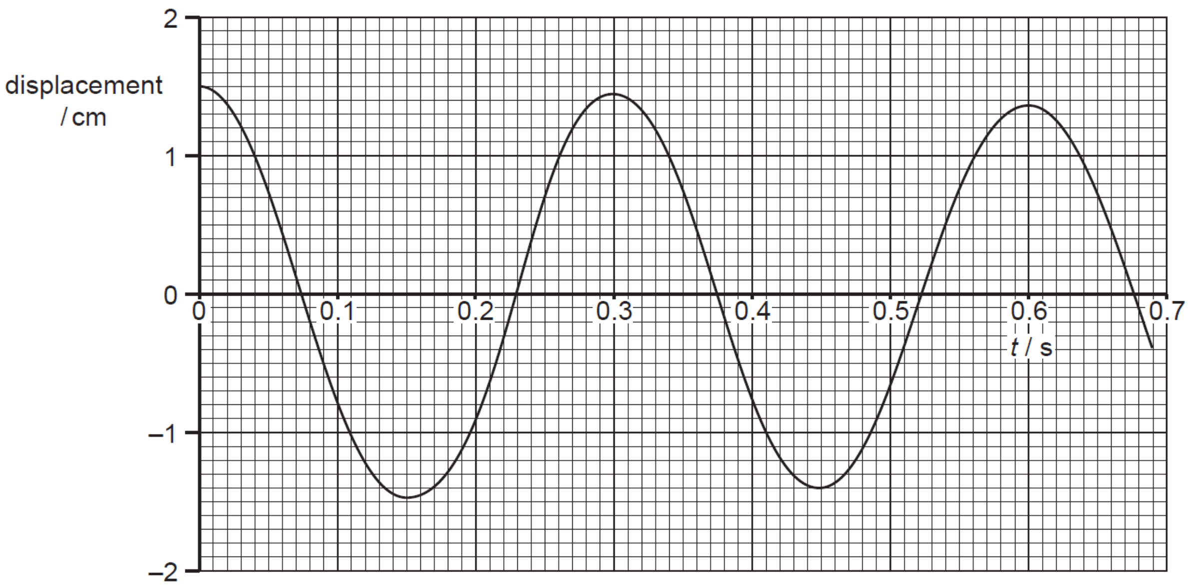

Fig. 4.2

The mass undergoes damped oscillation.

(a) (i) Suggest, with a reason, whether the damping is light, critical or heavy.

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

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

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

(ii) After eight complete oscillations of the mass, the amplitude of vibration is reduced from 1.5 cm to 1.1 cm.

1. Calculate the angular frequency of the oscillations.

angular frequency = …………………………….rad s^{-1} [1]

2. Calculate the loss of energy after eight complete oscillations.

loss of energy = …………………………….J [2]

3. State and explain whether, after another eight complete oscillations, the amplitude will be 0.7 cm.

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

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

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

(b) The variation of kinetic energy E_k of the mass with displacement x from its equilibrium position is shown in Fig. 4.3.

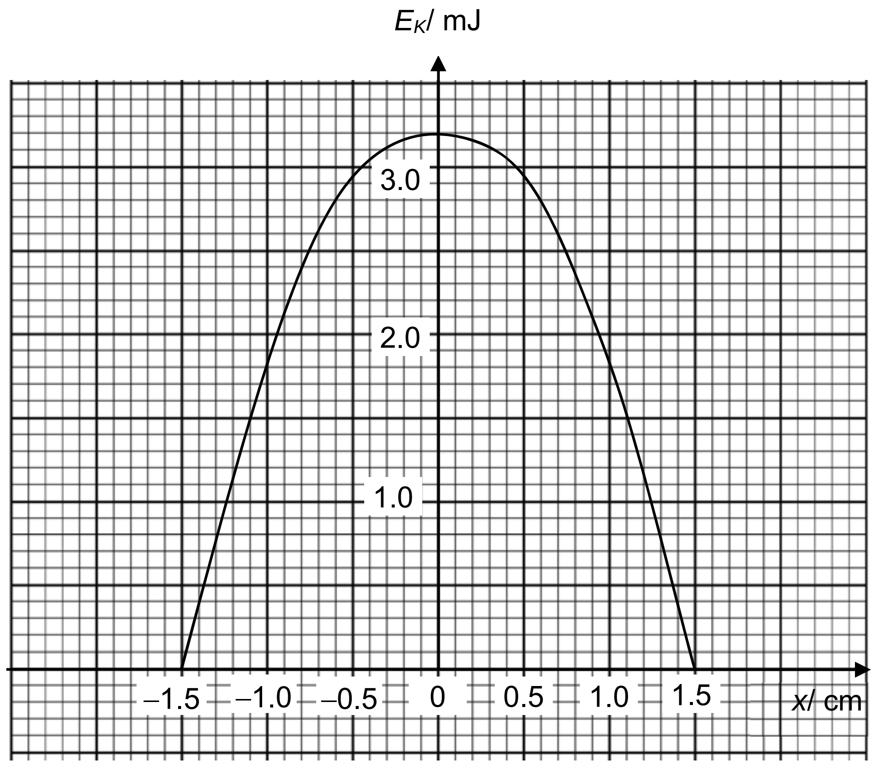

Fig. 4.3

The mass loses energy so that its maximum kinetic energy is reduced by 1.5 mJ.

Use Fig. 4.3, without further calculation, to determine the amplitude of the oscillations. Show your construction on Fig. 4.3.

amplitude = ... cm [2]

[Total: 9]

5 A circuit is set up as shown in Fig. 5.1. A cylindrical uniform resistance wire XY of length 1.20 m and resistivity 6.9 x 10^{-7} Ω m has resistance 7.5 Ω. Cell A has e.m.f. 2.0 V and internal resistance of 0.50 Ω. The current through cell A is I. Cell B has an e.m.f. E and internal resistance r.

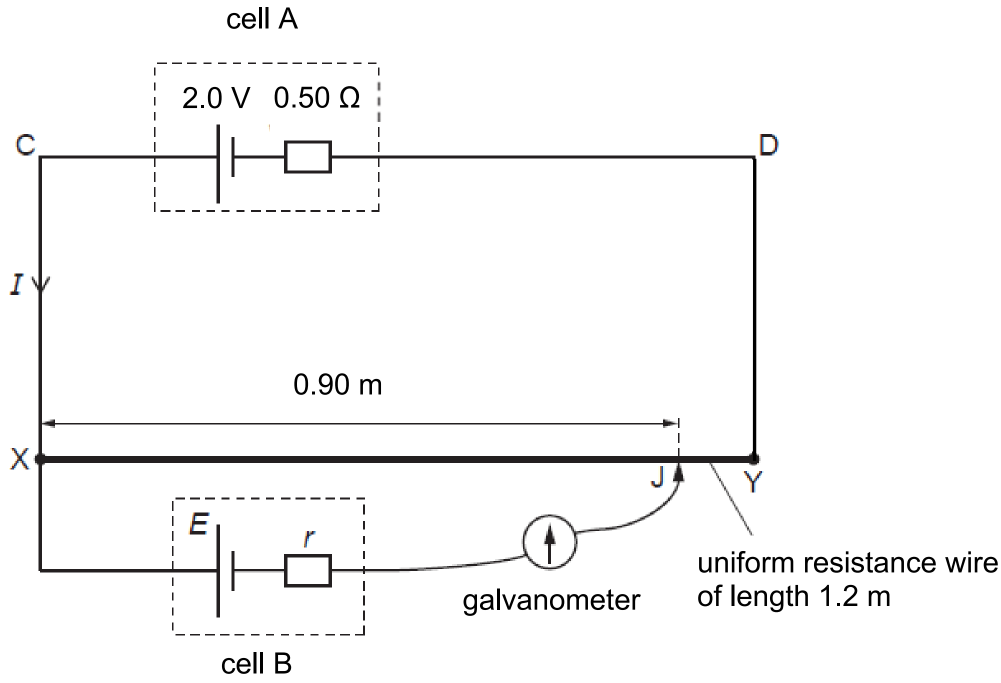

Fig. 5.1

The galvanometer shows no deflection when the movable connection J is adjusted so that the length XJ is 0.90 m.

(a) Show that, when the length XJ is 0.90 m, the current I is 0.25 A.

[1]

(b) **(i)** Determine the drift velocity of the electrons in the resistance wire XY given that the number density of the wire is 8.0 x 10^{28} m^{-3}.

drift velocity = …………………… m s^{-1} [3]

(ii) Explain the effect that stretching the wire will have on the drift velocity of electrons in the wire. Assume that the volume of the wire remains unchanged and that there is a constant potential difference across the wire.

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

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

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

(c) (i) Calculate the value of *E*.

E = ……………………. V [2]

(ii) State and explain what happens to the balanced length XJ when the galvanometer used has resistance.

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

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

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

(iii) On Fig. 5.1, add a resistor to the circuit such that the balance length is increased. [1]

[Total: 10]

6 **(a)** A student wishes to determine the I-V characteristics of a semiconductor diode.

(i) Draw a suitable labelled diagram of the circuit that would enable the student to collect data to determine the I-V characteristics of the semiconductor diode.

[2]

(ii) Sketch, on Fig. 6.1, the I-V characteristics of a semiconductor diode in forward bias.

Fig. 6.1

[1]

(iii) State how the resistance of the diode can be determined from Fig. 6.1.

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

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

(b) Four ideal diodes are arranged in the circuit as shown in Fig. 6.2.

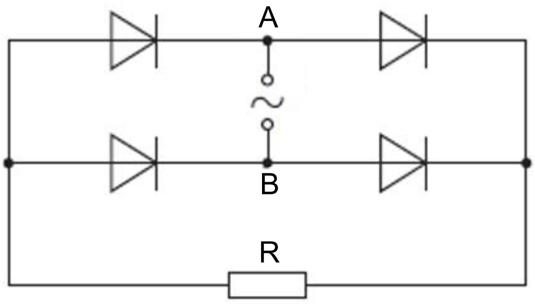

Fig. 6.2

A 7.0 V sinusoidal a.c. voltage supply at 25 Hz is applied between points A and B.

(i) Circle the diode(s) that conduct when point B is positive with respect to point A. [1]

(ii) Calculate the maximum voltage V_{max} across the resistor R.

V_{max} = …………………….. V [1]

(iii) Three of the diodes are removed and resistor R is connected to a diode, a cathode-ray oscilloscope (c.r.o.) and the 7.0 V sinusoidally-alternating voltage supply via a switch as shown in Fig. 6.3.

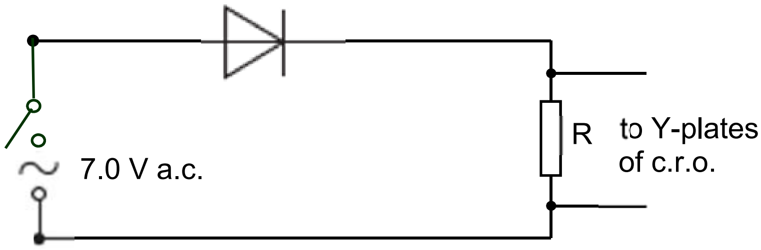

Fig. 6.3

The Y-plate sensitivity of the c.r.o is 5.0 V cm^{-1} and time base is 10 ms cm^{-1}.

When the switch is opened, a horizontal trace is obtained as shown in Fig. 6.4.

Fig. 6.4

1. Sketch, on Fig. 6.4, the full trace shown on the c.r.o. screen when the switch is closed. [2]

2. Calculate the resistance of resistor R given that the mean power dissipated in it is 4.5 W.

resistance = …………………………….Ω [2]

[Total: 10]

7 Echoes are produced by the reflection of sound waves from a surface such as a wall or a cliff. When the reflecting surface is far away from the source then the echo may be heard as a separate sound.

In an enclosed room, when a sound source ceases, the sound waves will continue to reflect off the hard wall, floor and ceiling surfaces until it loses enough energy and dies out. The prolongation of the reflected sound is known as reverberation. Reverberation time is the number of seconds it takes for the reverberant sound energy to die down to one millionth (or by 60dB) of its original value from the instant that the sound signal ceases.

Recording studios and music halls are acoustically designed to cover the walls with sound absorbing surfaces such as a perforated panel as shown in Fig. 7.1. In many cases it is necessary to absorb certain frequencies more than others, and one way to do this is to use the resonances of these perforated panels attached to the wall as shown in Fig. 7.2.

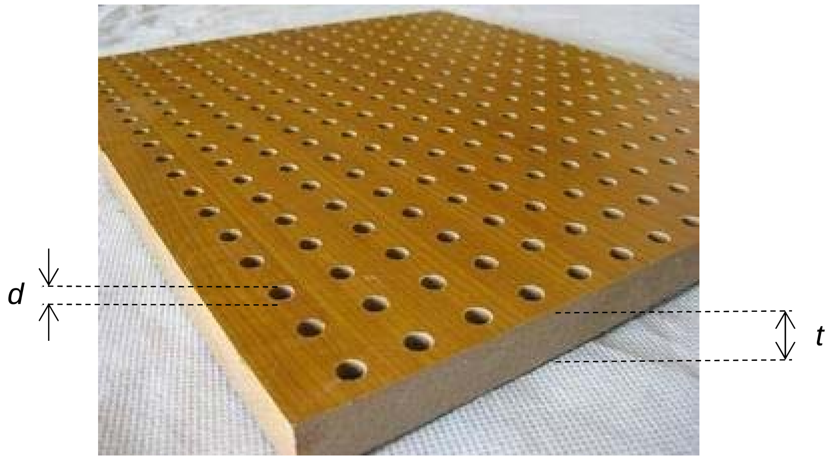

Fig. 7.1

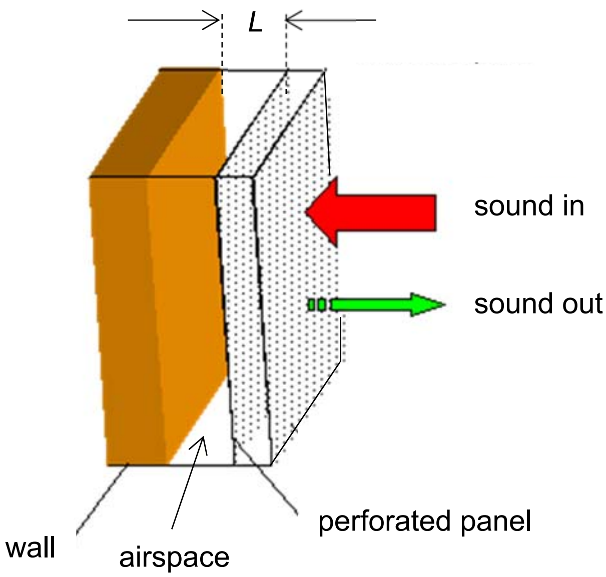

Fig. 7.2

It is found that a panel made of hardboard resonates at a particular frequency and absorbs sound of that frequency more than other frequencies. An approximate expression for this frequency is given by

$$f = 5000\sqrt{\frac{P}{L(t + 0.8d)}}$$

Where f = resonant frequency
L = depth of airspace
t = thickness of panel
d = hole diameter
P = percentage of open area
(all measurements are made in mm)

(a) State a difference between echo and reverberation.

....

.... [1]

(b) Explain why reverberation is not desirable for a conference room.

....

.... [1]

(c) The panelling of walls can reduce the reverberation time more significantly at certain frequencies.

(i) Explain why paneling the walls reduces reverberation time.

....

....

....[1]

(ii) Explain why the reduction of reverberation time is more significant at certain frequencies.

....

....

....

....

....

....[2]

(d) State two other factors which would affect the reverberation time of a room.

....

....

....

.... [2]

(e) A perforated panel with 10% open area, with various hole diameters are tested. The resonant frequencies f, together with values of $\frac{1}{f^2}$ obtained are shown in Fig. 7.3.

d/mm	f/Hz	$\frac{1}{f^2}$ / 10^{-6} s^2
1.0	1600	0.39
2.0	1480	0.46
3.0	1350	0.55
4.0	1280	
5.0	1180	0.72
6.0	1140	0.77

Fig. 7.3

(i) Complete Fig. 7.3 for the resonant frequency of 1280 Hz. [1]

(ii) Fig. 7.4 is a graph of some of the data in Fig. 7.3.

On Fig. 7.4,

1. plot the point corresponding to f = 1280 Hz, [1]

2. draw the line of best fit for all the points. [1]

(iii) Use Fig. 7.4 to determine for the line drawn in **(e)(ii)**

1. the gradient

gradient = ... s^2 mm^{-1} [2]

2. the y-intercept

y-intercept = ……………………………… s^2 [2]

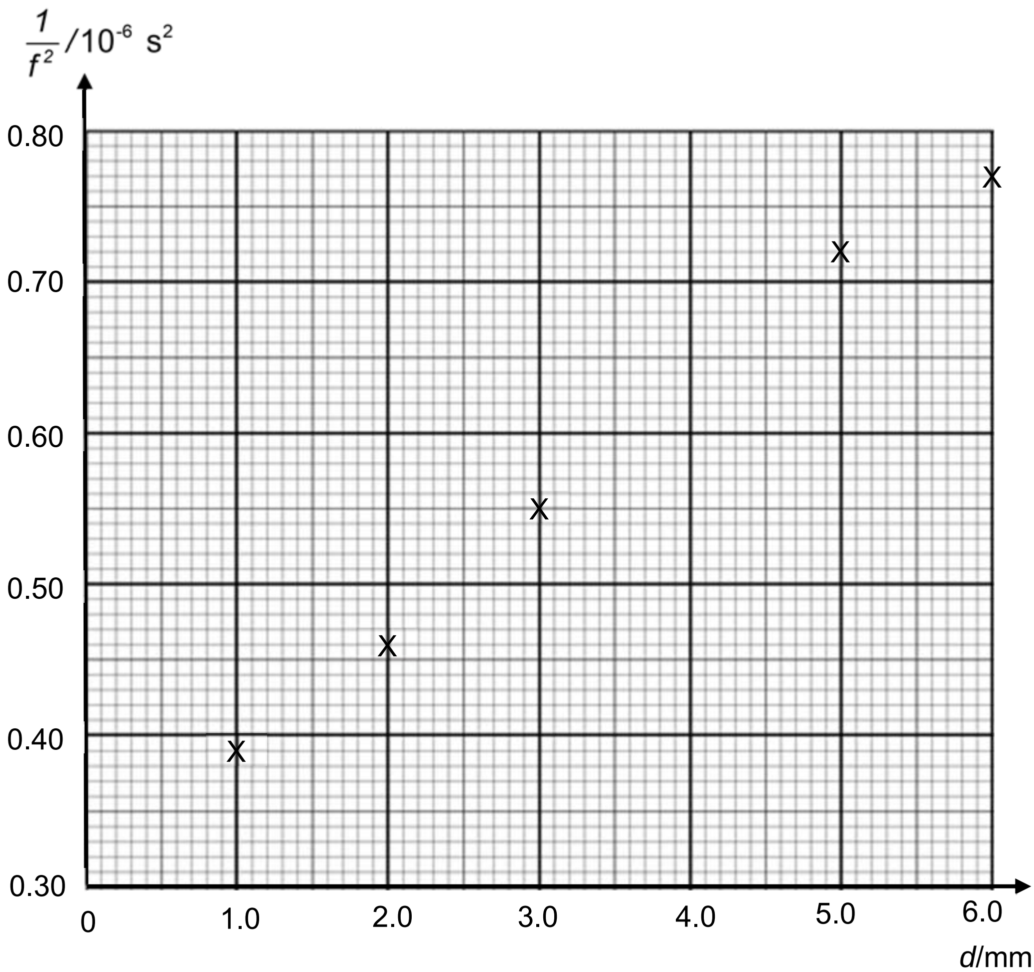

Fig. 7.4

(iv) Use your answers to **(e)(iii)** to determine

1. the depth L of the airspace

L = …………………………… mm [2]

2. the thickness t of the panel

t = ... mm [1]

(f) The panel with 5.0 mm holes is selected and tested with its airspace filled with absorber 1 and absorber 2 separately. The absorption characteristics shown in Fig. 7.5 were obtained, where the absorption coefficient is the ratio of energy absorbed to energy incident on the absorber.

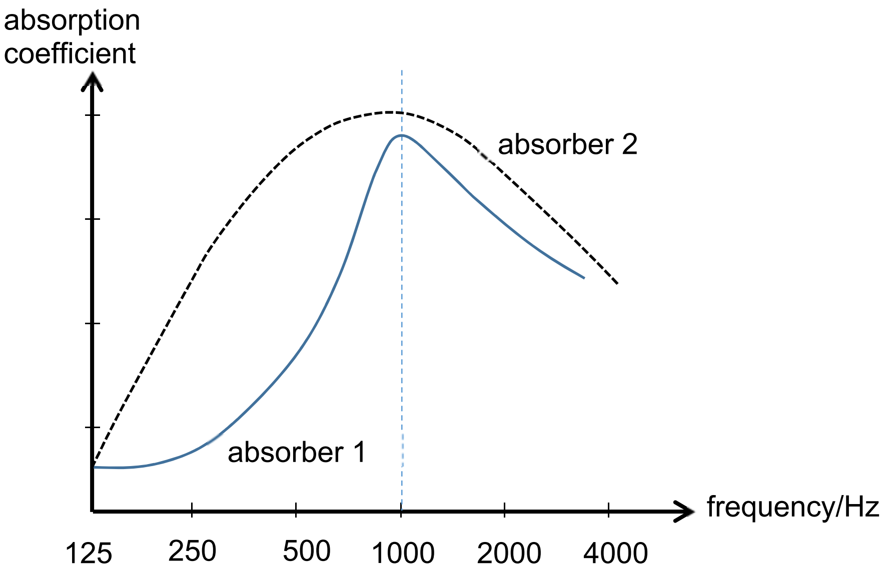

Fig. 7.5

(i) With reference to Fig. 7.3 and Fig. 7.5, state the effect absorbers have on the resonant frequencies when they were inserted in the airspace.

....

.... [1]

(ii) State and explain the absorber that is more suitable for use in a recording studio.

....

....

....

.... [2]

[Total: 20]

Name: ______________________________ (   )   Class: 20 / ______

ANDERSON SERANGOON JUNIOR COLLEGE

2020 JC2 Preliminary Examination

PHYSICS Higher 2 — 9749/03

Paper 3 Longer Structured Questions — **Thursday 17 September 2020**

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, class index number and class in the spaces provided above.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams, graphs or rough working.

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.

For Examiner's Use	
Paper 3 (80 marks)	
1	/ 14
2	/ 10
3	/ 21
4	/ 15
5	/ 20
6	/ 20
Deduction	
Total	

Data

speed of light in free space	$c = 3.00 \times 10^{8}$ m s^{-1}
permeability of free space	$\mu_0 = 4\pi \times 10^{-7}$ H m^{-1}
permittivity of free space	$\varepsilon_0 = 8.85 \times 10^{-12}$ F m^{-1}
	$(1/(36\pi)) \times 10^{-9}$ F m^{-1}
elementary charge	$e = 1.60 \times 10^{-19}$ C
the Planck constant	$h = 6.63 \times 10^{-34}$ J s
unified atomic mass constant	$u = 1.66 \times 10^{-27}$ kg
rest mass of electron	$m_e = 9.11 \times 10^{-31}$ kg
rest mass of proton	$m_p = 1.67 \times 10^{-27}$ kg
molar gas constant	$R = 8.31$ J K^{-1} mol^{-1}
the Avogadro constant	$N_A = 6.02 \times 10^{23}$ mol^{-1}
the Boltzmann constant	$k = 1.38 \times 10^{-23}$ J K^{-1}
gravitational constant	$G = 6.67 \times 10^{-11}$ N m^{2} kg^{-2}
acceleration of free fall	$g = 9.81$ m s^{-2}

Formulae

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work done on/by a gas	$W = p\Delta V$
hydrostatic pressure	$p = \rho gh$
gravitational potential	$\phi = -\frac{Gm}{r}$
temperature	$T/\text{K} = T/{}^\circ\text{C} + 273.15$
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	$B = \frac{\mu_o I}{2\pi d}$
magnetic flux density 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	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 A parachutist of mass 85 kg steps out of the doorway and falls from an aircraft.

The variation with time t of vertical speed v of the parachutist is shown in Fig. 1.1.

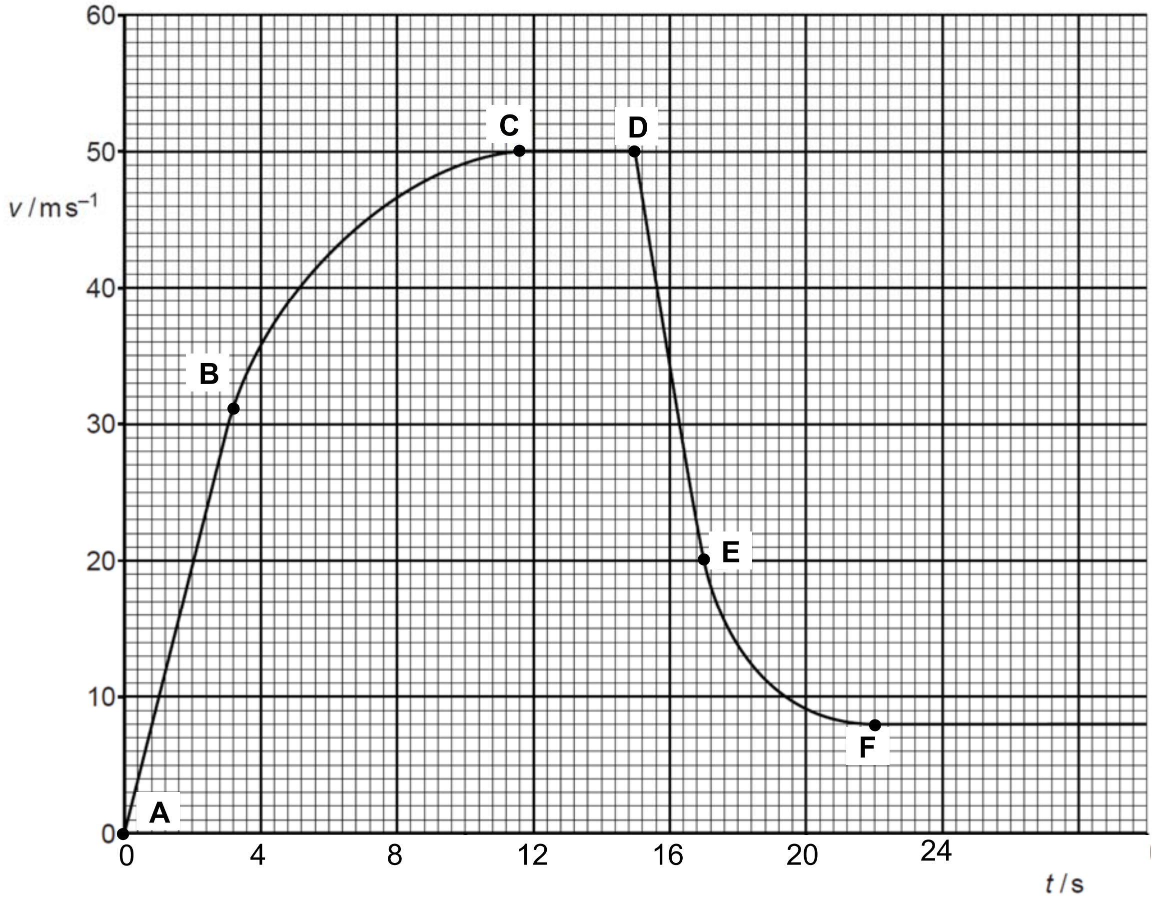

Fig. 1.1

(a) The parachutist activates his parachute at some point during the fall.
State the point (**A, B, C, D, E or F**) on the graph at which the parachute was activated.

point ……………………… [1]

(b) For the parachutist between t = 15 s (point **D**) and t = 17 s (point **E**),

(i) calculate the average vertical deceleration,

deceleration = …………………………… m s^{-2} [2]

(ii) determine the vertical distance fallen by the parachutist,

distance = ………………………….. m [2]

(iii) determine the average vertical air resistance acting on the parachutist.

average vertical air resistance = ………………………….. N [2]

(c) Explain why the vertical velocity decreases from t = 17 s (point **E**) to t = 22 s (point **F**) and reaches a constant velocity after point F.

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

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

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

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

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

(d) After point **F**, the parachutist continues to fall at the same constant speed and reaches the ground some time later. Upon first contact with the ground, he executes the parachute landing fall and goes from an upright position to a horizontal position by buckling his body while rotating to the side as shown in Fig. 1.2.

Fig. 1.2

(i) Explain two ways in which the parachute landing fall helps to prevent injury to the parachutist.

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

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

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

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

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

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

(ii) By considering the principle of conservation of linear momentum, state and explain whether momentum is conserved in this landing.

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

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

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

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

[Total: 14]

2 At Luna Amusement Park in Sydney, Australia, the Rotor and Big Dipper Rollercoaster are the most exciting rides.

(a) The popular Rotor ride consists of a large vertical cylinder of radius R, which spins about its axis so quickly that any person standing inside is held against the wall when the floor drops away. The passengers maintain horizontal circular motion at constant speed within the cylinder. The normal contact force N acting on each passenger is related to the frictional force f on the passenger by a constant μ as given by the expression $f = \mu N$.

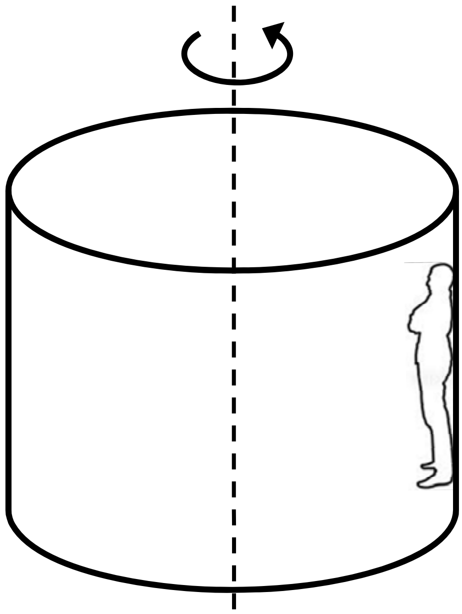

Fig. 2.1

(i) Draw and label, on Fig. 2.1, the forces acting on the passenger. [1]

(ii) Show that the linear velocity v at which the passenger must rotate is independent of his mass, m.

[3]

(b) The cart on the exhilarating Big Dipper Rollercoaster moves with negligible friction along the track as shown in Fig 2.2. The cart travels with an initial speed v_o of 25 m s^{-1} at the top of one hill, of height h, before reaching the top of a second hill, which forms a circular arc of radius 95 m.

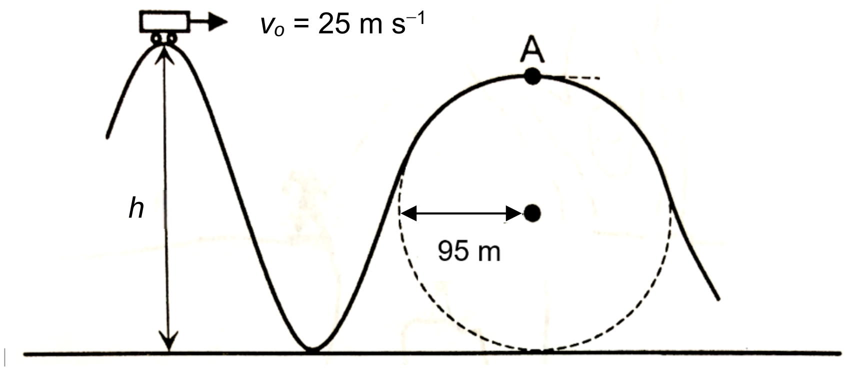

Fig. 2.2

(i) Calculate the maximum speed at which the cart can travel without leaving the track at the top of the second hill at point A.

maximum speed = ……………………………m s^{-1} [2]

(ii) Hence, determine the maximum h for the condition in **(b)(i)** to hold.

maximum h = ……………………………m [2]

(iii) The engineers want to modify the ride to allow the cart to move at a speed that is larger than that in **(b)(i)** without leaving the track at point A, for the same track radius. This can be done by designing the wheels to grip the track as shown in Fig. 2.3.

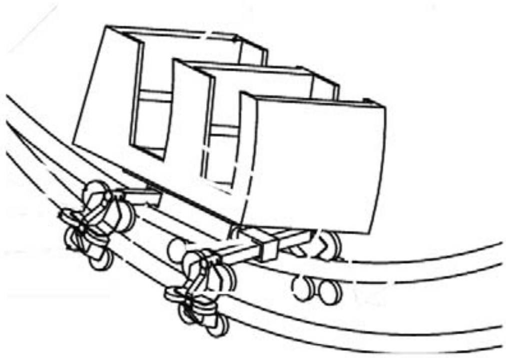

Fig. 2.3

By making reference to the centripetal force, explain how this design would allow the maximum speed in **(b)(i)** to be increased.

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

[Total: 10]

3 **(a)** **(i)** Explain what is meant by *diffraction*.

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…………………………………………………………………………………………………

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

(ii) A ripple tank experiment is used to observe the diffraction of plane water waves. Sketch on Fig. 3.1 the appearance of the water waves as they pass through the gaps.

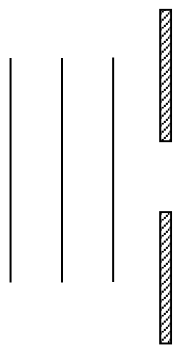

Fig. 3.1

[2]

(iii) A band is practising in a room along a corridor with the door slightly ajar.

Explain why a student walking along the corridor can hear the band but is unable to see the band.

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…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(b) A student is standing 5.5 m away from a loudspeaker S_1, which is transmitting with a power output of 20 W.

(i) Calculate the power intercepted by the student's ear with an effective area of 2.5 cm^2.

power = ………………… W [2]

(ii) State the assumption you have used in **(b)(i)**.

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

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

(c) The loudspeaker S_1 is placed at point X. A second loudspeaker S_2 is placed at point Y at a distance of 1.2 m from loudspeaker S_1 as shown in Fig. 3.2. The sound waves from the two loudspeakers have frequency 2.75 kHz and speed 330 m s^{-1}.

The student now stands at point A, a point equidistant from S_1 and S_2, and hears a sound of maximum intensity.

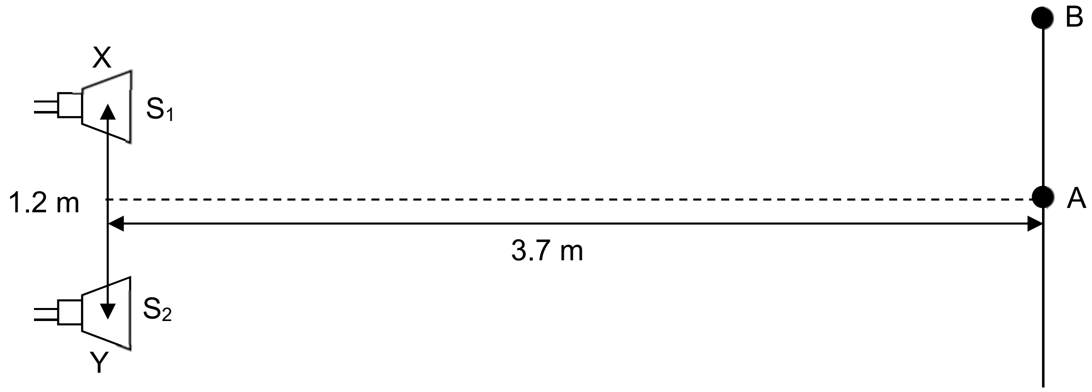

Fig. 3.2

(i) Show that the wavelength of the sound waves is 0.12 m.

[1]

(ii) As the student moves from point A to point B, the intensity varies between maximum and minimum values. The distance S_1B is 3.82 m and S_2B is 4.12 m.

Determine the number of maxima between points A and B. Do not include the maxima at point A.

number of maxima = ………………… [2]

(iii) The loudspeakers S_1 and S_2 emit sound waves that arrive at point B with intensity I and $2I$ respectively.

Determine the intensity of the sound at point B in terms of I.

intensity = ………………….. [3]

(iv) The two loudspeakers are placed closer together along the line joining X and Y. Without any calculations, state the difference detected by the student as he walks from point B back to point A.

……………………………………………………………………………………………..

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

(d) The loudspeaker S_1 is now placed facing a wall as shown in Fig. 3.3. A microphone is placed at the wall.

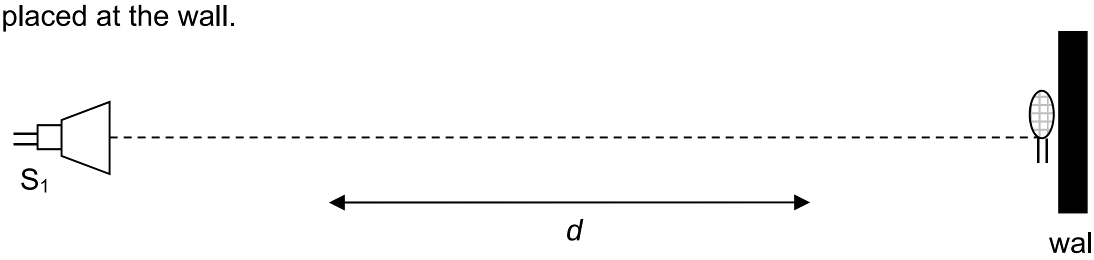

Fig. 3.3

(i) State and explain whether the microphone detects a maximum or minimum signal.

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

(ii) As the microphone moves through the distance *d* as shown in Fig. 3.3, it detects 3 positions of minima, with maxima at the ends.

Determine the value of *d*.

d = ……………….. m [2]

[Total: 21]

4 **(a)** Define *electric potential* at a point.

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

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

(b) Two charged solid metal spheres A and B are situated in a vacuum. Their centres are separated by a distance of 40 cm, as shown in Fig. 4.1. The charge on A is 3.2 nC and the charge on B is −1.6 nC. Point P is at a distance x from the centre of sphere A along the line joining the centres of the two spheres.

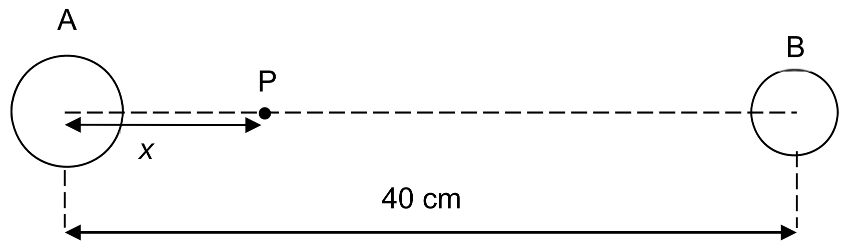

Fig. 4.1 (not to scale)

The variation with x of the electric potential V is shown in Fig. 4.2. V_1 is the potential inside sphere A and $-V_2$ is the potential inside sphere B.

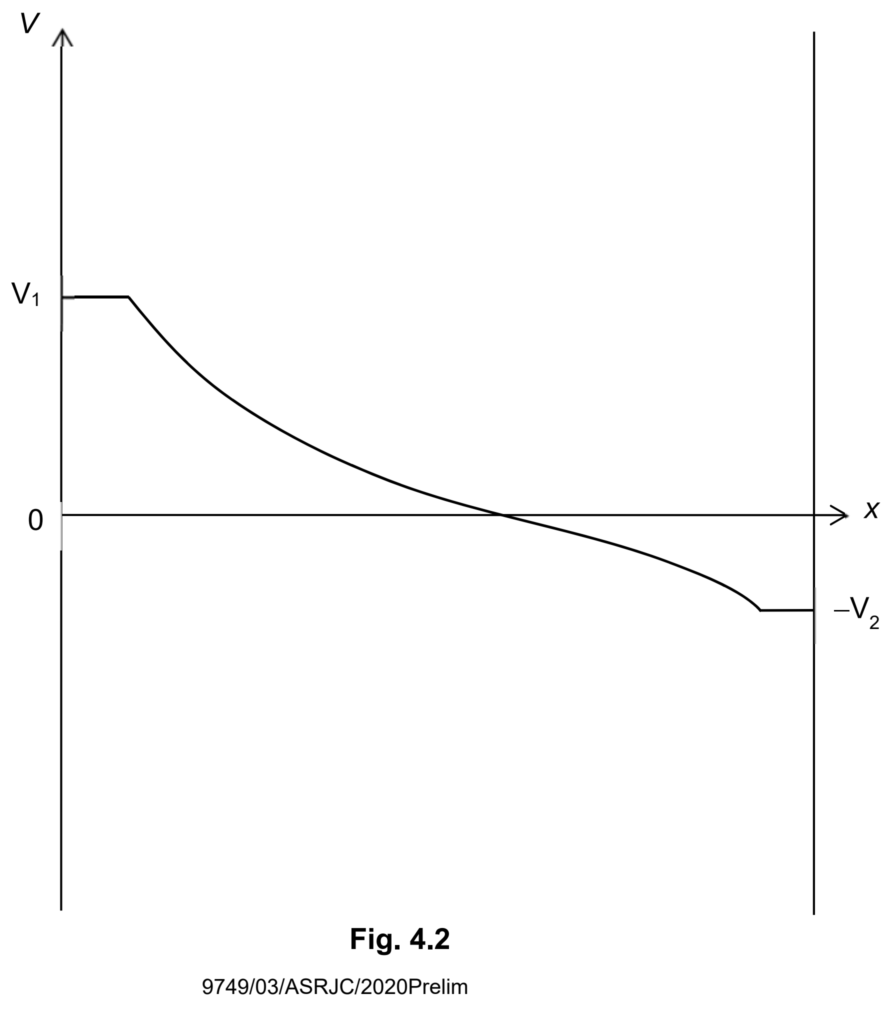

Fig. 4.2

(i) State a feature of the graph that is related to the magnitude of the electric field strength.

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

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

(ii) Sketch in Fig. 4.3, the variation with x of the electric field strength E.

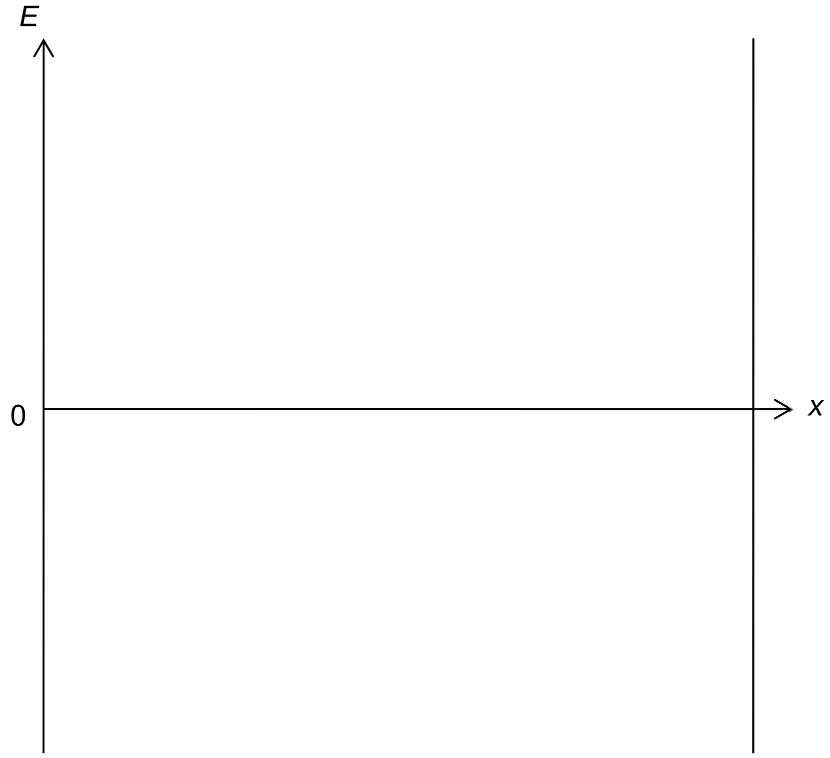

Fig. 4.3

[3]

(iii) Calculate the value of x where $V = 0$.

x = …………………………….m [2]

(iv) Sketch on Fig. 4.2 how V will change if the magnitude of the charges on both A and B are doubled. [2]

(c) Fig. 4.4 shows a small charged particle at a point X in a uniform electric field. The particle experiences an electric force F of 5.0×10^{-7} N. The grid lines are at intervals of 1.0 cm.

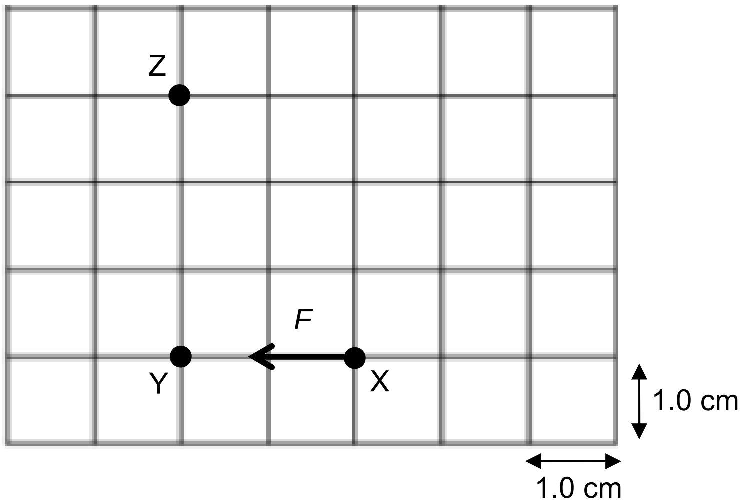

Fig. 4.4 (not to scale)

The particle carries a charge of 2.5×10^{-11} C and point X is at a potential of +200 V.

(i) Determine the work done by the electric force F if the particle is moved

1. from X to Y,

work done = ... J [1]

2. from X to Z.

work done = ... J [1]

(ii) Calculate the potential at point Y due to the uniform field.

potential = ... V [3]

[Total: 15]

Please turn over for Section B.

Section B

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

5 **(a)** A rectangular frame ABCD is supported on two knife-edges P and Q so that the section PBCQ of the frame lies within a solenoid. The solenoid has a current flowing in the direction as shown in Fig. 5.1.

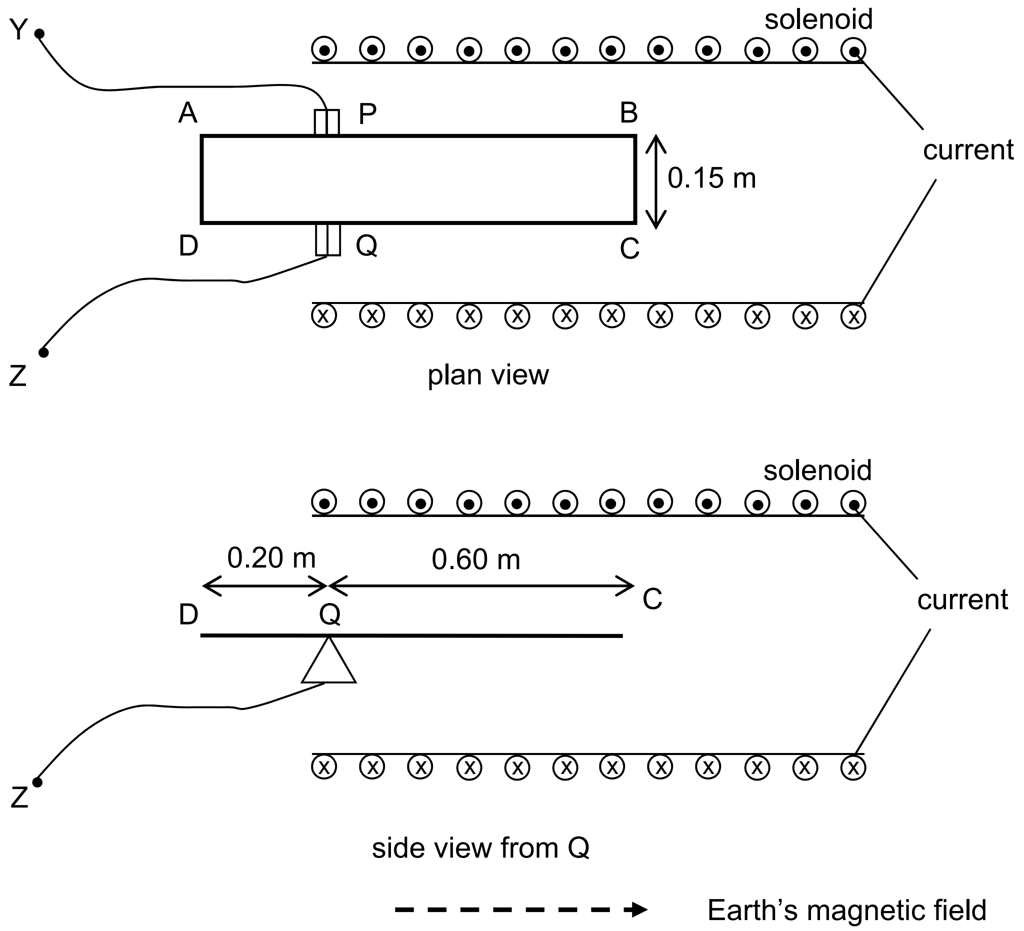

Fig. 5.1

It is given that BC = 0.15 m, DQ = 0.20 m and QC = 0.60 m.

The Earth's magnetic flux density is 5.0×10^{-5} T and in the direction as shown in Fig. 5.1.

When there is no current in the circuit, the frame is horizontal. When a current of 4.0 A passes through ZQCBPY, a small load of 3.0×10^{-4} N has to be hung at the middle of AD so that the frame can remain horizontal.

(i) Show that the magnetic flux density in the solenoid is 1.67×10^{-4} T.

[1]

(ii) Given that the solenoid has 6 turns per cm, determine the current in the solenoid considering the effect of the Earth's magnetic field.

current = ….……………… A [3]

(b) A uniform magnetic field is produced in the shaded region as shown in Fig. 5.2. The magnetic field is directed out of the plane of the paper. At point P, a gamma-ray photon interaction causes two particles X and Y that are of equal mass and opposite charges with the same magnitude to be formed. The paths of these two particles are shown in Fig. 5.2.

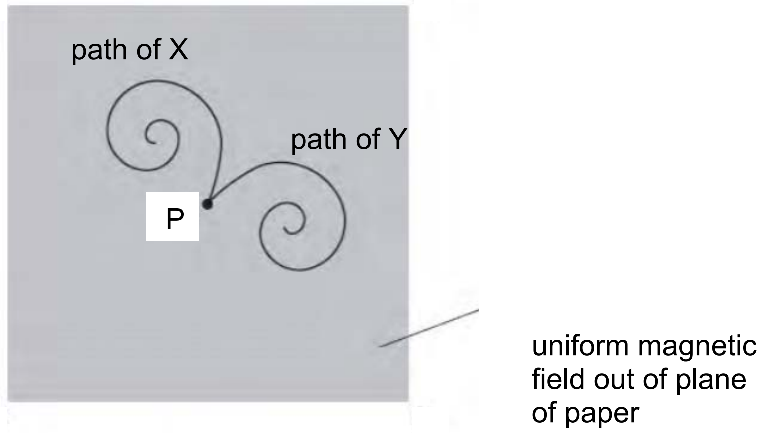

Fig. 5.2

(i) State which particle is the negatively-charged particle.

particle …………………… [1]

(ii) Suggest, with a reason, why each of the paths is a spiral, rather than arc of a circle.

………………………………………………………………………………………………

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………………………………………………………………………………………………

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

(iii) State and explain what can be deduced from the paths about the initial speeds of the two particles.

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

(c) Fig. 5.3 shows two aluminium blades. Blade A is a complete piece whereas blade B has been cut to form a comb.

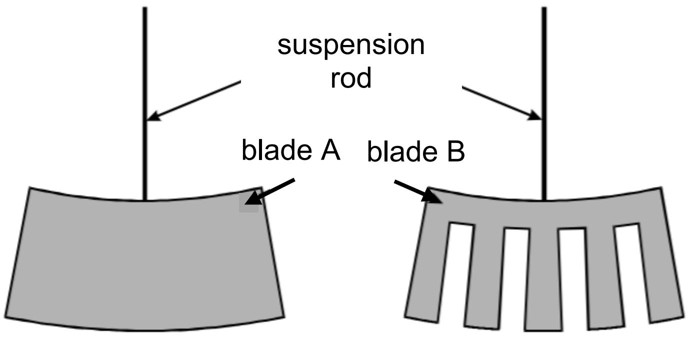

Fig. 5.3

(i) Each plate is suspended in turn between the poles of a strong permanent magnet as shown in Fig. 5.4.

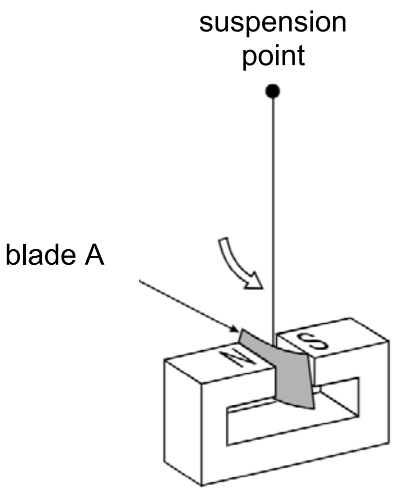

Fig. 5.4

The oscillations of blade A are rapidly damped. Use Faraday's law of electromagnetic induction to explain why the amplitude of the oscillations decreases.

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

(ii) State which electrical property of blade B is increased as compared to blade A.

property = …………………………… [1]

(iii) Hence, or otherwise, explain why the oscillations of blade B decrease less rapidly as compared to blade A.

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

(d) A rectangular coil measuring 20 mm by 35 mm and having 650 turns is rotating about a horizontal axis which is at right angles to a uniform magnetic field of flux density 2.5×10^{-3} T at a rate of 20 revolutions per second. The plane of the coil makes an angle θ with the vertical as shown in Fig. 5.5.

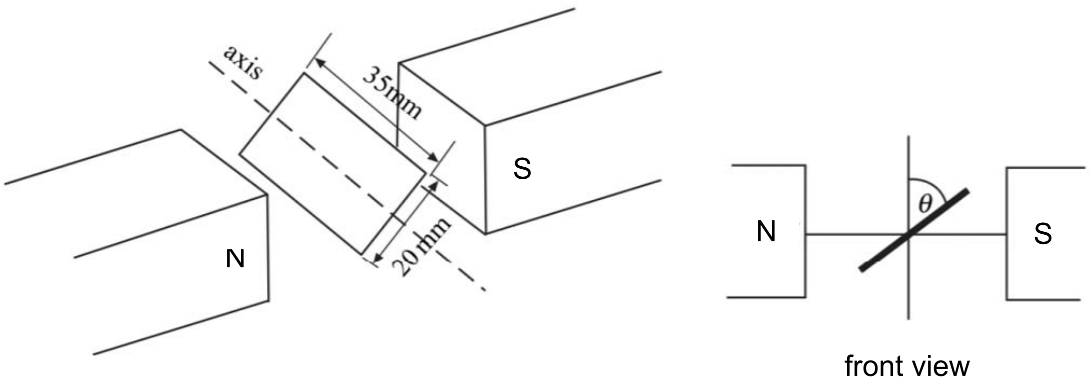

Fig. 5.5

(i) Calculate the magnetic flux linkage through the coil when $\theta = 30°$.

magnetic flux linkage = ………………………………Wb turns [2]

(ii) Show that the variation with time t of the e.m.f E induced in the coil is given by this equation

$$E = 0.14 \sin 40\pi t$$

given that when $t = 0$, $\theta = 0°$.

[2]

(iii) Fig. 5.6 shows the variation with t of E.

Sketch on the same graph the variation with t of E if the speed of rotation is halved.

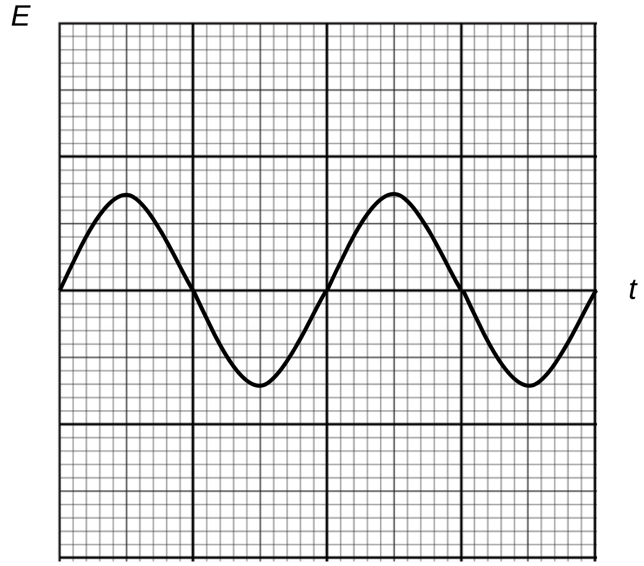

Fig. 5.6

[2]

[Total: 20]

6 **(a)** With reference to energy levels, explain briefly how an electric discharge lamp filled with hydrogen gas produces light.

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

(b) Describe the appearance of a visible emission line spectrum.

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

(c) Some electron energy levels of an isolated hydrogen atom are illustrated in Fig. 6.1.

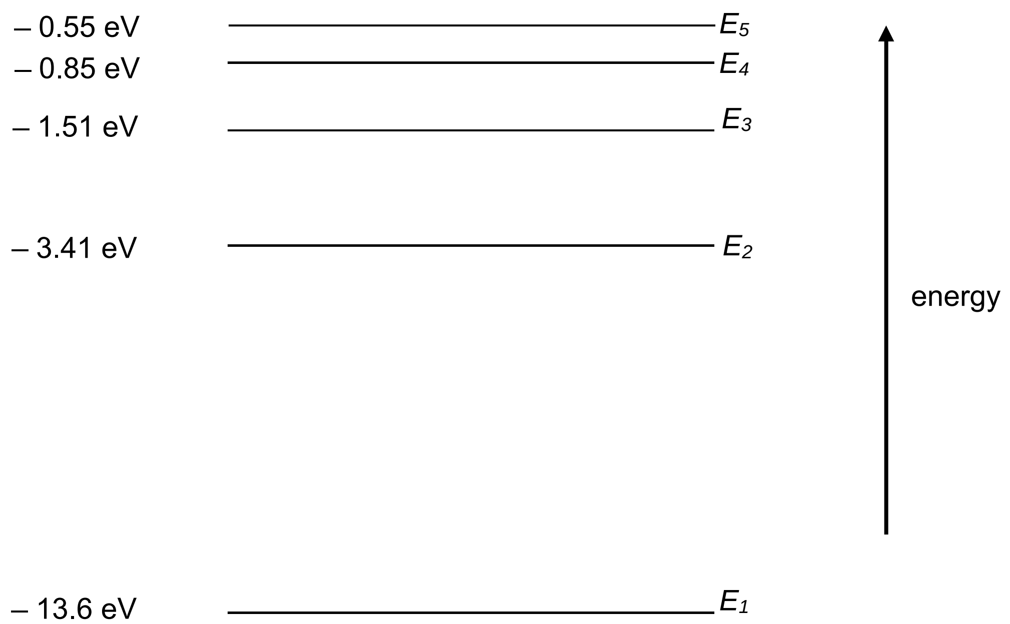

Fig. 6.1 (not to scale)

(i) On Fig 6.1, draw an arrow to show a transition that results in the emission of electromagnetic wave of the shortest wavelength. [1]

(ii) A line spectrum is produced from the electron energy levels shown in Fig. 6.1.

1. Determine the shortest wavelength of photon in this spectrum,

wavelength = …………………………… m [2]

2. state the number of lines that lie in this spectrum,

number = …………………………… [1]

3. sketch the line spectrum formed by the three shortest wavelength in Fig. 6.2.

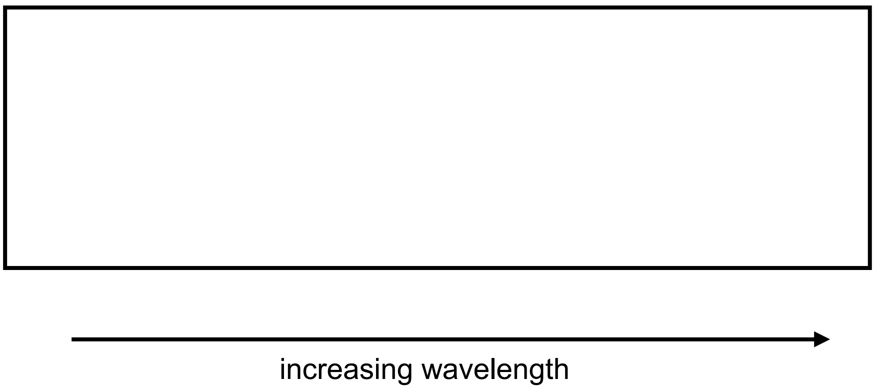

Fig. 6.2

[1]

(d) The radiation emitted from transitions between levels shown in Fig. 6.1 is incident on the surface of a sheet of metal A as shown in Fig. 6.3.

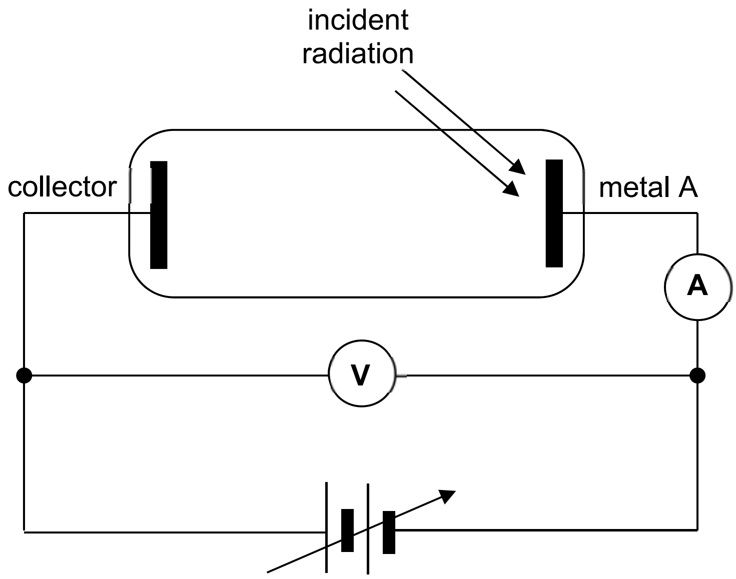

Fig. 6.3

The e.m.f. is varied and the corresponding readings on ammeter and voltmeter are plotted as shown in Fig. 6.4.

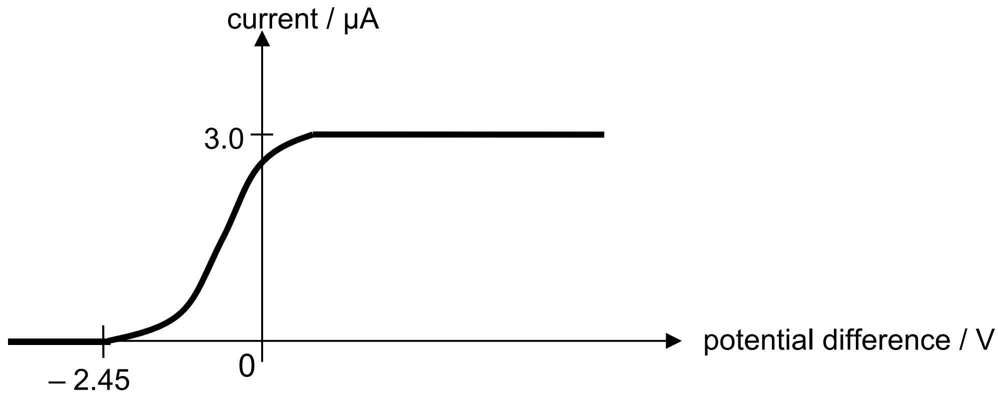

Fig. 6.4

(i) Determine the work function energy of metal A.

work function energy = ……………………………. J [3]

(ii) **1.** This irradiation of metal A has a quantum yield of 9.2×10^{-7}. Quantum yield is defined as the ratio

$$\frac{\text{number of photoelectrons emitted per second}}{\text{number of photons incident per second}}.$$

Determine the number of photons incident per second on metal A.

number of photons incident per second = ……………………………. s^{-1} [2]

2. State a possible reason why the quantum yield is so much smaller than 1.

……………………………………………………………………………………………

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

(iii) Describe and explain the change on the graph in Fig. 6.4 when the following changes are made independently.

1. The unpolarised radiation was polarised before it is incident on metal A.

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

2. Metal A was replaced with another metal with a lower work function energy.

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

(iv) By reference to the de Broglie equation, suggest whether light incident on the metal surface exerts a pressure on the surface.

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

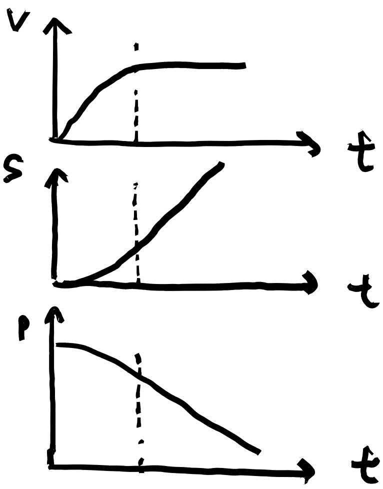
[Total: 20]

Anderson Serangoon Junior College 2020 H2 Physics Prelim Solutions

Paper 1 (30 marks)

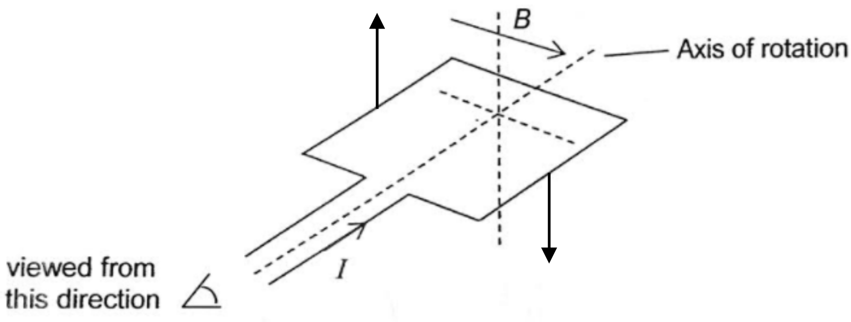
Q1	**Q2**	**Q3**	**Q4**	**Q5**	**Q6**	**Q7**	**Q8**	**Q9**	**Q10**
C	B	B	A	D	B	C	B	A	C
Q11	**Q12**	**Q13**	**Q14**	**Q15**	**Q16**	**Q17**	**Q18**	**Q19**	**Q20**
C	B	A	D	C	C	C	C	D	D
Q21	**Q22**	**Q23**	**Q24**	**Q35**	**Q26**	**Q27**	**Q28**	**Q29**	**Q30**
B	D	D	B	B	A	D	A	D	C

1	**C** density of ruler = 13.78 /(31.2 × 0.32) = 1.3802 g cm^{-3} fractional uncertainty of density = $\frac{0.001}{0.312} + \frac{0.02}{0.32} + \frac{0.01}{13.78} = 0.066$ percentage uncertainty of density = 0.066 × 100% = 6.6 % actual uncertainty of density = 0.066 × 1.3802 = 0.09 g cm^{-3} Hence, density = 1.38 ± 0.09 g cm^{-3}
2	**B** velocity of motorcyclist relative to passenger on car, $v_R = \overrightarrow{v_M} - \overrightarrow{v_C} = \overrightarrow{v_M} + (-\overrightarrow{v_C})$ Hence, answer is B.
3	**B** Area under acceleration time graph represents the change in velocity of the object. Hence, the speed at point B will be greatest.
4	**A** Both stones have the same initial horizontal velocity and hence same final horizontal velocity. In the vertical component, both stones experience the same change in displacement (s). Using $v^2 = u^2 + 2as$, the same final vertical velocity will be obtained. Also, using COE, it can also be derived that the speeds in both cases will be the same.
5	**D** Since there is no external forces acting along the horizontal direction, COM applies.
6	**B** The impulse is the product of resultant force and time the force acts.

7	**C** Upthrust is weight of fluid displaced, so upthrust in I & II are the same which is more than that in III. In I & III, the ball is in equilibrium and hence resultant force is 0. In II, there is a resultant force acting upwards, hence the ball rises.
8	**B** Resultant force is zero in all cases. However, taking moments about the CG, assuming length of the square is d : A will result in a 2Fd – Fd = Fd clockwise moments C will result in 2Fd – Fd = Fd anticlockwise moments & D will result in 2Fd + Fd = 3Fd clockwise moments.
9	**A** Considering the effect of viscous force, the body would eventually reach terminal velocity. Hence:  Since work has to be done against viscous force, the total energy (sum of E_p and E_k) would decrease. Considering that the velocity in viscous fluid would eventually reach terminal velocity (constant v), E_k would also reach a constant value eventually (horizontal flat graph).
10	**C** For old lamp, $P_o = 0.05 \times 60 = 3.0$ W For new lamp, efficiency = 3.0/ 4.0 × 100% = 75%
11	**C** For the carriage to turn left, the tension in the string must be directed to the left to provide for the necessary centripetal force. The centripetal force should not be drawn on the free body diagram.
12	**B** $v_e = r_e \cos 30° \, \omega$ $= 6.38 \times 10^6 \cos 30° \times 2\pi/(24 \times 3600)$ $= 402$ m s^{-1}

13	**A** G M m / r^2 = m v^2 / r → G M / r = v^2 → $v_X / v_Y = (r_Y / r_X)^{1/2}$ = (10R / 6R)$^{1/2}$ = 1.29
14	**D** $P_1 = m_1 l_v + h$ $P_1 - h = m_1 l_v$ $P_2 = m_2 l_v + h$ $P_2 - h = m_2 l_v$ $\frac{P_1 - h}{P_2 - h} = \frac{m_1}{m_2}$ $P_1 m_2 - P_2 m_1 = (m_2 - m_1)h$ $h = \frac{P_1 m_2 - P_2 m_1}{m_2 - m_1}$
15	**C** This relationship is not required in the derivation of the expression.
16	**C** For full cycle processes, the net change in internal energy is zero. $\Delta U = Q + W$ $0 = Q + [(-4.2) + (1.0 \times 10^5 \times (20.0 - 5.0) \times 10^{-6})]$ $Q = 2.7$ J
17	**C** KE is always positive, so cannot be **A** or **B**. Since at *t* = 0, displacement is 0 (i.e. at equilibrium), KE is max.
18	**C** Using $I = I_0 \cos^2 \theta$: $\frac{I}{4} = I \cos^2 \theta$ $\theta = 60°$
19	**D** Using $d \sin\theta = n\lambda$: $\frac{1}{N_1} \sin\theta = 2\lambda$ _(1) $\frac{1}{N_2} \sin\theta = 3\lambda$ _(2)

	Dividing the 2 equations will give $\frac{N_1}{N_2} = 1.5$
20	**D** Minimum angle of resolution $\theta_{\min} = \frac{\lambda}{b}$ (Rayleigh criterion) Images are resolved if the angular separation between the 2 sources is at least $\theta_{\min}$. Since the images just failed to be resolved, θ is smaller than $\theta_{\min}$. Option A is wrong: If aperture size *b* becomes smaller, $\theta_{\min}$ will become larger, and so the images will still not be resolved. Option B is wrong: Moving the slit further from the 2 sources will decrease the angular separation of the 2 sources, so the images will still not be resolved. Option C is wrong: Moving the screen nearer to the source has no effect on $\theta_{\min}$. $\lambda_G > \lambda_V$ Using violet light will decrease $\theta_{\min}$, hence allowing θ to be larger than $\theta_{\min}$.
21	**B** Since electric force, $F = qE$ where *F* is the electric force on charge *q* *q* is the charge in the electric field *E* is the electric field strength at that point due to some other charge Hence, the electric field strength due to *q* at position of charge $Q = F/Q$.
22	**D** Electric force $F_E = qE = q(\Delta V/d)$ on the oil drop due to the electric field is upwards. When p.d. is V_1 and oil drop is moving up at constant speed, qV_1/d – mg – resistive force = 0 ➔ resistive force = qV_1/d – mg …………….. (1) When p.d. is V2 and oil drop is moving down at the same constant speed, qV_2/d – mg + resistive force = 0 ➔ resistive force = mg – qV_2/d ……………… (2) Solving, we have $q = 2mgd / (V_1 + V_2)$.
23	**D** Effective resistance of the circuit increases when Bulb Q blows. Hence ammeter reading decreases. By PDP, the pd across P now decreases whereas pd across R increases, hence brightness of P decreases whereas R increases.
24	**B** For maximum power to be delivered the value of the load resistor is equal to the internal resistance of the cell. i.e. $R = r = 2\ \Omega$

	$I = \dfrac{E}{R+r} = \dfrac{10.0}{4} = 2.5$ A P = $(2.5)^2$ x 2 = 12.5 W
25	**B** The potential difference across the resistance *R* is given as *V* = *IR*. Hence, *IR* = *E* – *Ir* From the data, we form two equations: $3.0 = E - 1.0\,r$ … (1) $4.8 = E - 0.4\,r$ … (2) Solving the equations simultaneously, *r* = 3.0 Ω and *E* = 6.0 V
26	**A**  By FLHR, the direction of the forces acting on the sides of the coil are as shown in the diagram hence leading to a rotation in the clockwise direction. As the coil rotates, the perpendicular distance between the forces decrease and hence the torque decreases.
27	**D** The distance here refers to the distance between the wingtips which is *s* and the magnetic flux density perpendicular to *v* is $B\cos\theta$. Thus induced e.m.f. is $Bsv\cos\theta$.
28	**A** $P_{mean(p)} = V_{rms(p)} I_{rms(p)}$ $3600 = 500 I_{rms(p)}$ $I_{rms(p)} = 7.2$ A $\dfrac{I_{rms(p)}}{I_{rms(s)}} = \dfrac{N_s}{N_p}$ $\dfrac{7.2}{I_{rms(s)}} = \dfrac{480}{120}$ $I_{rms(s)} = 1.8$ A $P_{mean(cables)} = I^2_{rms(s)} R = 1.8^2(80) = 260$ W

29	**D** When speed of electrons is halved, the KE of electrons is reduced to ¼ of its original value. Hence, maximum photon energy will be reduced to ¼ of its original value as well. $E_p^{'} = \frac{hc}{4\lambda} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{4(0.48\times10^{-9})} = 1.036\times10^{-16}\ \text{J}$ For formation of characteristic peaks, KE of electrons must be at least $E_p^{'} = \frac{hc}{4\lambda} = \frac{6.63\times10^{-34}(3.0\times10^{8})}{(0.64\times10^{-9})} = 3.108\times10^{-16}\ \text{J}$ Hence, the peaks are no longer observable.
30	**C** Based on HUP, $\Delta x \Delta p \geq h$ $(1.00\times10^{-20})(\Delta p) \geq 6.63\times10^{-34}$ $\Delta p \geq 6.63\times10^{-14}$ Percentage change in uncertainty of momentum $= \frac{6.63\times10^{-14} - 4.00\times10^{-14}}{4.00\times10^{-14}} \times 100\%$ $= 66\%$

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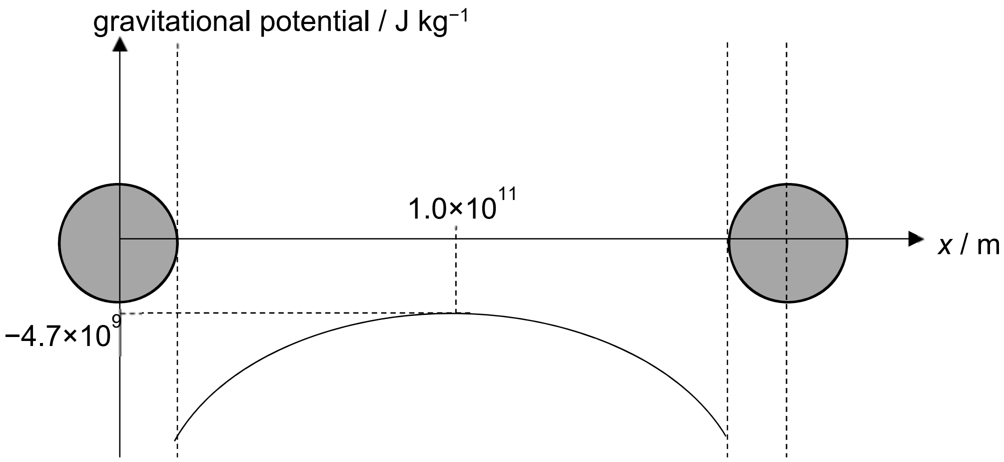
Paper 2 (80 marks)

1ai	Taking moments about X, (3.0)(0.30)(12) = (2)(0.30)(d) d = 18 cm
1aii	$k_{eff} = k_1 + k_2$ $= 3.0 + 2.0$ $= 5.0$ N m^{-1} Or Let the effective spring constant be k_{eff} $k_{eff}\, x = mg$ k_{eff} (0.30) = 0.15(10) k_{eff} = 5.0 N m^{-1}
1bi	Let the new extension be e. 3e + 2e = (0.15 + 0.050)(10) e = 0.40 m (or 40 cm)
1bii	Difference in EPE = ½ (3.0+2.0)(0.40)^2 – ½ (3.0+2.0)(0.30)^2 = 0.175 J Alternatively, difference in EPE = ½ F_2x_2 - ½ F_1x_1 = ½ (0.20)(10)(0.4) – ½ (0.15)(10)(0.3) = 0.175 J
1c	Let the new CG be y cm away from X. Taking moments about G (the new CG), (0.15)(10)(y) = (0.050)(10)(8-y) y = 2.00 cm

2ai	The gravitational potential at a point is the <u>work done per unit mass</u> (by an external force) in bringing a <u>small test mass</u> from infinity to that point.
2aii	gravitational potential at O = gravitational potential due to M at O + gravitational potential due to N at O $= -\frac{GM}{0.5d} + (-\frac{GM}{0.5d})$ where d is the distance between the centres of the stars $= -\frac{4GM}{d}$ $= -\frac{4(6.67\times10^{-11})(3.5\times10^{30})}{2.0\times10^{11}}$ $= -4.67\times10^{9}$ J kg^{-1}

2aiii	For the asteroid to escape from the stars, it needs to reach infinity with min k.e. By principle of conservation of energy, **EITHER** total energy of asteroid at O = total energy of asteroid at infinity $m_{asteroid}\phi+\frac{1}{2}m_{asteroid}v_{\min}{}^{2}=0+0$ $\frac{1}{2}m_{asteroid}v_{\min}{}^{2}=\frac{4GM}{d}m_{asteroid}$ $v_{\min}=\sqrt{\frac{8GM}{d}}$ $=\sqrt{\frac{8(6.67\times10^{-11})(3.5\times10^{30})}{2.0\times10^{11}}}$ $=9.7\times10^{4}$ m s^{-1} **OR** loss in KE of the asteroid = gain in GPE of the asteroid $\frac{1}{2}m_{asteroid}v_{\min}{}^{2}-0=0-m_{asteroid}\phi$ $\frac{1}{2}m_{asteroid}v_{\min}{}^{2}=\frac{4GM}{d}m_{asteroid}$ $v_{\min}=\sqrt{\frac{8GM}{d}}$ $=\sqrt{\frac{8(6.67\times10^{-11})(3.5\times10^{30})}{2.0\times10^{11}}}$ $=9.7\times10^{4}$ m s^{-1}
2aiv	Inverted U shape below horizontal axis Symmetrical 

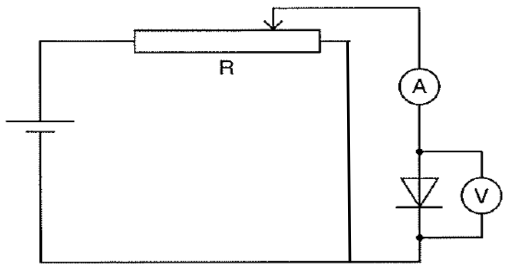
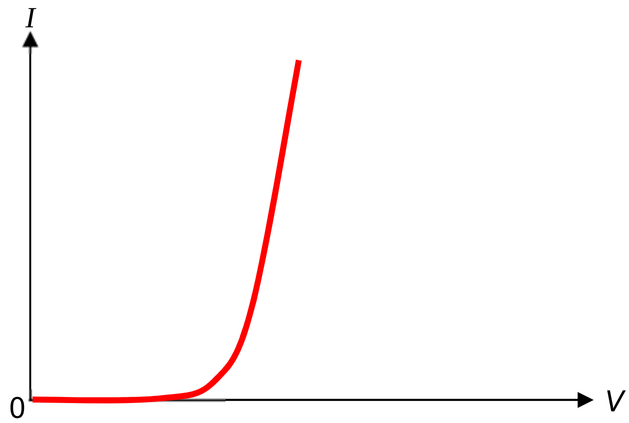
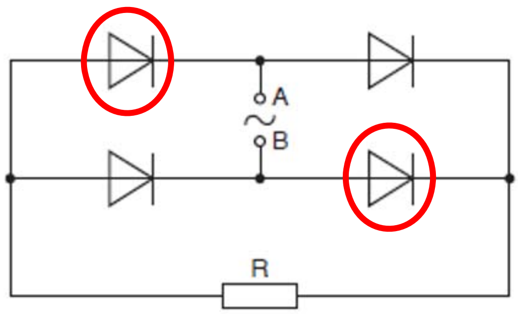
2bi	The gravitational force is <u>just sufficient</u> to provide the centripetal force **OR** The acceleration/force and velocity of the stars are <u>constantly/always</u> perpendicular to each other
2bii	The gravitational force on the star provides the centripetal force $\frac{GMM}{d^2} = M(\frac{d}{2})\omega^2$ $\omega = \sqrt{\frac{2GM}{d^3}}$ $= \sqrt{\frac{2(6.67\times10^{-11})(3.5\times10^{30})}{(2.0\times10^{11})^3}}$ $= 2.416\times10^{-7}$ rad s^{-1} $T = \frac{2\pi}{\omega}$ $= \frac{2\pi}{2.416\times10^{-7}}$ $= 2.601\times10^{7}$ s $= 0.82$ years

3a	the <u>*increase* in internal energy</u> of a system is equal to the <u>sum</u> of the <u>*heat supplied to*</u> the system and the <u>*work done*</u> <u>*on*</u> the system. Only get 1 mark if candidate did not use the word “system”.
3b	At <u>constant volume</u>, <u>no work is done</u> by the gas. <u>Heat</u> is required to increase the temperature of unit mass of gas by one unit <u>is solely to increase its internal energy</u>. At constant pressure, work is done by the gas as it expands. <u>Heat is required for the increase of its internal energy and the work done by the gas</u>. Hence the specific heat capacity of ideal gas at constant pressure is greater than the specific heat capacity at constant volume.
3c	Internal energy consists of potential energy due to intermolecular forces and kinetic energy due to random motion. Temperature is only making reference to the kinetic energy due to random motion. Temperature is proportional to the average kinetic energy due to random motion and not the total kinetic energy of all the particles.
3di1	Equation of state: $pV = nRT$ $2.62\times10^{5}(0.0360) = n(8.31)(273.15+25)$ $n = 3.809 \text{ mol} = 3.8 \text{ mol}$

3di2	$pV = nRT$ $p(0.0360) = (0.30 + 3.809)(8.31)(273.15 + 25)$ $p = 2.827 \times 10^5$ Pa

4ai	amplitude is decreasing (very) gradually / oscillations would continue (for a long time) /many oscillations light damping
aii1	$\omega = 2\pi/T$ $= 2\pi/0.3$ $= 20.9$ rad s^{-1}
aii2	Loss of Energy = total initial energy of oscillation – total final energy of oscillation = k.e. max initial (when oscillation has an amplitude of 1.5 cm) – k.e. max final (when oscillation has an amplitude of 1.1 cm) $= ½\, m\omega^2 x_{o,initial}^2 – ½\, m\omega^2 x_{o,final}^2$ $= ½ \times 0.065 \times 20.9^2 \times (0.015^2 – 0.011^2)$ = 0.00147 = 0.0015 J
aii3	amplitude <u>reduces exponentially</u> / <u>does not decrease linearly</u> so will be not be 0.7 cm
b	Construction of horizontal line at E_k = 1.5 mJ amplitude = 1.1 cm If shifted curve is shown with the correct 3 key points, 2 marks. If shifted curve is shown with only the correct max point (wrong amplitude values), 1 mark

5a	Current = E / (R+r) = 2.0 / (7.5+0.5) = 0.25 A
bi	$I = Anvq$ $R = \rho L/A \Rightarrow A = (6.9 \times 10^{-7})(1.2) / 7.5 = 1.104 \times 10^{-7}$ $v = (0.25) / [(1.104 \times 10^{-7})(8.0 \times 10^{28})(1.6 \times 10^{-19})$ $= 1.77 \times 10^{-4}$ $= 1.8 \times 10^{-4}$ m s^{-1}
ii	Since volume remains unchanged, stretching the wire will reduce the cross sectional area but increasing the length since v [= $\frac{I}{Anq} = \frac{V}{RAnq} = \frac{V}{\frac{\rho L}{A}(Anq)} = \frac{V}{\rho Lnq}$] is inversely proportional to L, drift velocity decreases.
ci	$V_{XJ} = 0.25(7.5) \times (0.90/1.20)$ = 1.4 V

ii	Since there is no current flowing through the cell B at balanced length, the presence of the resistance in the galvanometer will have no effect on the balanced length
iii	The additional resistor is added **in series with cell A** or **parallel with resistance wire** in the primary circuit.
6ai	
aii	
aiii	The resistance can be obtained by taking the ratio of V to I
bi	
ii	$V_{max} = \sqrt{2} \times 7.0 = 9.9$ V

iii (1)

Shape (half wave) – 3 complete cycles
Correct period & amplitude
T = 1/25 = 40 ms
V_o = 9.9 V

iii(2)

$$P_{mean,rectified} = \frac{P_0}{4} = \frac{V_0^2}{4R}$$

$$R = \frac{\left(\sqrt{2} \times 7\right)^2}{4 \times 4.5}$$

$$= 5.44 = 5.4\ \Omega$$

7a

Echo	Reverberation
Reflection from distant surface	Reflection from near surfaces
Single reflection	Multiple reflections
Distinct sound	Garbled/overlapping/mixed sound

Any one of the above.

7b

With reverberation, speech becomes muddled / can’t hear clearly because the reverberations overlapped/interfere with the sound waves generated either by speaker or the reflected waves.

7ci

Energy is absorbed by the panels.

7cii

When frequency of sound is equal to natural frequencies of the panel, resonance occurs. Maximum energy is transferred from the sound to the panel, and hence less energy is reflected off the walls, thus reducing reverberation times.

7d

Other factors that would affect reverberation time:
1. Size/volume of room
2. surface area of absorbing area
3. distance between source and reflecting surface
4. texture of reflecting surface (soft/hard, smooth/rough)
5. room that is filled with objects that can absorb sound
6. Intensity of sound
7. temperature/pressure/density/humidity of air

7ei	f = 1280 Hz, $\frac{1}{f^2} = 0.61 \times 10^{-6} s^2$
7eii	1. Point plotted correctly 2. Balanced line drawn
7eiii 1	$\text{Gradient} = \frac{(0.700\text{-}0.400)\times 10^{-6}}{(5.00\text{-}1.30)}$ $=0.0811\times 10^{-6}$ s^2 mm^{-1}
7eiii 2	subst (5.00, 0.700 x 10^{-6}) in y = mx + c, 0.700 x 10^{-6} = 0.0811 x 10^{-6} (5.00) + c c = 2.95 x 10^{-7} s^2
7eiv 1	$f = 5000\sqrt{\frac{P}{L(t + 0.8\ d)}}$ $\frac{1}{f^2} = \left(\frac{0.8L}{5000^2 P}\right) d + \frac{Lt}{5000^2 P}$ Gradient = $\frac{0.8L}{5000^2 P}$, sub P =10 L = 25.3 mm
7eiv 2	$\frac{Lt}{5000^2 P} = 2.95 \times 10^{-7}$ t = 2.92 mm
7fi	From Fig. 7.3, resonant frequency for 5.0 mm hole is 1180 Hz. From Fig. 7.5, it can be seen that resonant frequencies have been reduced to 1000 Hz.
7fii	Absorber 2 will be more suitable since it has a higher coefficient of absorption than absorber 1 at all frequencies, implying more energy is absorbed for every frequency and therefore less reverberations.

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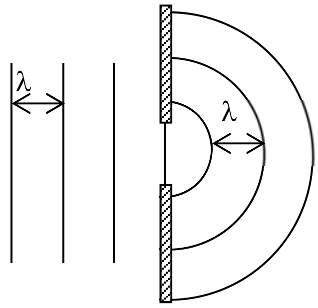
Paper 3 (80 marks)

1a	point D (vertical speed first starts to decrease)
1bi	Deceleration = $\frac{(50-20)}{2}$ = 15 m s^{-2}
1bii	s = ut + ½ a t^2 = 50 (2) + ½ (-15) (2)^2 = 70 m Alternative method is calculate area under graph = ½ (50+20)(2) = 70 m
1biii	F_{net} = ma mg – F_R = ma 85 x 9.81 – F_R = 85(-15) F_R = 2100 N
1c	<u>Air resistance is larger than weight</u>, hence resultant force points upwards but velocity is downwards, hence parachutist slows down. <u>Air resistance decreases (as speed decreases)</u>, hence resultant force decreases to 0 After which, <u>air resistance equals to the weight</u> at point F and hence velocity remains constant.
1di	<u>The parachutist comes to a complete stop over a longer period</u> (for a given change in momentum, with a longer period, this) <u>reducing the force of impact.</u> <u>The force of impact on the parachutist is also distributed across various parts of the body (instead of a single part), reducing the risk of injury.</u>
1dii	Considering the parachutist only as a system, As there is net external force by Earth on parachutist, momentum is not conserved. Or Considering the parachutist and Earth as a system, As there is no external force acting on the system, momentum is conserved as there is a corresponding change in the momentum of the Earth.
2ai	Normal contact (reaction) force towards centre of circular motion Weight downwards Friction upwards
ii	By Newton's 2nd Law, (taking upwards +ve) $\sum F_y = ma = 0$ $f - W = 0$ $f = mg$ (1)

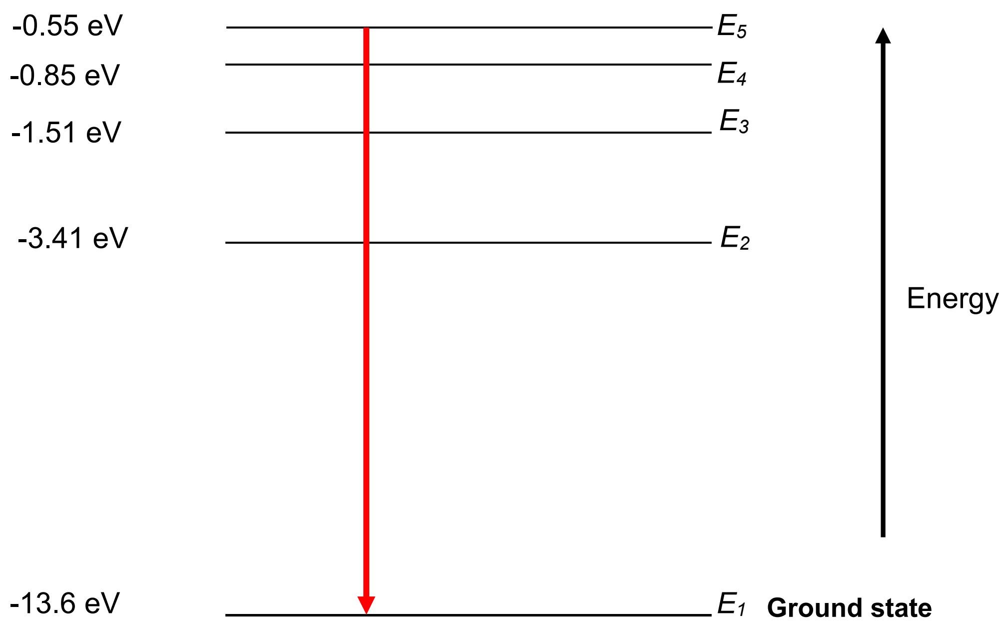
	Normal contact force provides the centripetal force for the passenger to be in circular motion. $\sum F_c = ma_c$ $N = \frac{mv^2}{R}$ $\frac{f}{\mu} = \frac{mv^2}{R}$ (2) Taking (2) / (1): $\frac{\frac{f}{\mu}}{f} = \frac{\frac{mv^2}{R}}{mg}$ $\frac{1}{\mu} = \frac{v^2}{Rg}$ $v = \sqrt{\frac{Rg}{\mu}}$ where velocity v is independent of mass m
bi	$\sum F_c = ma_c$ $W - N = \frac{mv^2}{r}$ At maximum speed, $N = 0$ $W = \frac{mv^2}{r}$ $mg = \frac{mv^2}{r}$ $v = \sqrt{rg}$ $= \sqrt{95 \times 9.81}$ $= 30.528$ $= 30.5\,\text{m s}^{-1}$
ii	By Principle of Conservation of Energy, $GPE_{top\ of\ hill} + KE_{top\ of\ hill} = GPE_{At\ A} + KE_{At\ A}$ $mgh + \frac{1}{2}m(25)^2 = mg(95 \times 2) + \frac{1}{2}m(30.528)^2$ $h = 206\,m$
iii	For a larger speed, the centripetal force required is larger, Which means that another physical force (other than the weight) needs to act towards the centre of circular path which can now be provided by the track on cart.

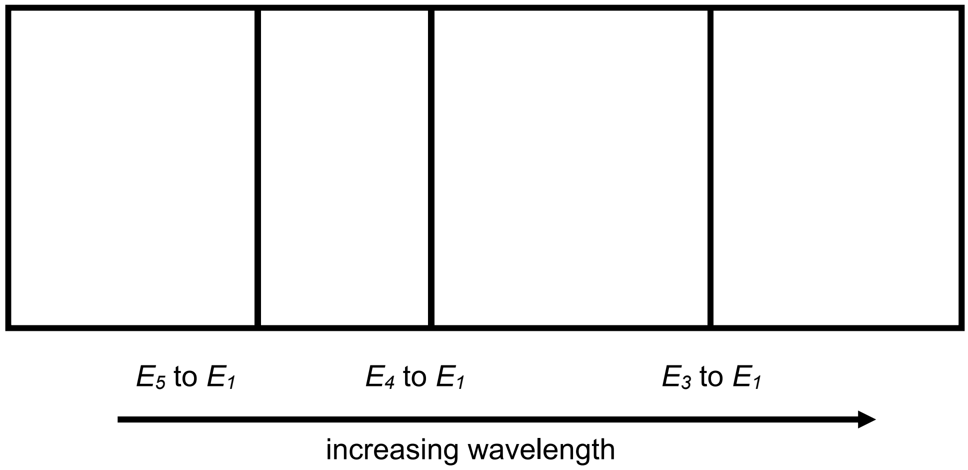
3ai	Diffraction is the <u>spreading of waves</u> when they pass through an opening or round an obstacle. Diffraction effects are the greatest when the <u>width of the opening is comparable with the wavelength of the waves</u>.
3aii	 **Fig. 3.1** Contrast between spreading and curvature Constant wavelength, including drawing of wavefront at the apertures for both figures
3aiii	The wavelength of sound waves is <u>comparable to the size of door gap</u> while the wavelength of light waves is <u>very small compared to the size of door gap</u>. Hence, <u>more significant diffraction</u> is observed for sound than light.
3bi	Intensity at 5.50 m from loudspeaker S_1 = $\frac{P}{4\pi r^2} = \frac{20.0}{4\pi(5.50)^2} = 0.05261\text{ W m}^{-2}$ Power received by ear = intensity × area of ear = 0.05261 × (2.5 × 10^{-4}) = 1.32 × 10^{-5} W
3bii	Loudspeaker is transmitting energy uniformly in all directions.
3ci	Using v = f λ ⇒ λ = v / f = 330 / (2.75 × 10^3) = 0.12 m
3cii	Path difference = 4.12 – 3.82 = 0.30 m = 2.5 λ Number of maxima = 2
3ciii	Point A (with path difference = 0) is loud Path difference at point B is 2.5λ hence point B is a soft sound Since intensity ∝ (amplitude of Δpressure)^2, $\frac{I_{A2}}{I_{A1}} = \left(\frac{A_2}{A_1}\right)^2 \Rightarrow \frac{2I}{I} = \left(\frac{A_2}{A_1}\right)^2 \Rightarrow A_2 = \sqrt{2}A_1$ At point B, amplitude of Δpressure, A_B = √2 A_1 – A_1 , $\Rightarrow \frac{I_B}{I_{A1}} = \left(\frac{\sqrt{2}A_1 - A_1}{A_1}\right)^2 \Rightarrow I_B = 0.172I$

3civ	The spacing between consecutive maxima increases / Number of maxima decreases
3di	The incident wave is reflected at the wall and a stationary wave is formed. The reflected wave is antiphase with the incident wave at the wall or a displacement node is formed at the wall. (Since displacement node is a pressure antinode,) loud signal at the wall
3dii	$d = 1.5\lambda = 1.5\,(0.12)$ $= 0.18$ m L – Loud region S – Soft region L S L S L S L $\longleftrightarrow$ λ

4a	work done per unit positive charge in bringing a small test charge from infinity to that point
bi	Gradient of the V-r graph
bii	Horizontal line showing $E = 0$ within the conductor (at right and left sides of graph) *has to be drawn even though it is at zero Shape of graph with a turning point (min in the +ve segment) Graph is asymmetrical with turning point nearer to left side, with the left side of the curve being higher than the right side.
biii	Since $V_P + V_Q = 0$ $\dfrac{3.2\times10^{-9}}{4\pi\varepsilon_o x}+\dfrac{-1.6\times10^{-9}}{4\pi\varepsilon_o\left(0.40-x\right)}=0$ $x = 0.27$ m
biv	V at all points doubled Position when V = 0 remains unchanged
ci1	$W_{AB\ (by\ electric\ force)} = 5.0 \times 10^{-7} \times 2.0 \times 10^{-2} = 1.0 \times 10^{-8}$ J
ci2	$W_{AD\ (by\ electric\ force)} = 1.0 \times 10^{-8}$ J
cii	Since $W_{\text{by external force}} = -W_{\text{by electric force}}$, $W_{AB\ (\text{by external force})} = -\,W_{AB\ (\text{by electric force})} = -1.0 \times 10^{-8}$ J Since $\Delta U_{AB} = W_{AB\ (\text{by external force})}$ $q\Delta V_{AB} = -1.0 \times 10^{-8}$ J $V_B - V_A = -1.0 \times 10^{-8} / (2.5 \times 10^{-11}) = -400$ $V_B = -400 + 200 = -200$ V

5ai	Taking moments about PQ, F x QC = W x DQ B(4.0)(0.15) x 0.60 = 3.0 $\times$ 10^{-4} x 0.20 B = 1.667 x 10^{-4} = 1.67 x 10^{-4} T
5aii	Magnetic flux density produced by the solenoid = 1.67 x 10^{-4} – 5.0 $\times$ 10^{-5} = 1.17 $\times$ 10^{-4} Since B = $\mu_o nI$ 1.17 $\times$ 10^{-4} = $4\pi \times 10^{-7} \times 6.0 \times 10^2\ I$ I = 0.155 A
5bi	Using Fleming's LHR, particle X is the negatively-charged particle.
5bii	Since Bqv = mv^2/r Therefore, r = mv/Bq The particle loses energy / speed / momentum so the radius becomes smaller
5biii	Equal initial radii So equal speed
5ci	As the blade moves, the different parts of the blade experiences changing magnetic flux density, resulting in a <u>change in magnetic flux</u>. By Faraday's law of electromagnetic induction, an emf is induced in the blade. This gives rise to (eddy) currents in the blade and hence heating of the blade. The thermal energy is derived from the mechanical energy (or energy of oscillations) of the blade, so the amplitude decreases.
5cii	resistance
5ciii	The eddy currents will be reduced, hence the opposing (electromagnetic) force will also be smaller.
5di	Φ = NBA cos θ = $650 \times 2.5 \times 10^{-3} \times 20 \times 10^{-3} \times 35 \times 10^{-3} \times \cos 30°$ = 9.85×10^{-4} Wb turns
5dii	Φ = NBA cos ωt $E = -\dfrac{d\emptyset}{dt} = -\dfrac{d(NBA\cos\omega t)}{dt}$ $= \omega NBA \sin \omega t$ = $2\pi(20) \times 650 \times 2.5 \times 10^{-3} \times 20 \times 10^{-3} \times 35 \times 10^{-3} \sin 40\pi t$ = 0.143 sin 40πt = 0.14 sin 40πt (shown)
5diii	Peak emf halved to 3.5 units And period doubled to 20 units

6a	Electrons from heated cathode bombarded electrons in hydrogen atoms/molecules. Causing electrons in hydrogen atoms/molecules to be excited from lower energy levels to higher energy levels. The excited electrons at higher energy levels subsequently de-excite and gives off energy in the form of photons, with energy exactly equal to the difference in energies between the energy levels. (The emitted photons thus made up the visible light).
6b	(Well-defined, distinct) Coloured lines on dark background.
6ci	
6cii1	Energy of photon = Difference in energies between energy levels $\frac{hc}{\lambda} = [-0.55-(-13.6)](1.6\times10^{-19})$ $\lambda = 95.3\times10^{-9}$ m
6cii2	10

6cii3	 Note: Labelling not required. The 2 shorter wavelengths should be closer. Shorter wavelengths to be located at the left.
6di	Energy of most energetic photon = biggest difference in energies between energy levels $\frac{hc}{\lambda} = [-0.55-(-13.6)](1.60\times10^{-19})$ $\frac{hc}{\lambda} = 2.088\times10^{-18}\ J$ $Energy\ of\ photon\ = \phi\ +\ KE_{\max}$ Loss in KE = Gain in EPE $KE_{\max}\ =\ eV_s$ $Energy\ of\ photon\ = \phi\ +\ eV_s$ $2.088\times10^{-18} = \phi + 2.45(1.60\times10^{-19})$ $\phi = 1.696\times10^{-18}\,\text{J}$
6dii 1	$I_{sat} = \frac{n_e e}{t}$ $\frac{n_e}{t} = \frac{3.0\times10^{-6}}{1.60\times10^{-19}} = 1.875\times10^{13}$ $\text{Quatum yield} = \frac{\frac{n_e}{t}}{\frac{n_p}{t}}$ $\frac{n_p}{t} = \frac{\frac{n_e}{t}}{\text{quantum yield}} = \frac{1.875\times10^{13}}{9.2\times10^{-7}}$ $= 2.038\times10^{19}$
6dii 2	Reflection [1] or Low rate of collision between electrons and photons due to large empty spaces. [1] or

	Absorption of photons by electron does not result in emission as the electrons deeper within the metal loses too much energy on way to surface. [1] or Some of the photons have energy less than the work function [1]
6diii 1	Intensity is reduced (by 50%) when unpolarised radiation is polarized, or the number of photons incident per second is thus also halved (and therefore, the maximum number of electrons emitted per unit time and) hence saturation current is also halved (to 1.5 μA)
6diii 2	The electrons will be emitted with higher maximum kinetic energy as a smaller part of energy received from photon is used to overcome work function energy. (Use eqn to explain, can accept) As a result, the potential necessary to stop the fastest electron is thus also increased. Or As there was a good range of photons incident on the metal plate, with the lower of work function energy, a bigger group of photons will have more energy than the work function energy and therefore be capable of releasing electrons. As a result, the saturation current/ max current increases.
6div	De Broglie equation suggested that the photons of the light will have particle like behavior with a finite momentum. Since the photons experience a change in momentum upon impact with the metal surface, the metal surface exerts a force on the photons. By Newton's 3rd law, the photons also exert a force on the metal surface. As pressure is force per unit area and force is rate of change of momentum, the impact of photons on metal surface will exert a force and hence pressure on the metal.