EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

PHYSICS

9749/01

Paper 1 Multiple Choice

20 September 2018

1 hour

Additional Materials: Multiple Choice Answer Sheet

READ THESE INSTRUCTIONS FIRST

Write in soft pencil.
Do not use paper clips, glue or correction fluid.
Write your name, civics group and registration number on the Answer Sheet in the spaces provided.

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 **18** 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	$= \rho g h$
gravitational potential,	ϕ	$= -\frac{Gm}{r}$
temperature,	T/K	$= T/^{\circ}C + 273.15$
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	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t$
		$= \pm \omega\sqrt{(x_o^{\ 2} - x^2)}$
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	$= x_o \sin \omega t$
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	$= \frac{\mu_o N I}{2r}$
magnetic flux density due to a long solenoid	B	$= \mu_o n I$
radioactive decay,	x	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \frac{\ln 2}{t_{\frac{1}{2}}}$

1 Measurements are subject to both systematic error and random error.

Which measurements have high accuracy and low precision?

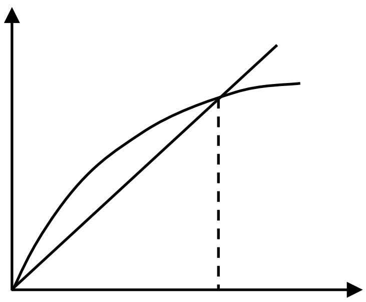
A High random error and high systematic error

B High random error and low systematic error

C Low random error and high systematic error

D Low random error and low systematic error

2 The diagram below shows the variation of displacement with time for 2 trains, Train A and Train B, running on parallel tracks.



Which of the following statements is correct?

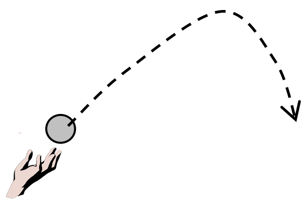
A At time t_B, both trains have the same velocity.

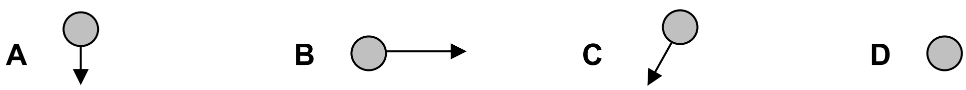
B Both trains speed up all the time.

C Both trains have the same velocity at some time before t_B.

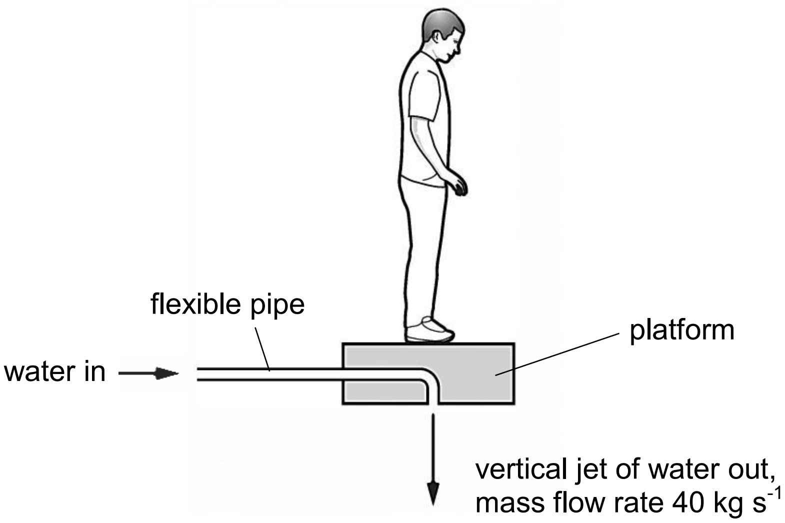
D Somewhere on the graph, both trains have the same acceleration.

3 A ball thrown at an angle travels in a trajectory as shown below. When the ball is at the top of its flight, which of the following shows the direction its resultant acceleration?





4 The diagram shows a man standing on a platform that is attached to a flexible pipe. Water is pumped through the pipe so that the man and platform remain at a constant height.



The resultant vertical force on the platform is zero. The combined mass of the man and platform is 96 kg. The mass of water that is discharged vertically downwards from the platform each second is 40 kg.

What is the speed of the water leaving the platform?

A 2.4 m s^{-1} **B** 6.9 m s^{-1} **C** 24 m s^{-1} **D** 47 m s^{-1}

5 Two objects A and B collide head-on on a horizontal, frictionless surface. The velocities of the objects before the collision and after the collision are shown in the diagram below.

Which of the following statements is correct?

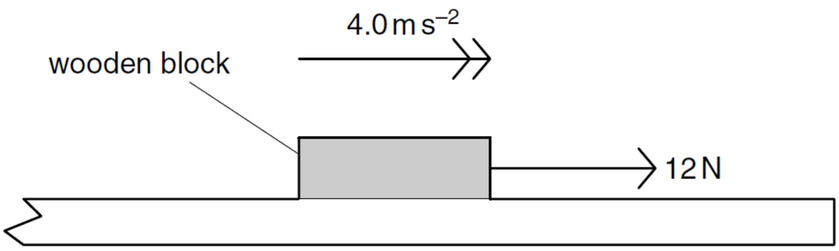
A The sum of the kinetic energies of A and B is conserved.

B The collision is possibly inelastic.

C The total momentum of the two objects cannot be conserved since no net external force acts on them.

D The momentum of each object is conserved.

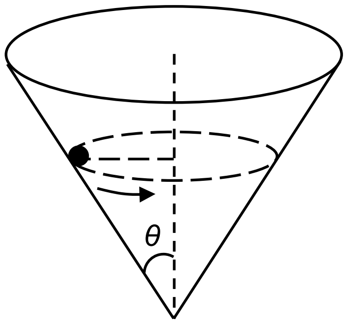
6 A wooden block of mass 1.0 kg is on a rough horizontal surface. A force of 12 N is applied to the block and it accelerates at 4.0 m s^{-2}.



What is percentage of work done is used to overcome frictional force when the block is being moved a distance of 10 m?

A 33.3% **B** 66.7% **C** 75.0% **D** 100%

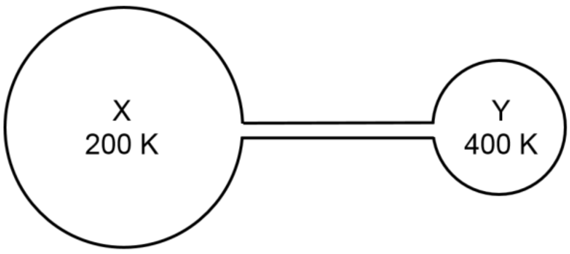
7 A small bead is set into circular motion in a horizontal plane within a smooth conical cone as shown below.



If the bead is moving with a centripetal acceleration of *g*, what is the angle *θ*?

A 30° **B** 45° **C** 55° **D** 70°

8 In the diagram below, the volume of bulb **X** is twice that of bulb **Y**. The system is filled with an ideal gas and a steady state is established with the bulbs held at 200 K and 400 K.

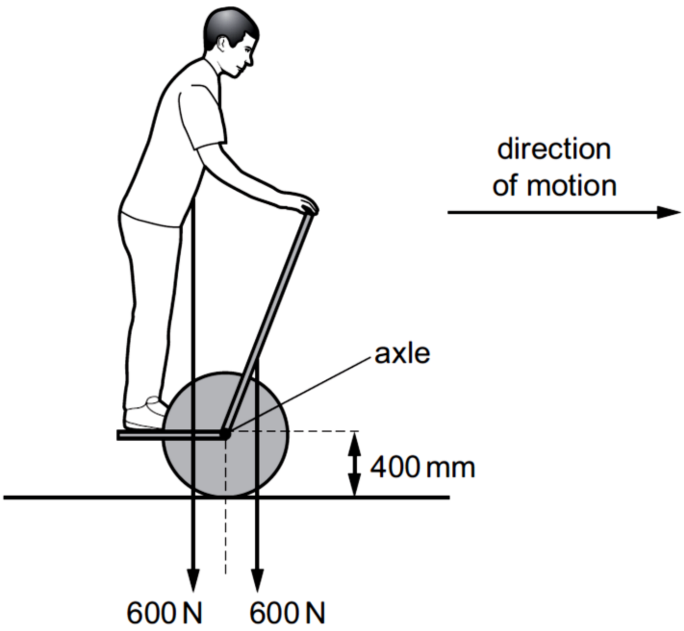


There are *b* moles of gas in **X**.

How many moles of gas are there in **Y**?

A *b* / 4 **B** *b* / 2 **C** *b* **D** 2*b*

9 The diagram below shows a motorised vehicle for carrying one person.



The vehicle has two wheels on one axle. The passenger stands on a platform between the wheels.

The weight of the machine is 600 N. Its centre of mass is 200 mm in front of the axle. The wheel radius is 400 mm.

When stationary, a passenger of weight 600 N stands with his centre of mass 200 mm behind the axle to balance the machine.

The motor is now switched on to provide a horizontal force of 90 N at the ground to move the vehicle forwards.

How far and in which direction must the passenger move his centre of mass to maintain balance?

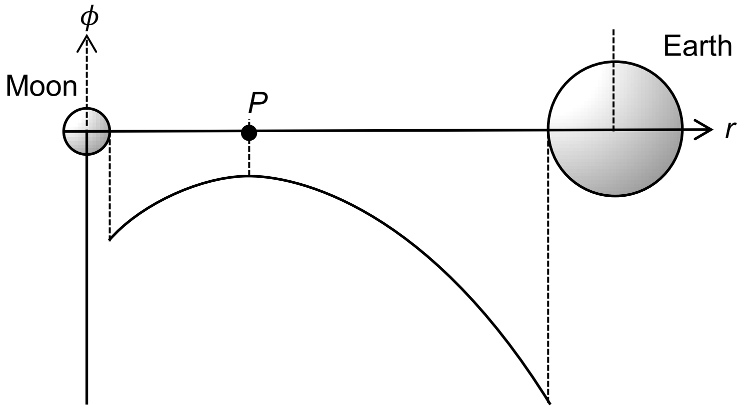
A 60 mm backward

B 60 mm forward

C 140 mm backward

D 140 mm forward

10 The gravitational potential ϕ as it varies with distance r from the centre of the Moon to the centre of Earth as shown in the diagram below.



Which of the following statements is **not** true?

A The gravitational field strength at P is zero.

B The gravitational field strength at P is the scalar sum of the individual field strengths of the Moon and the Earth at point P.

C The gravitational field strength at P is the vector sum of the individual field strengths of the Moon and the Earth at point P.

D The gravitational field strength at P is given by the rate of change of ϕ with respect to r.

11 A fixed amount of ideal gas undergoes the following changes:

Process 1: The gas is heated at constant volume.
Process 2: The gas is compressed at constant pressure.

How does the internal energy of the gas for each process change?

	Process 1	**Process 2**
A	increase	increase
B	increase	decrease
C	decrease	increase
D	decrease	decrease

12 Which of the following statements is **false** in describing a mass moving in simple harmonic motion?

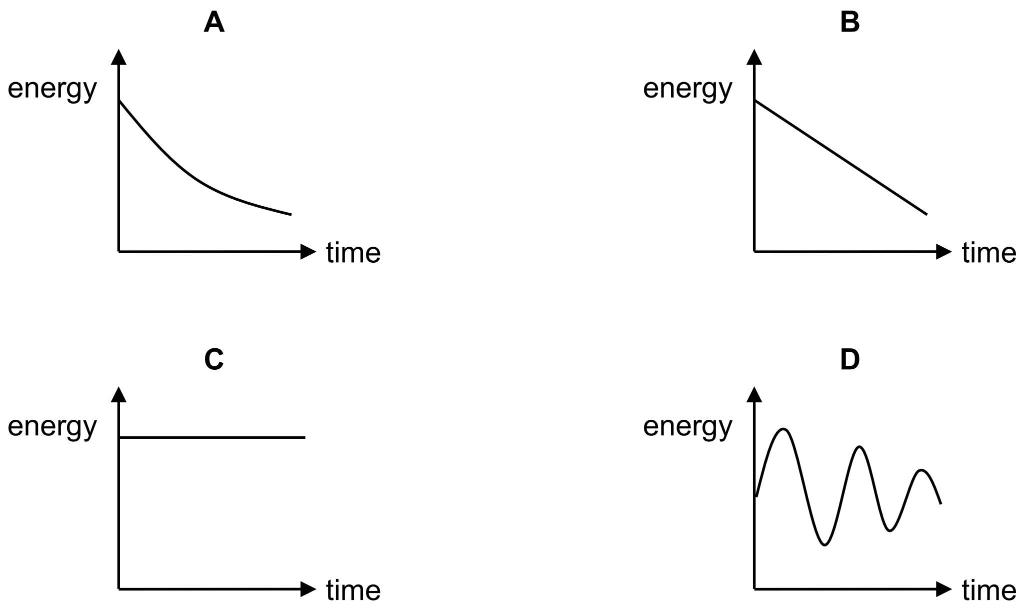
A The maximum kinetic energy is dependent on the frequency of the oscillation.

B The time taken for the system to change from maximum kinetic energy to maximum potential energy is a quarter of the period of the oscillation.

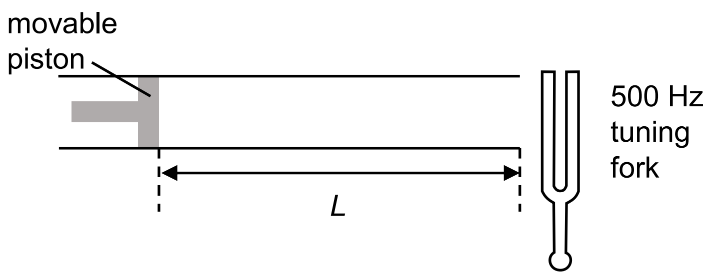
C An oscillating system with larger amplitude will have a longer period.

D An oscillating system with larger amplitude will have a greater maximum velocity.

13 Which of the following graphs show the variation in the total energy of an object under light damping as time passes?



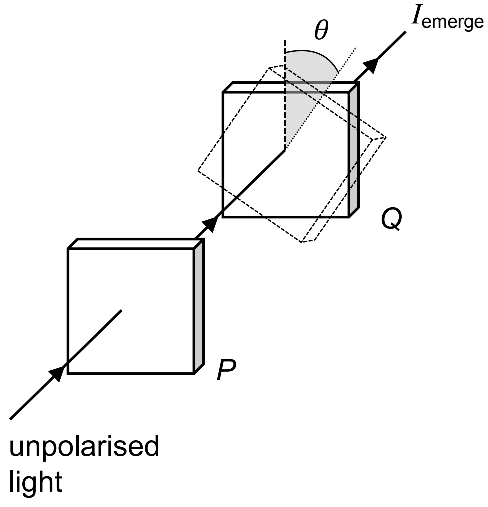
14 A 500 Hz tuning fork is held at the open end of an air-filled glass tube, which is closed at the other end by a movable piston.



Resonance is achieved when L = 82.5 cm. Given that the speed of sound in air is 330 m s^{-1}, which of the following other values of L will **not** result in resonance?

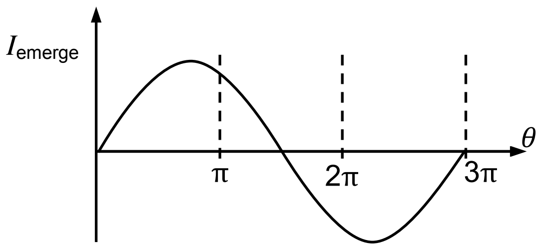
A 16.5 cm **B** 49.5 cm **C** 99.0 cm **D** 115.5 cm

15 Unpolarised light is incident normally on a linear polarizer *P* and subsequently on a second linear polarizer *Q* as shown below.

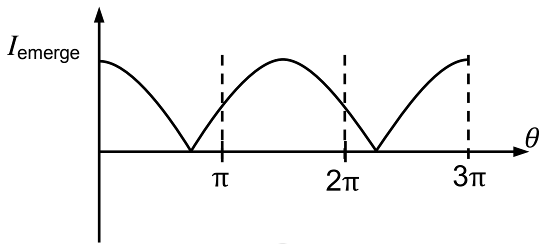


Which graph best represents the relationship between the emergent light intensity I_{emerge} and the angle of rotation of *Q* about the axis of light transmission θ?

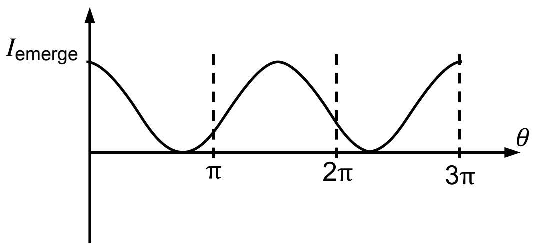
A



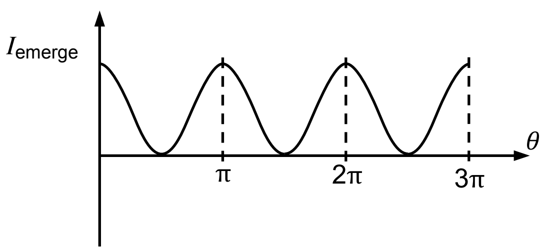
B



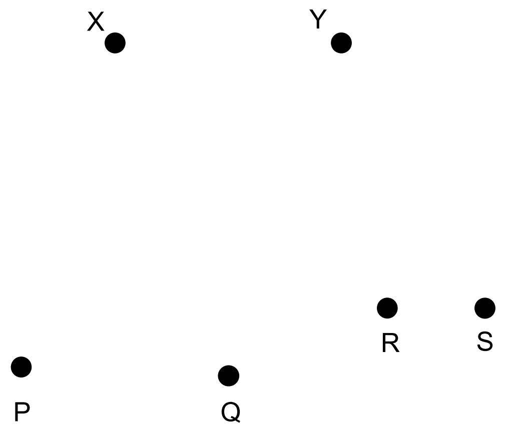
C



D



16 In the diagram below (drawn to scale), X and Y are identical point sources of waves that exhibit a constant phase difference of π at source. The waves have a wavelength of 1.0 cm.



Which of the following statements is true?

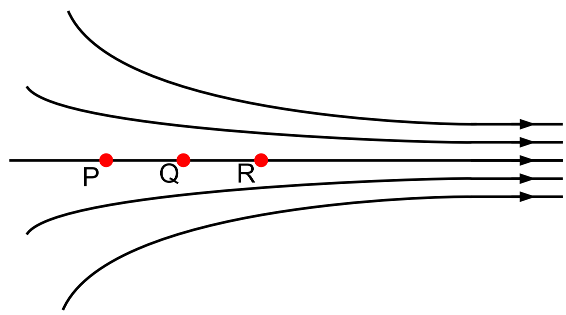
A P is a point of destructive interference.

B $XQ - YQ = m\frac{\lambda}{2}$, where m is an odd integer.

C $XR - YR = n\lambda$, where n is an integer.

D S is a point of destructive interference.

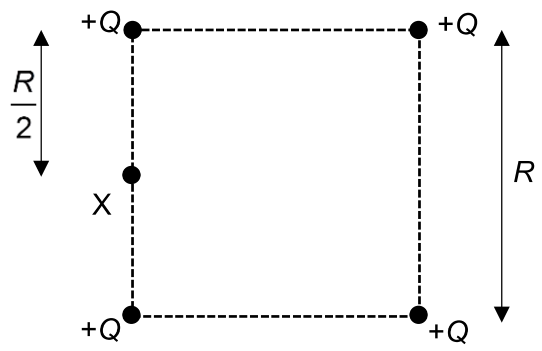
17 The diagram below shows electric field lines with points P, Q and R on one of the field lines. The distance between PQ is equal to the distance between QR.



If the potential at P and Q are 0 V and – 200 V, respectively, which of the following can be a possible value of the potential at R?

A - 450 V **B** - 400 V **C** + 200 V **D** + 250 V

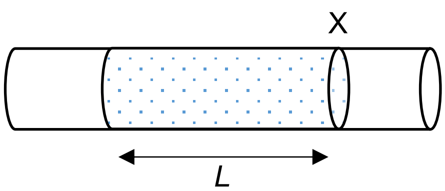
18 Four identical point charges are arranged at the corners of a square of length R as shown below.



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	$\frac{4}{\sqrt{5}^3}\ \frac{Q}{\pi\varepsilon_0 R^2}$	$\left(1+\frac{1}{\sqrt{5}}\right)\ \frac{Q}{\pi\varepsilon_0 R}$

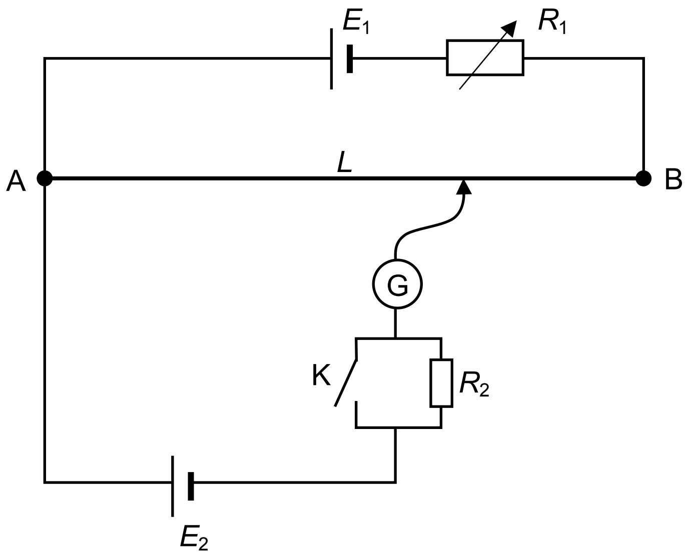
19 A copper wire has a number density of 8.5×10^{28} conduction electrons per cubic metre, and an cross-sectional area of 3.2×10^{-7} m^2. When a potential difference is applied to the ends of the wire, the current is 1.0 A.



If all the electrons within a cylinder of length L pass point X in 60 s, what is the value of L?

A 0.00015 m **B** 0.014 m **C** 0.025 m **D** 0.20 m

20 Which of the following statements is true about the circuit shown?



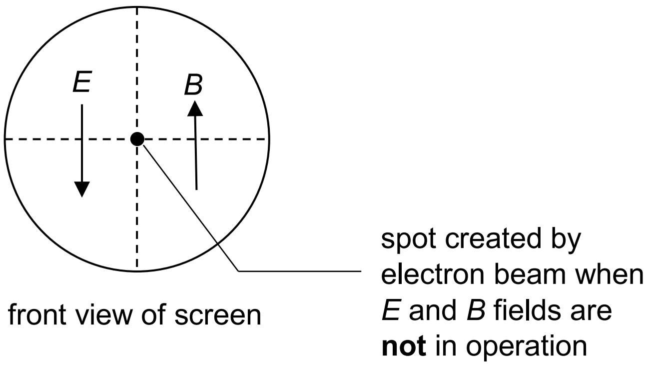
A When switch K is closed, as the resistance R_2 increases, the balanced length L decreases.

B When switch K is open, as the resistance R_2 increases, the balanced length L does not change.

C When switch K is open, as resistance R_1 increases, the balanced length L decreases.

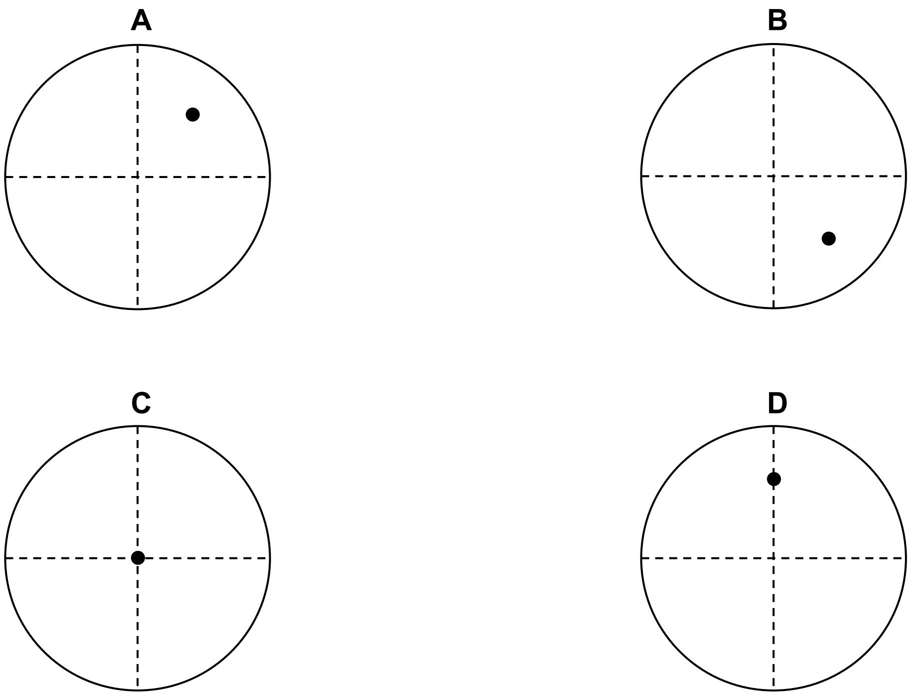
D When switch K is closed, changes in the internal resistance of E_2 will produce an increase in the balanced length L.

21 In a cathode-ray oscilloscope tube, the electron beam passes through a region where there is an electric field directed vertically downwards and a magnetic field directed vertically upwards as shown in the diagram below.

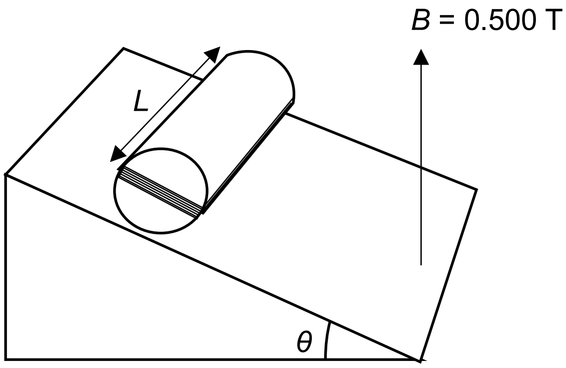


front view of screen

Which of the diagrams below shows a possible position of the spot on the screen when both fields are operating together?



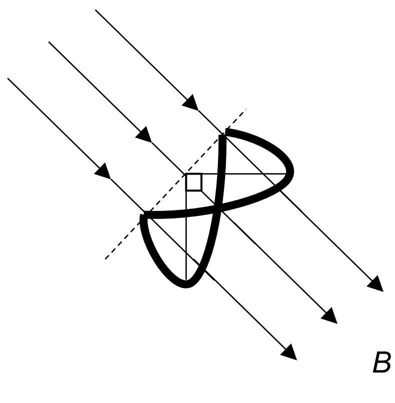
22 A wooden cylinder of mass 0.250 kg and length *L* of 0.100 m, has 10 turns of wire wrapped around it longitudinally. The cylinder is released on a plane inclined at an angle θ to the horizontal, with the plane of the coil parallel to the incline plane, as shown in the diagram below.



If there is a vertical uniform magnetic field of magnitude 0.500 T acting throughout the plane, what is the least current through the coil that keeps the cylinder from rolling down the plane?

A 1.25 A **B** 2.45 A **C** 6.77 A **D** 11.2 A

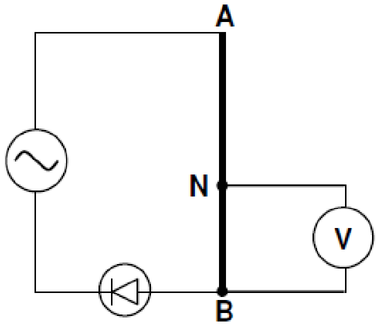
23 A closed circular loop of wire has a radius of 3.7 cm. It is bent along a diameter such that the two halves are perpendicular to each other. A uniform magnetic flux density of *B* = 76 mT is directed perpendicular to the fold diameter and makes equal angles (45°) with the planes of the semicircle.



If the magnetic flux density *B* is reduced to zero at a uniform rate during a time interval of 4.5 ms, what is the magnitude of the induced e.m.f in the loop?

A 0.026 V **B** 0.051 V **C** 0.073 V **D** 0.098 V

24 The uniform wire AB has length 1.0 m and resistance of 10 Ω. When NB is 40.0 cm, the a.c. voltmeter reads a steady r.m.s. voltage of 2.5 V.



What is the instantaneous peak power provided by the supply?

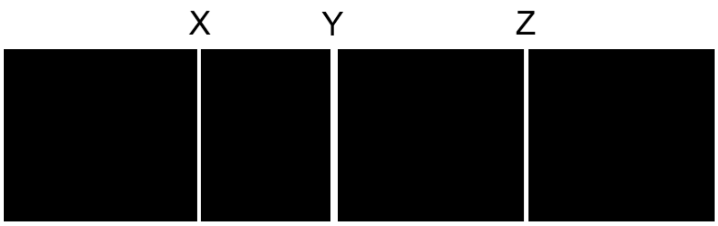
A 0.63 W **B** 3.9 W **C** 7.8 W **D** 16 W

25 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

26 The diagram below shows the line spectrum from a hot gas.



Which of the following statements can account for line Y being much brighter than lines X and Z?

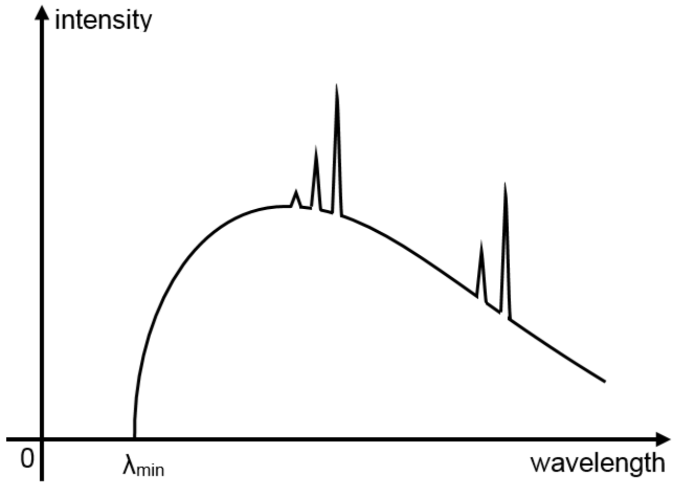
A Line Y has the highest frequency.

B Line Y originates in the hottest part of the gas.

C Line Y is the result of electrons undergoing transition between two states of greatest energy difference.

D Line Y is the result of most electrons undergoing the same transition between the two states involved in the emission.

27 An X-ray spectrum is shown in the diagram below.



What does the value of λ_{min} represent?

A The threshold wavelength of the target metal used to produce X-ray.

B The wavelength corresponding to the ionization energy of the target metal.

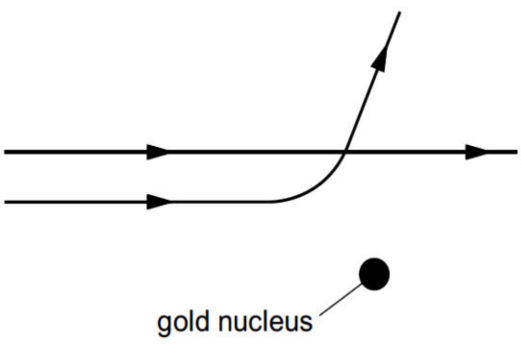
C The de Broglie wavelength of the electron with maximum energy.

D The wavelength corresponding to all the energy supplied to an electron in the accelerating electric field being converted into a single X-ray photon.

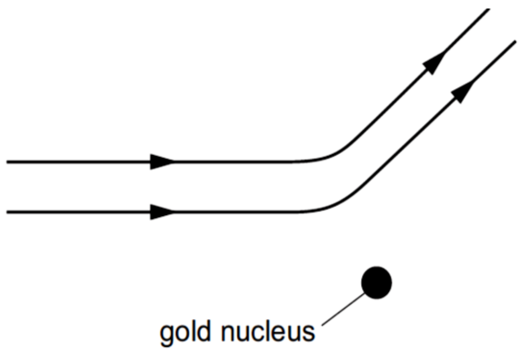
28 Two alpha particles with equal energies are fired towards the nucleus of a gold atom.

Which diagram best represents their paths?

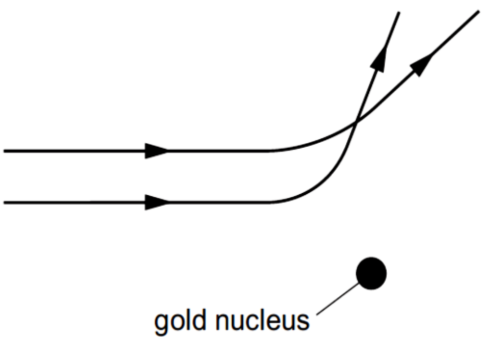
A



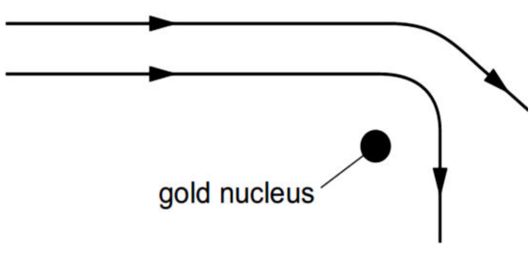
B



C



D



29 Uranium-235 undergoes fission in a reaction shown below, releasing 195 MeV of energy. The binding energy per nucleon for uranium-235 is 7.6 MeV, and those for caesium and rubidium are approximately **X** MeV.

$$^{235}_{92}\text{U} + ^{1}_{0}\text{n} \rightarrow ^{143}_{55}\text{Cs} + ^{90}_{37}\text{Rb} + 3^{1}_{0}\text{n}$$

What is the value of **X**?

A 6.7 **B** 6.8 **C** 8.4 **D** 8.5

30 Radon $^{222}_{86}\text{Ra}$ is the start of a decay chain that forms bismuth $^{214}_{83}\text{Bi}$ by α and β emission.

For the decay of each nucleus of radon, how many α-particles and β-particles are emitted?

	α-particles	β-particles
A	1	1
B	2	1
C	1	2
D	2	2

END OF PAPER

Paper 1 Answer Key

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

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	1	7	-			REGISTRATION NUMBER		

PHYSICS 9749/02

Paper 2 Structured Questions

14 September 2018

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, 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	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

This document consists of **22** printed pages and **0** blank pages.

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,	$p = \rho gh$
gravitational potential,	$\phi = -\frac{Gm}{r}$
temperature,	$T/K = T/^{o}C + 273.15$
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.	$x = x_o \sin \omega t$
velocity of particle in s.h.m.	$v = v_o \cos \omega t$
	$= \pm \omega\sqrt{(x_o^2 - x^2)}$
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,	$x = x_o \sin \omega t$
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,	$x = x_o \exp(-\lambda t)$
decay constant	$\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$

1 **(a)** State Newton's three laws of motion.

First Law: ....

....

....

Second Law: ....

....

....

Third Law: ....

....

.... [3]

(b) Using the appropriate laws of motion, answer the question for each given situation.

(i) A passenger claimed that he was sitting in the middle of a bus that was moving forward. The driver suddenly applied the brakes and a suitcase that was in the front of the bus flew backwards and hit him.

State and explain if his claim is valid.

....

....

....

.... [2]

(ii) A labourer was tasked with pulling a cart. He reasoned that whatever he exerts on the cart, the cart will exert an equal and opposite force on him. The forces will cancel out and hence it is pointless for him to pull the cart as both he and the cart will not be able to move.

State and explain if his reasoning is correct.

....

....

....

[2]

(iii) A man is stranded in the middle of a frozen lake with a heavy bag of gold. As there is no friction between him and the surface of the ice, he is unable to crawl back to shore.

State and explain the action that he can take to get back to shore.

....

....

....

....

.... [2]

(c) A small sedan car makes a head-on collision with a large truck.

(i) State and explain if the force experienced by the car is different from that experienced by the truck.

....

....

.... [1]

(ii) Both drivers are securely fastened to their vehicle seats. State and explain if the driver of the truck is likely to experience more severe injuries as compared to the driver of the car.

....

....

....

....

....

.... [2]

2 Fig. 2.1 shows an archer with a bow.

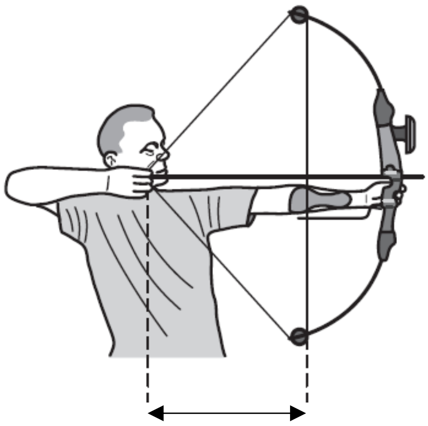


Fig. 2.1

The force *F* required to bend the bow and the corresponding displacement *d* of the arrow are measured. A plot of *F* against *d* is shown in Fig. 2.2.

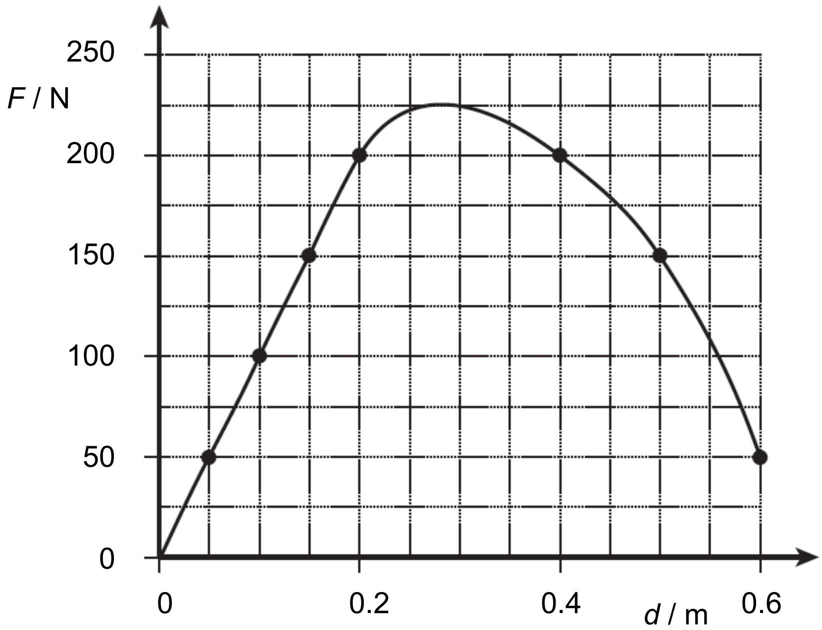


Fig. 2.2

(a) An experienced archer is able to draw an arrow further back, resulting in a greater displacement of arrow, *d*, as compared to a novice archer.

Using Fig. 2.2 and the principle of conservation of energy, suggest an advantage that this extra displacement provides.

....

....

....

....

.... [2]

(b) **(i)** Using Fig. 2.2, estimate the elastic potential energy stored in the bow when an arrow is displaced by 0.50 m.

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

(ii) The arrow in **(b)(i)** is then released by the archer from the bow.

Determine the maximum possible speed of the arrow which has a mass of 3.5×10^{-2} kg.

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

3 **(a)** Define the *tesla*.

....

....

.... [1]

(b) Charged particles, of speed 4500 m s^{-1} and mass 2.66×10^{-26} kg, are travelling in a narrow beam in a vacuum as shown in Fig. 3.1.

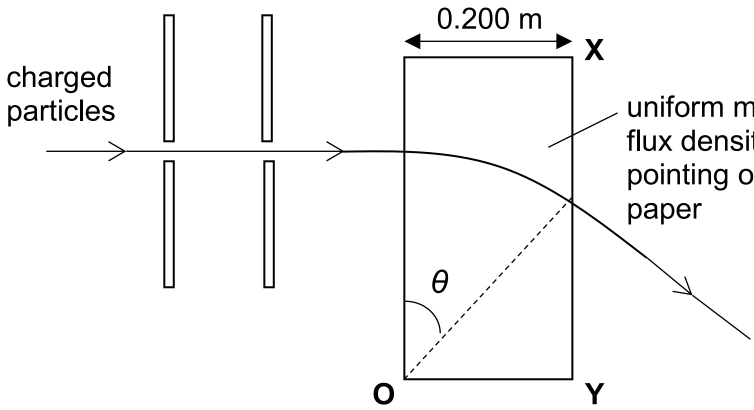


Fig. 3.1

The charged particles enter a region of uniform magnetic flux density which is 0.200 m wide. The direction of the magnetic flux is pointing out of the paper.

(i) Using Newton's Law of motion, state and explain the speed of the particles as they exit the uniform magnetic field.

....

....

....

.... [2]

(ii) Given that the magnitude of the charge on the particles is *e*, calculate the radius of the circular motion of the charged particles in the uniform magnetic field.

radius = ……………………m [2]

(iii) Hence, calculate the angular velocity of the charged particles in the uniform magnetic field.

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

(iv) Point **O** is the centre of the circular motion of the charged particles as shown in Fig. 3.1. Show that the angle θ is 0.564 rad. [2]

(v) In another experiment, similar charged particles are now fired into the magnetic field in Fig. 3.1 with different momentum.

1. Determine the maximum momentum of particles such that the particles will not exit the magnetic field through XY.

momentum = …………………… kg m s^{-1} [2]

2. Show that the time taken for the particle of mass m and charge q in **(b)(v)1** to complete a semi-circle within a region of magnetic flux density B is given by:

$$\frac{\pi m}{Bq}$$ [2]

4 **(a)** State the *principle of superposition*.

....

....

.... [1]

(b) Noise-cancelling headphones use both Active Noise Control and passive sound-proofing to reduce undesired ambient sounds reaching the ears of the user. In Active Noise Control, a microphone detects ambient noise and a noise-cancellation speaker emits a corresponding "anti-noise" that undergoes destructive interference with the noise.

Suggest the features that the "anti-noise" should have in order to achieve the optimal noise-cancelling effect.

....

....

....

.... [2]

(c) A student measured the waveforms of the noise and the anti-noise. The following observations were made:

1. There is a 1.0 ms time-lag between the noise and the anti-noise.
2. The amplitudes of the noise and anti-noise were effectively similar.

A sample noise waveform is shown in Fig. 4.1.

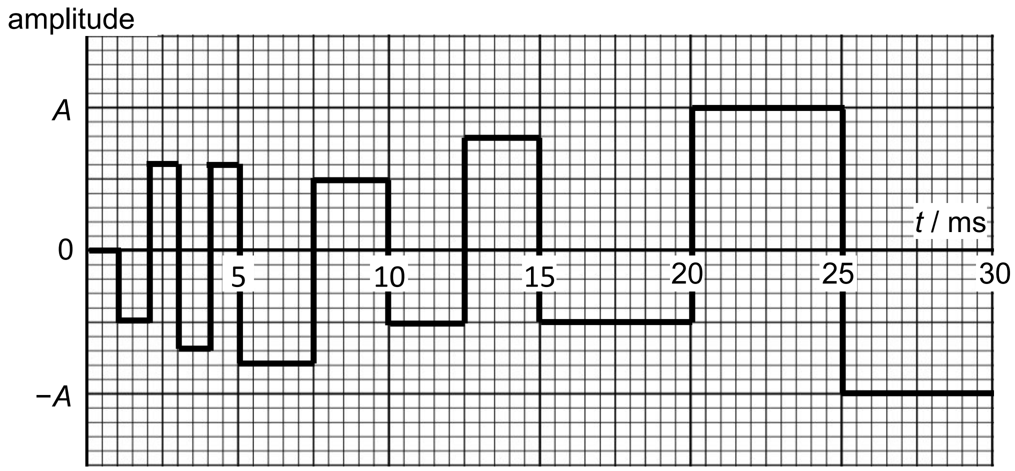


Fig. 4.1

(i) On Fig. 4.2, sketch the anti-noise waveform for 15 ms < t < 30 ms. [2]

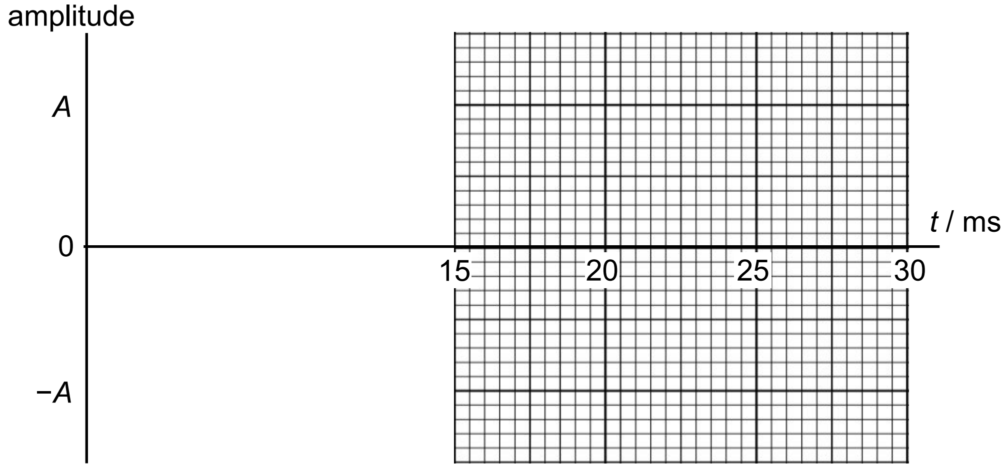


Fig. 4.2

(ii) The final resultant waveform reaching the ears is shown in Fig. 4.3.

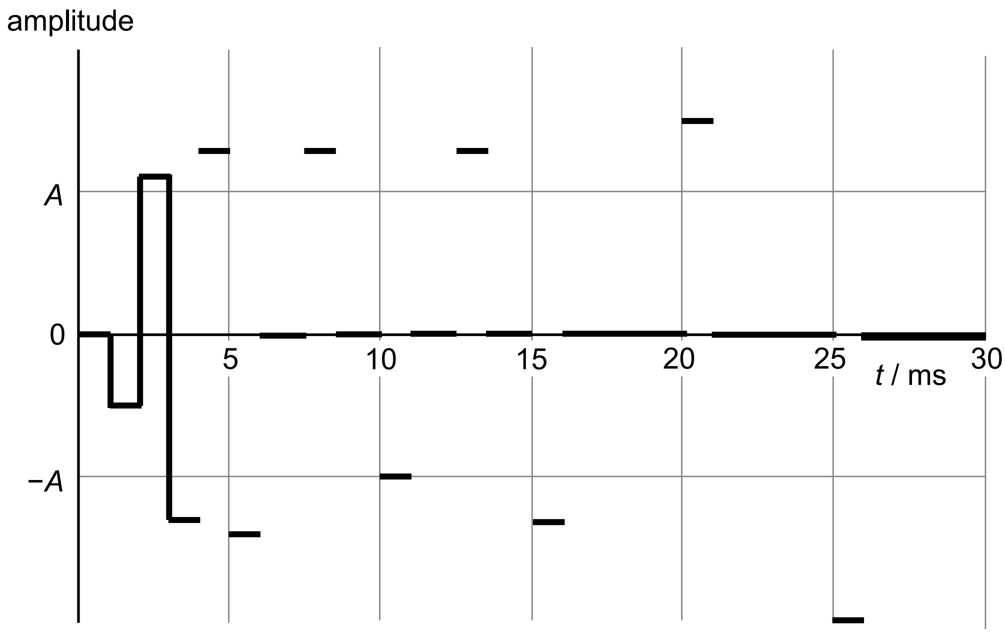


Fig. 4.3

Using Fig. 4.3, suggest if Active Noise Control is better suited for noises of higher or lower frequencies.

....

....

.... [2]

5 **(a)** You are provided with a galvanometer, a switch, a 100 Ω fixed resistor, and some connecting wires.

By completing the potentiometer circuit diagram in Fig. 5.1, explain how the internal resistance of an unknown cell ε may be determined.

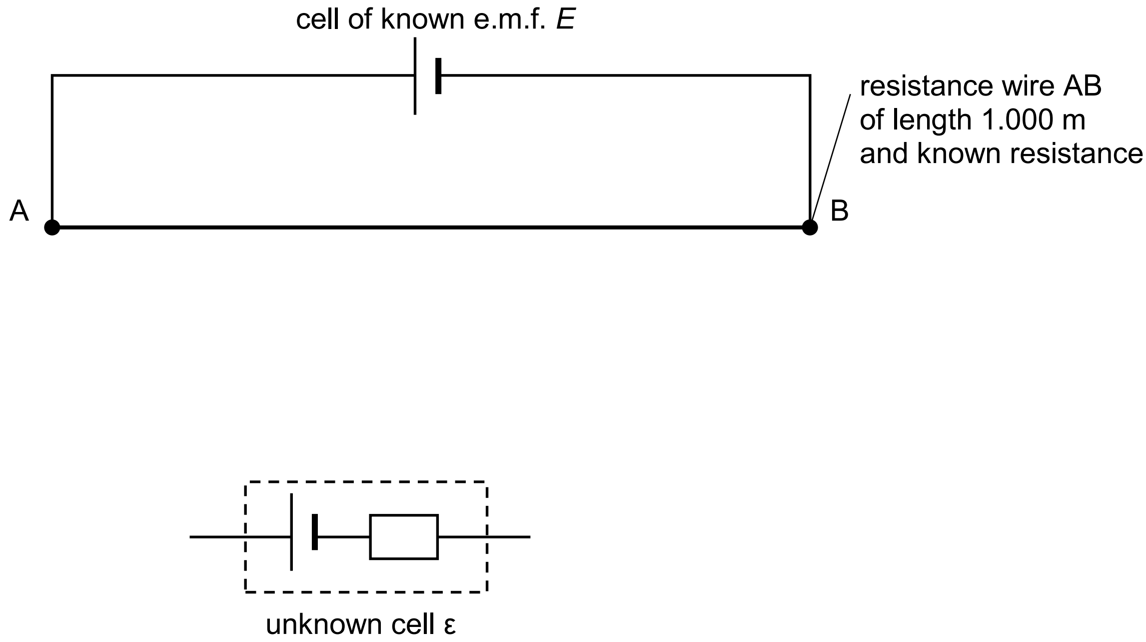


Fig. 5.1

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....

.... [3]

(b) Fig 5.2 shows a potentiometer circuit in which the resistance wire is made up of 7 identical strands of unshielded constantan wire.

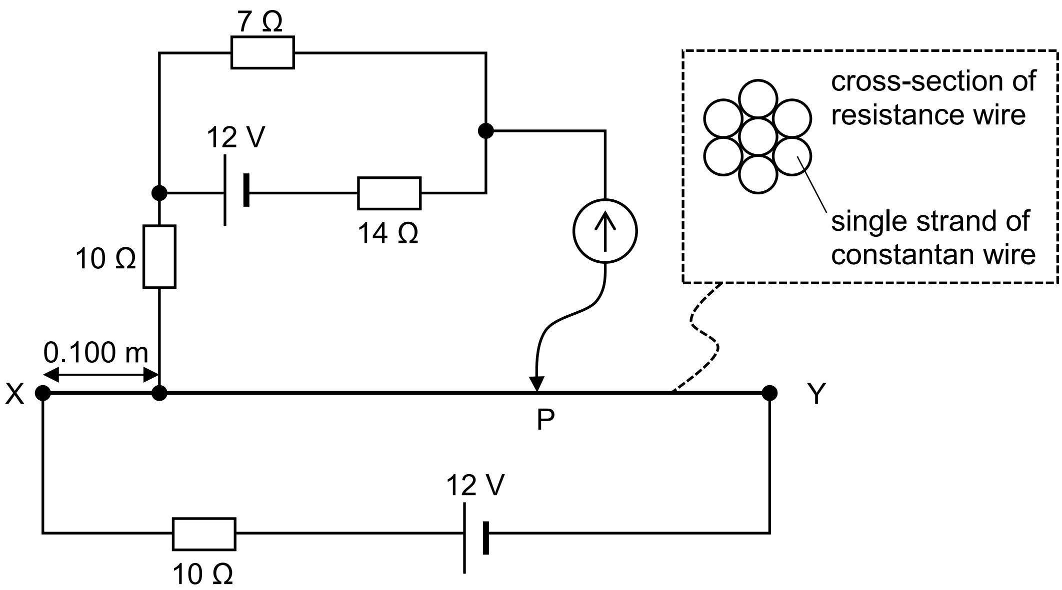


Fig. 5.2

(i) Each constantan strand has a diameter of 0.15 mm. Given that XY is 1.00 m long, show that XY has a resistance of 4.0 Ω.(Resistivity of constantan is 4.90×10^{-7} Ω m.) [2]

(ii) The cells have negligible internal resistances. Explain quantitatively whether a balance length can be found. [3]

6 Radiation of wavelength 4.0×10^{-7} m is incident on the photo-cathode **C** of a photo-cell. The photo-cell is connected to a potential divider arrangement as shown in Fig. 6.1. The material of **C** has a work function of value 3.0×10^{-19} J.

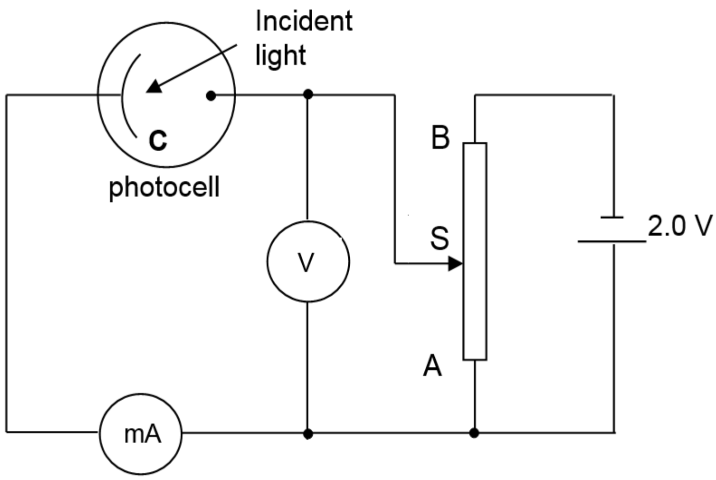


Fig. 6.1

(a) Explain what is meant by *work function*.

....

....

.... [1]

(b) (i) Calculate the maximum kinetic energy of the electrons emitted from the photo-cathode.

maximum kinetic energy = …………………… eV [3]

(ii) Suggest a reason why not all photoelectrons have this maximum energy.

....

....

.... [1]

(iii) Calculate the minimum reading of the voltmeter when the milli-ammeter registers no current flowing through it.

voltmeter reading = …………………… V [1]

(c) The sliding contact S is moved from A towards B.

On Fig. 6.2, sketch a graph of current registered by milli-ammeter against potential difference *V* measured across the analog voltmeter. [2]

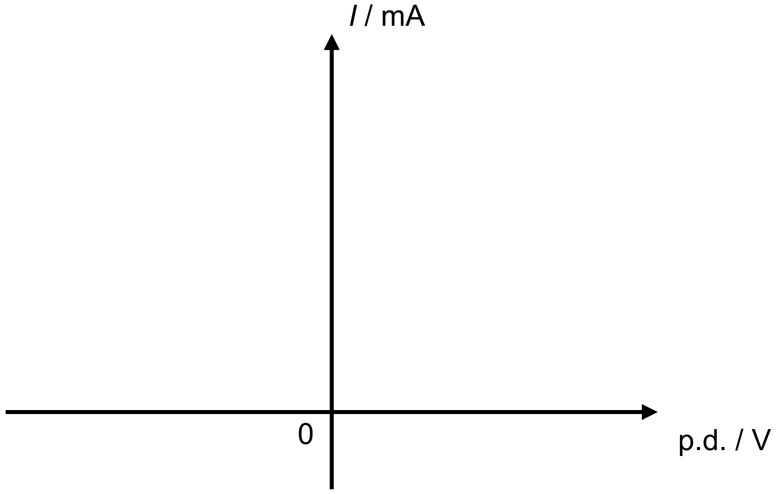


Fig. 6.2

(d) The polarity of the battery is now reversed. Explain why the milli-ammeter will always register a current flowing through it, regardless of the position of the sliding contact S on AB.

....

....

....

.... [2]

(e) In an actual experiment using the setting in **(d)**, the frequency of the irradiating photons is equal to the threshold frequency. However, there is no photocurrent registered by the milli-ammeter regardless of the position of the sliding contact S on AB.

Suggest a reason for this observation.

....

.... [1]

7 **(a)** For a steady and streamline flow of an incompressible and non-viscous fluid, the total hydraulic head H of the flow through a particular cross-section of a pipe is given by the expression

$$H = \frac{P}{\rho g} + \frac{v^2}{2g} + h$$

where P is the pressure of the fluid at the cross-section,
ρ is the density of the fluid,
v is the velocity of the fluid at the cross-section, and
h is the height of the centreline of pipe above a reference level.

H is related the energy in the fluid.

Suggest the type of energy associated with the following terms:

(i) $\frac{v^2}{2g}$

.... [1]

(ii) h

.... [1]

(b) Fig. 7.1 shows a steady and fully developed flow through a horizontal pipe of varying diameter. The inlet has an inner pipe diameter D_A and fluid velocity V_A while the outlet has an inner pipe diameter D_B and fluid velocity V_B.

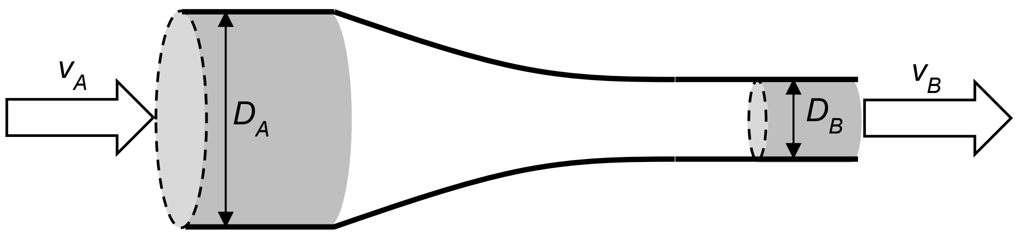


Fig. 7.1

(i) Assuming there are no energy losses within the pipe, state how the total hydraulic head at the inlet and at the outlet are related.

.... [1]

(ii) If the fluid can be considered incompressible, show that v_A and v_B are related by the expression

$$\frac{v_A}{v_B} = \frac{D_B^{\ 2}}{D_A^{\ 2}}$$ [2]

(iii) The inner diameter of the inlet is 0.100 m and the inner diameter of the outlet is 0.050 m. Water flows into the inlet at a speed of 8.0 m s^{-1}.

Using the hydraulic head expression given in **(a)** and your answers to **(b)**, determine the pressure difference between the inlet and outlet. (Density of water is 1000 kg m^{-3}.)

pressure difference = ………………………… Pa [3]

(c) In a typical flow between 2 cross-sections of a pipe, there will be energy losses due to frictional forces between the walls of the pipe and the fluid. This is accounted for by including an additional head loss term,

$$H_{Loss} = f_D \frac{v^2 L}{2gD}$$

where f_D is the friction factor,
L is the length of the pipe, and
D is the inner diameter of the pipe.

(i) State how this additional term will affect your answer to **(b)(iii)**.

....

.... [1]

(ii) If the pipe in **(b)** has a length of 10 m and a friction factor of 0.0038, estimate the magnitude of the difference to your answer in **(b)(iii)** if frictional losses are considered.

difference = ………………………… Pa [2]

(d) A student suggests using water flow in rigid pipes to model blood flow in blood vessels.

(i) State a difference between water flow in rigid pipes and blood flow in blood vessels.

....

....

.... [1]

(ii) The accumulation of fat and cholesterol deposits along the arterial walls has an effect of narrowing the arteries leading to an increase in blood pressure.

State and explain if the modelling proposed by the student will able to correctly predict this observation.

....

....

....

....

....

.... [3]

8 The International Space Station (ISS) is a habitable artificial satellite. It is maintained at 340 km above the Earth's surface, in what is known as a Low Earth Orbit (LEO). The radius of the Earth is 6.37×10^6 m. Fig 8.1 shows how the gravitational field strength of the Earth, g, varies with distance from the Earth's surface.

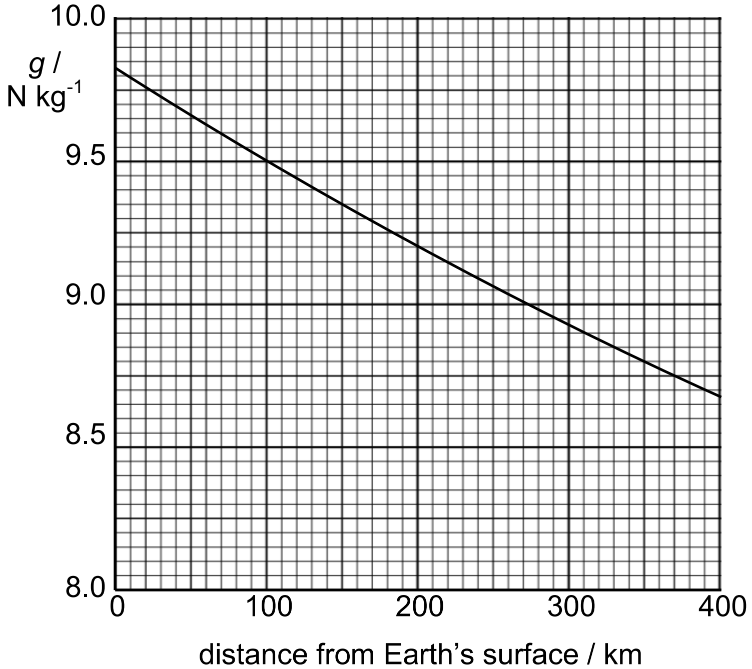


Fig. 8.1

(a) Using Fig 8.1, explain why an astronaut experiences apparent weightlessness in the ISS despite a non-zero gravitational field strength at LEO.

....

....

....

.... [2]

(b) Astronauts in apparent weightlessness may lose muscle mass. Fig. 8.2 shows a model of a spring system which can be used to monitor changes in mass.

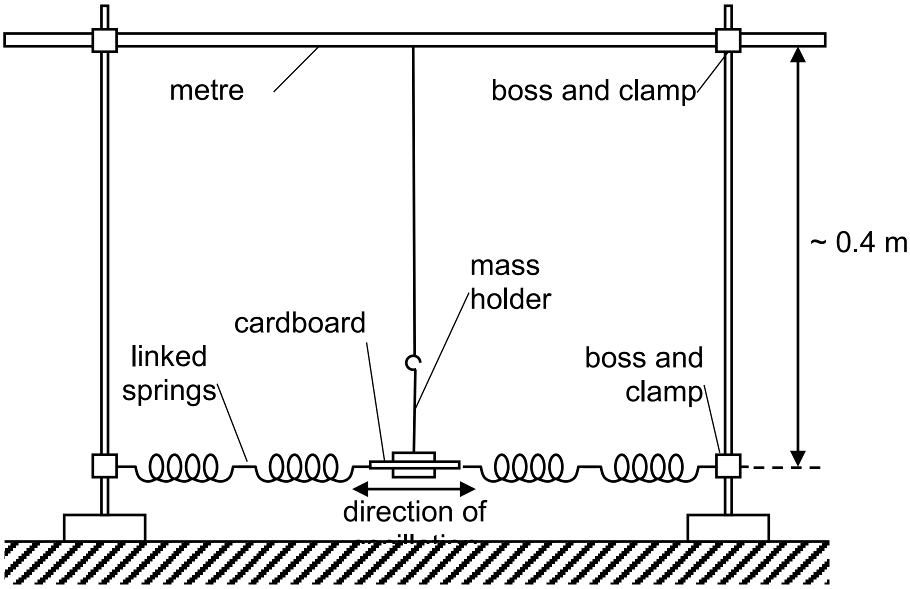


Fig. 8.2

It has been suggested that the relationship between the period of oscillation T and the mass M is given by:

$$\frac{1}{T^2} = \frac{p}{M} + q$$

where p and q are constants.

Fig. 8.3 shows the experimental results obtained using a stopwatch to measure the time taken for oscillations.

M / kg	time taken for 20 oscillations		T / s	$\frac{1}{T^2}$ / s^{-2}	$\frac{1}{M}$ / kg^{-1}
	t_1 / s	t_2 / s			
0.100	10.34	10.38	0.5180	3.727	10.0
0.150	12.07	11.93	0.6000	2.778	6.67
0.200	13.39	13.43	0.6705	2.242	5.00
0.250	14.34	14.32	0.7165	1.948	4.00
0.300	15.23	15.23	0.7615	1.724	3.33
0.350	15.70	15.64	0.7835	1.629	2.86

Fig. 8.3

The corresponding values of $\frac{1}{T^2}$ and $\frac{1}{M}$ are plotted on the graph in Fig. 8.4.

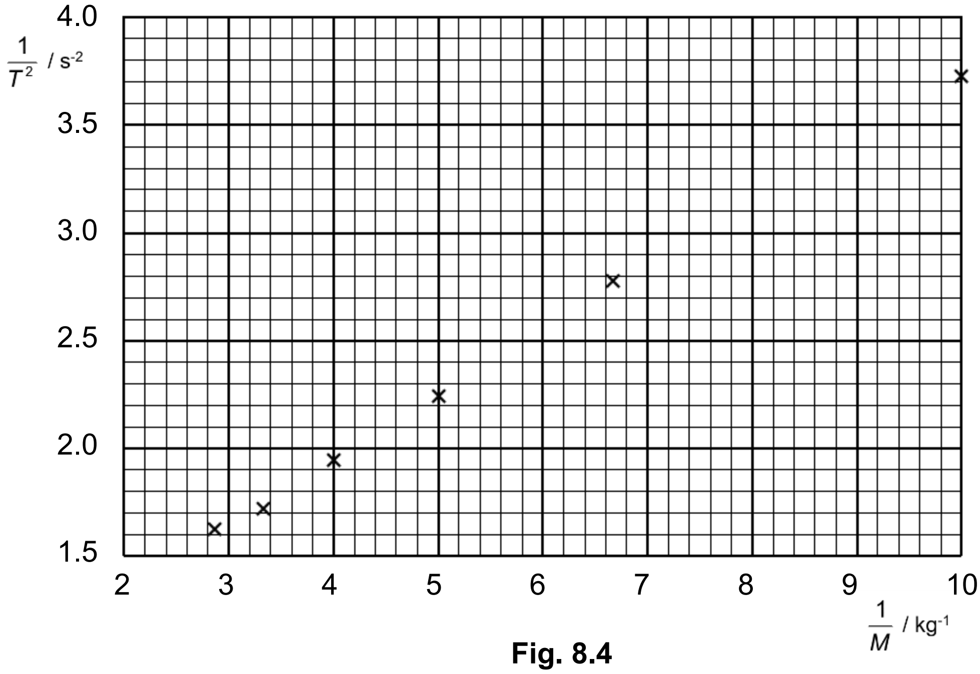


Fig. 8.4

(i) Using Fig. 8.4, determine *p* and *q*.

p = ...

q = ... [3]

(ii) It has been suggested that the variation of period, ∂T, is related to an astronaut's mass loss by $\partial T = \dfrac{2pT^3}{M} \times (\text{fractional mass loss})$.

Determine ∂T corresponding to an initial mass of M = 0.5 kg and a fractional mass loss of 0.10.

∂T = ...s [2]

(iii) According to medical opinion, a muscular mass loss of 10% is concerning. Taking reference from the data available, discuss if the experiment is able to detect the variation ∂T for a mass as small as 0.5 kg.

....

....

.... [2]

END OF PAPER

PHYSICS

9749/02

Paper 2 Structured Questions
MARK SCHEME
Maximum Mark: 80

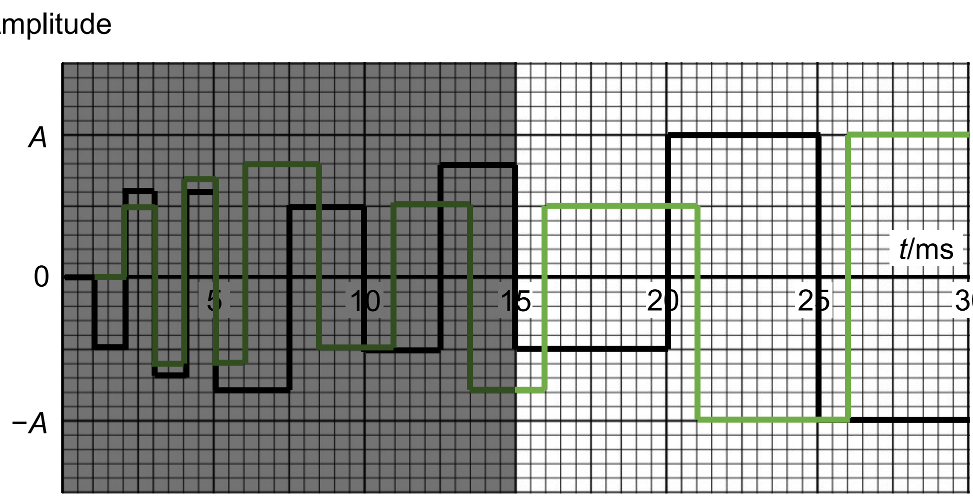
14 September 2018

Question		Marks
1(a)	N1L: An object at rest will remain at rest and an object in motion will remain in motion at constant velocity in the absence of an external resultant force.	B1
	N2L: The rate of change of momentum of a body is directly proportional to the resultant force acting on the body and occurs in the direction of the resultant force.	B1
	N3L: If body A exerts a force on body B, then body B exerts a force of the same type that is equal in magnitude and opposite in direction on body A.	B1
1(b)(i)	Initially, suitcase moving with **same velocity as bus** before braking	B1
	By N1L, suitcase will continue to move forward in the absence of external force acting on it because not secured (or small frictional force between when the suitcase was still in contact with the bus that is not sufficient to stop it from moving forward) when brakes applied	B1
	Claim invalid	A0
1(b)(ii)	The two equal and opposite forces act on cart and labourer separately	B1
	Cart pulled forward by the force applied by the labourer on the cart. Labourer moved forward by the frictional force between feet/shoes and ground.	B1
	Reasoning false	A0
1(b)(iii)	Throw bag of gold in direction away from shore	B1
	By N3L, man experiences a force equal in magnitude and opposite in direction from the force he exerted on the bag of gold. This forces accelerates the man towards shore during pushing, thereafter he will glide over ice at constant speed	B1
1(c)(i)	By N3L, force experienced by car same as force experienced by truck	B1
1(c)(ii)	Total mass of truck and its driver larger than total mass of car and its driver, hence the truck and its driver experiences smaller change in velocity over same duration of time	B1
	Safety belt exert smaller force on truck driver in stopping his forward velocity	B1
	Truck driver likely less injured than car driver	A0

2(a)	Area under F-x graph is w.d. in stretching bow. More potential energy is stored	B1
	Arrows gain more KE, has less deviation from intended flight path **OR** Arrows gain more KE, has farther range	B1
2(b)(i)	By counting squares under F-x graph, Elastic potential energy = area under F-x graph = 1.25 J × 64.5 (±2 squares) = 81 J (78.1 J to 83.1J)	M1 A1
2(b)(ii)	By Conservation of Energy, Loss in elastic PE = Gain in KE for arrow $81 = \frac{1}{2}\left(3.5 \times 10^{-2}\right)v^2$ v = 68.0 m s^{-1} (66.8 J to 68.9 J)	M1 A1
3(a)	The tesla is the uniform magnetic flux density which when acting at right angle to a straight conductor carrying a current of 1 ampere produces a force per unit length of 1 Newton per metre on the conductor. Or If a conductor carrying a current of 1 ampere is placed at right angles to a uniform magnetic field of flux density 1 Tesla, then the force per unit length on the conductor is 1 newton per metre.	B1
3(b)(i)	Charged particles moving perpendicular to a magnetic field will experience a resultant magnetic force perpendicular to its motion. Hence no work is done. By Newton's 2nd Law, the acceleration of the particles is in the same direction as the resultant force. The direction of the particles changes but not its speed. By Newton's 1st law, upon exit, the particles will move in a straight line with a speed of 4500 ms^{-1}.	B1 B1
3(b)(ii)	Magnetic force provides centripetal force for particle's circular motion $F = Bqv = \frac{mv^2}{r}$ $r = \frac{mv}{Bq}$ $= \frac{\left(2.66 \times 10^{-26}\right)(4500)}{\left(2 \times 10^{-3}\right)(1.6 \times 10^{-19})}$ = 0.374 m	B1 A1
3(b)(iii)	$v = r\omega$ $\omega = \frac{v}{r} = \frac{4500}{0.374}$ = 12030 rad s^{-1}	M1 A1

Question		Marks
3(b)(iv)	$\sin\theta = \frac{OX}{r}$	M1
	$\theta = \sin^{-1}\left(\frac{0.2}{0.374}\right)$	
	= 0.564 rad	A1
3(b)(v)1.	$r = \frac{mv}{Bq} = \frac{P}{Bq}$	M1
	$P = rBq = (0.2)(2\times10^{-3})(1.6\times10^{-19})$	
	= 6.4 x10^{-23} kg m s^{-1}	A1
3(b)(v)2.	magnetic force F provides centripetal force for the particle's circular motion	M1
	$F = Bqv = mr\omega^2$	
	$Bq(r\omega) = mr\omega^2$	
	$Bq = m(\frac{2\pi}{T})$	
	$T = 2\pi\frac{m}{Bq}$	
	For semicircle, $t = \frac{T}{2} = \frac{\pi m}{Bq}$	A1

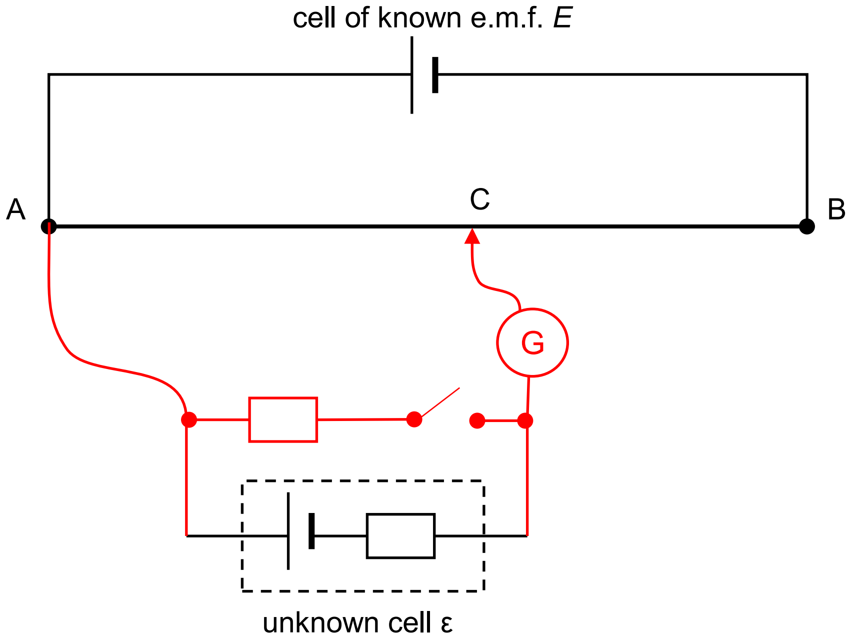
4(a)	Two or more waves of the same kind meet at a point at the same time, displacement of the resultant wave is vector sum of the displacements of the individual waves at that point at that time.	B1
4(b)	constant phase difference of **π** (rad)	B1
	same amplitude	B1
4(c)(i)		



	phase difference (shown by reflection in x-axis)	B1
	time lag (shown by translation of 2 small squares to right)	B1

Question		Marks
4(c)(ii)	longer durations of destructive interference for noise waves of longer periods; correspond to lower frequencies	M1 A1

5(a)



- Correct drawing with switch in the correct position. B1

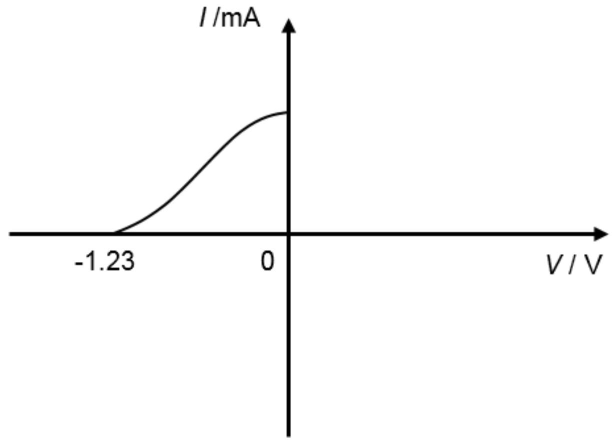
Turn off the switch. Find balance length when galvanometer shows null reading. B1
Find ε using $\varepsilon = V_{AC} = kL_{AC}$ and $V_{AB} = E = kL_{AB}$

Turn on the switch.
Find the new balance length, L_{AC}'

B1

To find r:
Compare $V_{AC}' = kL_{AC}'$ and $V_{AB} = E = kL_{AB}$
$V_{AC}' = kL_{AC}' = (R/R+r).\ \varepsilon$
Solve r.

Question		Marks
5(b)(i)	For single strand: $R = \frac{\rho L}{A}$ $= \frac{(4.9\times10^{-7})(1)}{\pi\left(\frac{0.15\times10^{-3}}{2}\right)^2}$ (= 27.7 Ω)	M1
	For 7 strands: $\frac{1}{R_{eff}} = 7\left(\frac{1}{R}\right)$ $R_{eff} = \frac{R}{7}$ $= \frac{(4.9\times10^{-7})(1)}{\pi(7)\left(\frac{0.15\times10^{-3}}{2}\right)^2}$ = 3.96 Ω = 4.0 Ω	A1
5(b)(ii)	Potential difference across the 7 Ω resistor = $\frac{7}{14+7}\times 12 = 4\ V$	B1
	By potential divider rule, potential difference across 0.9 m potentiometer = $\frac{0.9\times 3.96}{3.96+10}\times 12 = 3.06\ V$	B1
	Since the potential difference across the potentiometer is less than the potential difference across the 7 Ω resistor, balance length cannot be achieved.	B1
6(a)	Work function is the minimum amount of energy required for an electron to escape from the surface of a metal.	B1
6(b)(i)	Using conservation of energy,	
	$KE_{\max} = hf - \phi$ $= \frac{6.63\times10^{-34}\times3.0\times10^{8}}{4.0\times10^{-7}} - 3.0\times10^{-19}$	M1
	$= 1.97\times10^{-19}$ J	C1
	$= \frac{1.97\times10^{-19}}{1.60\times10^{-19}} = 1.23$ eV	A1
6(b)(ii)	Some of the electrons in material C may <u>need energy greater than the work function energy to be liberated as photoelectrons as they are beneath the metal surface</u>. Hence, not all photoelectrons have this maximum kinetic energy.	B1

Question		Marks
6(b)(iii)	p.d. = 1.23 V	B1
6(c)		
	Correct shape of curve (Only in 1 quadrant of graph)	B1
	Stopping potential clearly and correctly labelled numerically.	B1
6(d)	When the polarity is being reversed, C will always be at a lower potential compared to D. Photoelectrons released from C will therefore always be attracted to D and close the circuit for current to flow through the milliammeter.	M1 A1
6(e)	Metal surface is oxidized. **OR** The intensity of the radiation is not sufficiently high enough to liberate enough photoelectrons for them to be measureable by the milliammeter. Any one of the above points.	B1
7(a)(i)	kinetic energy (of the fluid)	B1
7(a)(ii)	gravitational potential energy (of the fluid)	B1
7(b)(i)	They are the same/ equal.	B1
7(b)(ii)	mass flow (rate) at inlet = mass flow (rate) at outlet	B1

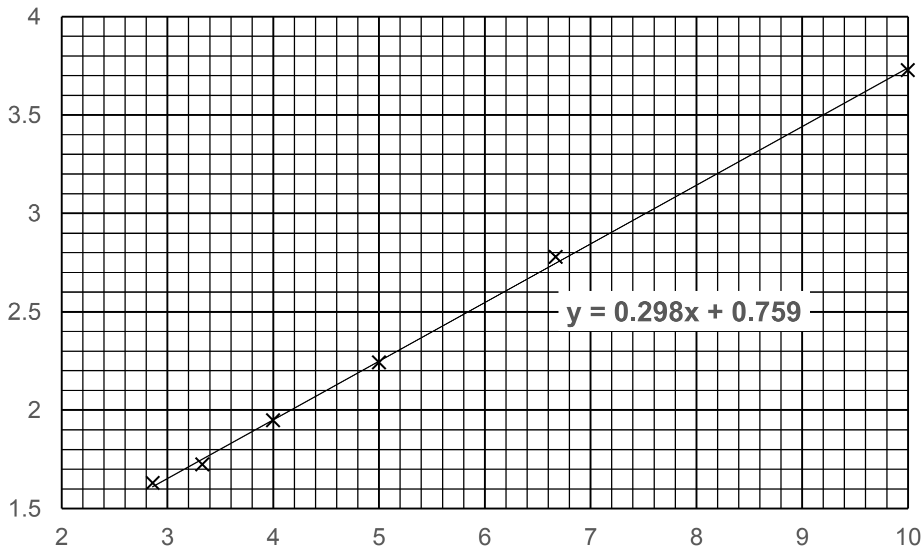
$$\frac{m_A}{t} = \frac{m_B}{t}$$

$$\frac{\rho \frac{\pi D_A^{\ 2}}{4} l_A}{t} = \frac{\rho \frac{\pi D_B^{\ 2}}{4} l_B}{t} \qquad \text{B1}$$

$$D_A^{\ 2} v_A = D_B^{\ 2} v_B$$

$$\frac{v_A}{v_B} = \frac{D_B^{\ 2}}{D_A^{\ 2}}$$

Question		Marks
7(b)(iii)	$\dfrac{v_{out}}{v_{in}} = \dfrac{D_{in}^{\ 2}}{D_{out}^{\ 2}}$	
	$v_{out} = \left(\dfrac{0.100}{0.050}\right)^2 v_{in}$	
	$= 4v_{in}$	C1
	$\dfrac{P_{in}}{\rho g} + \dfrac{v_{in}^{\ 2}}{2g} + h_{in} = \dfrac{P_{out}}{\rho g} + \dfrac{v_{out}^{\ 2}}{2g} + h_{out}$	M1
	$\dfrac{P_{out} - P_{in}}{\rho g} = \dfrac{v_{in}^{\ 2} - v_{out}^{\ 2}}{2g}$	
	$\Delta P = \dfrac{\rho\left(v_{in}^{\ 2} - v_{out}^{\ 2}\right)}{2}$	
	$= \dfrac{\rho\left(v_{in}^{\ 2} - \left(4v_{in}\right)^2\right)}{2}$	
	$= –480 \text{ kPa}$	A1
7(c)(i)	The pressure difference will be higher.	B1
7(c)(ii)	$v_{ave} = 2.5v_{in}$ $D_{ave} = 0.075 \text{ m}$ (or any other appropriate averaging done)	C1
	$p_{Loss} = H_{Loss} \times \rho g$	
	$= f_D \dfrac{v_{ave}^{\ 2} L}{2gD_{ave}} \times \rho g$	
	$= 0.0038 \times \dfrac{(2.5 \times 8)^2 \times 10}{2 \times 0.075} \times 1000$	A1
	$= 101 \text{ kPa}$	
7(d)(i)	✓ Blood vessels are flexible ✓ (Higher) friction factor / viscosity of blood ✓ Blood is a suspension rather than a pure fluid. ✓ Capillary action due to the small diameter of blood vessels.	B1
7(d)(ii)	As the arteries narrow, the model predicts that the <u>velocity of the flow</u> at this cross section will be <u>higher</u>.	M1
	From the expression in (a), the <u>pressure of the blood</u> at the narrow cross-section will be <u>lower</u>.	M1
	Thus, this model proposed by the student <u>will not be able to correctly predict</u> this observation.	A1

Question		Marks
8(a)	gravitational force provides (just enough) centripetal acceleration of 8.825 m s^{-2} on both ISS and astronaut to keep them in circular orbit around Earth OR both ISS and astronaut experience 8.825 ms^{-2} of acceleration directed to the centre of the earth due to gravity no contact force by ISS on astronaut.	M1 A1
8(b)(i)	 best fit straight line with line thickness not comparable to half sq *p* = 0.298 kg s^{-2} *q* = 0.759 s^{-2}	B1 B1 B1
8(b)(ii)	For $\frac{1}{T^2} = \frac{p}{M} + q \rightarrow T = \sqrt{\left(\frac{p}{M}+q\right)^{-1}}$ For *M* = 0.5 kg, $T = \sqrt{\left(\frac{0.298}{0.5}+0.759\right)^{-1}} = 0.859$ s $\partial T = \frac{2(0.298)(0.858)^3}{0.5} \times (10\%) = 0.08$ s (1 s.f.)	C1 A1
8(b)(iii)	Yes. Period has more precision that what is required of variation from table of values (Fig. 8.3), the period is to 4 decimal points while the variation which is to 2 d.p.	B1 B1

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME	

CIVICS GROUP	1	7	-			REGISTRATION NUMBER		

PHYSICS

9749/03

Paper 3 Longer Structured Questions

18 September 2018

2 hours

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

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number on all the work you hand in.
Write in dark blue or black pen on both sides of the paper.
You may use an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

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	
1	
2	
3	
4	
5	
6	
7	
8	
Total	

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

Data

speed of light in free space,	c	=	3.00×10^{8} m s^{-1}
permeability of free space,	μ_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	$= \rho gh$
gravitational potential,	ϕ	$= -\dfrac{Gm}{r}$
temperature,	T/K	$= T / {}^{o}C + 273.15$
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	$= \dfrac{3}{2}kT$
displacement of particle in s.h.m.	x	$= x_o \sin \omega t$
velocity of particle in s.h.m.	v	$= v_o \cos \omega t$
		$= \pm \omega\sqrt{(x_o{}^2 - x^2)}$
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	$= x_o \sin \omega t$
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	$= x_o \exp(-\lambda t)$
decay constant	λ	$= \dfrac{\ln 2}{t_{\frac{1}{2}}}$

Section A

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

1 A spring is attached at one end to a fixed point and hangs vertically with a cube attached to the other end. The cube is initially supported at a height *h* above the water surface such that the spring is at its natural length, as shown in Fig. 1.1.

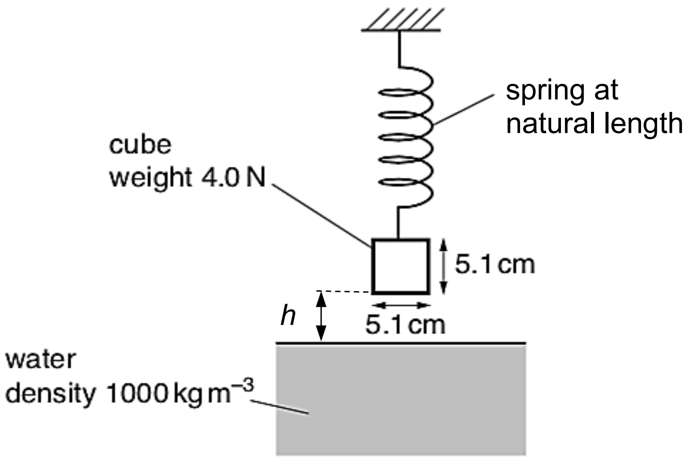


Fig. 1.1

The cube has a weight of 4.0 N and sides of length 5.1 cm. The cube is lowered gently into water. The cube reaches equilibrium with its base at a depth of 7.0 cm below the water surface, as shown in Fig. 1.2. The density of the water is 1000 kg m^{-3}.

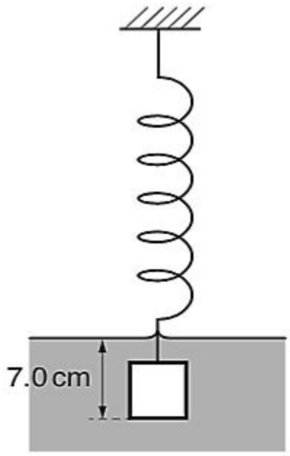


Fig. 1.2

(a) Calculate the difference in the pressure exerted by the water on the bottom face and on the top face of the cube.

difference in pressure = …………………………….. Pa [2]

(b) Using your answer in **(a)**, show that the upthrust acting on the cube is 1.3 N. [1]

(c) Determine the force exerted on the spring by the cube when it is in equilibrium in the water.

force = …………………………… N [2]

(d) The spring obeys Hooke's law and has a spring constant of 30 N m^{-1}.

Determine the height *h*.

h = …………………………… m [3]

(e) The cube in the water is suddenly detached from the spring.

(i) Determine the initial acceleration of the cube.

initial acceleration = …………………………… m s^{-2} [2]

(ii) Describe and explain the variation of the acceleration of the cube as it sinks in the water.

....

....

.... [2]

2 **(a)** State what is meant by *simple harmonic motion*.

....

....

.... [2]

(b) A small frictionless trolley is attached to a fixed point **P** by means of a spring. A second spring is used to attach the trolley to a variable frequency oscillator, as shown in Fig. 2.1.

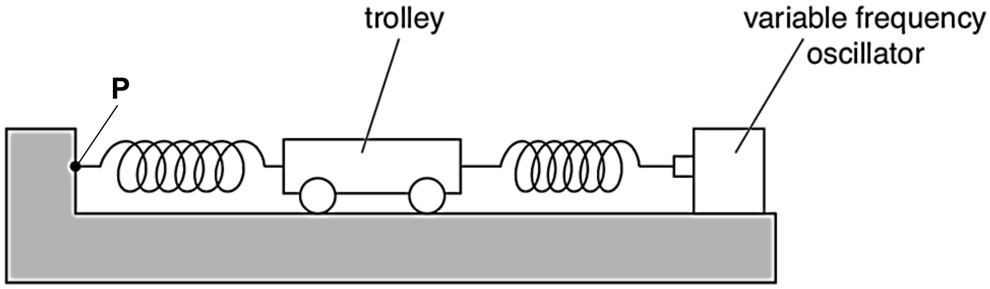


Fig. 2.1

Both springs remain extended within their limits of proportionality. Initially, the oscillator is switched off. The trolley is displaced horizontally along the line joining the two springs and is then released. The variation with time t of the velocity v of the trolley is shown in Fig. 2.2.

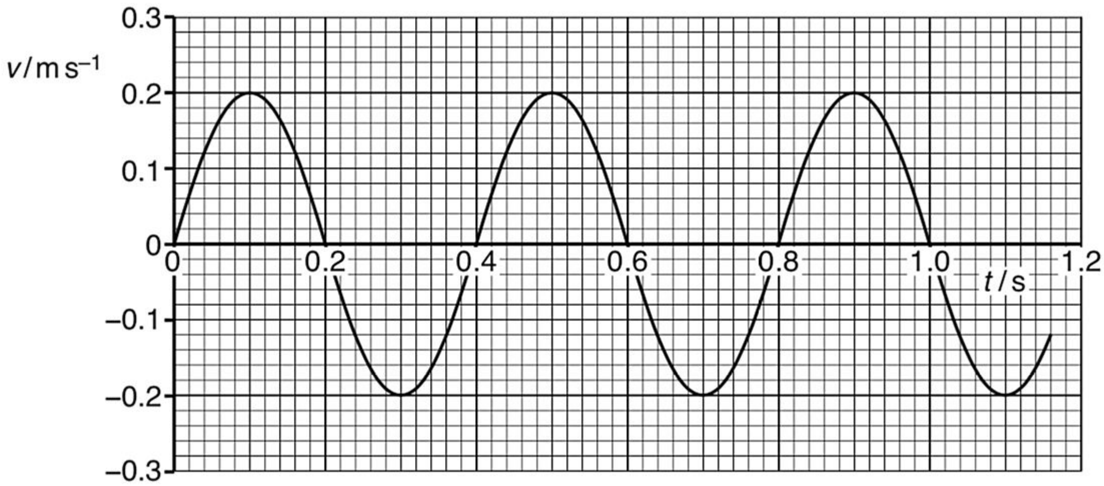


Fig. 2.2

(i) Using Fig. 2.2, state two different times at which

1. the displacement of the trolley is zero,

time = ………………… s and ………………… s [1]

2. the acceleration in one direction is maximum.

time = ………………… s and ………………… s [1]

(ii) Determine the frequency of oscillation of the trolley.

frequency = …………………………… Hz [1]

(iii) The variation with time of the displacement of the trolley is sinusoidal. The variation with time of the velocity of the trolley is also sinusoidal.

State the phase difference between the displacement and the velocity.

phase difference = …………………………… ° [1]

(c) The oscillator is now switched on. The amplitude of variation of the oscillator is constant. The frequency *f* of vibration of the oscillator is varied. The trolley is forced to oscillate by means of vibrations of the oscillator.

(i) Distinguish between *free oscillations* and *forced oscillations*

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

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

(ii) It was observed that the trolley vibrates with different amplitudes as the frequencies of the oscillator changes.

On the axis provided on Fig. 2.3, sketch a possible amplitude-frequency graph for this trolley. [1]

Fig. 2.3

(iii) State the approximate frequency at which the amplitude is maximum.

frequency = …………………………… Hz [1]

(iv) The amplitude of the oscillations may be reduced without changing significantly the frequency at which the amplitude is a maximum.

State and explain how this may be done. You may draw on Fig. 2.1 to support your answer.

....

....

....

.... [2]

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

....

....

.... [1]

(b) Two similar positive point charges of magnitude e are set up along the line XY as shown in Fig. 3.1.

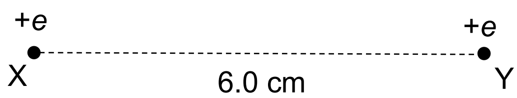


Fig. 3.1

(i) On Fig 3.2, sketch how the electric potential varies over XY. [2]

Fig. 3.2

(ii) Describe how the electric force acting on a known charge q placed at a point along XY could be obtained from Fig 3.2.

....

.... [2]

(c) **(i)** A negative point charge of – e is now placed at the midpoint of XY.

State the magnitude of electric force experienced by the point charge

electric force = …………………………… N [1]

(ii) The negative point charge at the midpoint in XY in **(c)(i)** is moved to the position Z as shown in Fig 3.3.

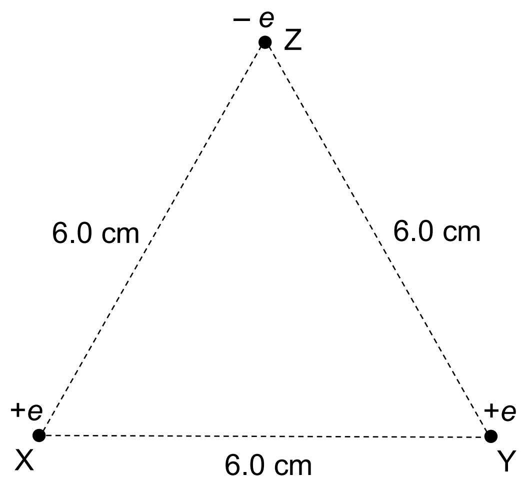


Fig. 3.3

Within the bounded region of Fig 3.4, sketch the resultant electric field lines of the 3 point charges. [3]

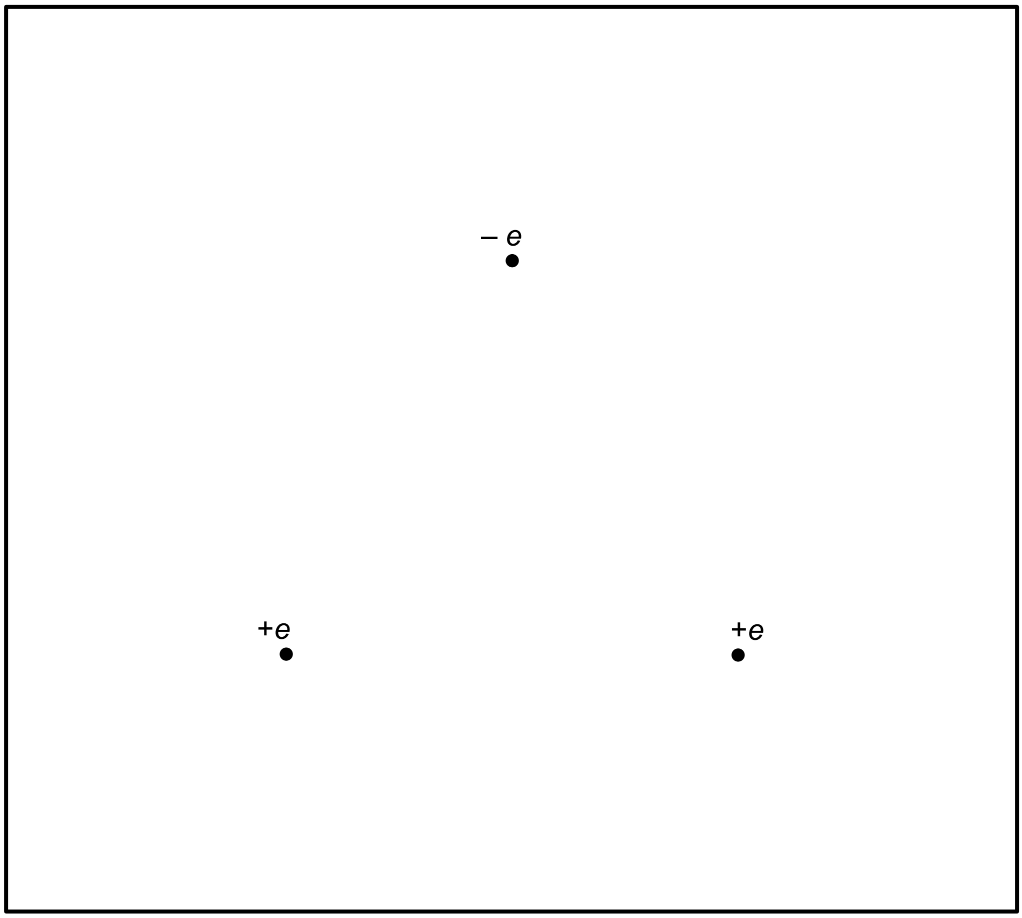


Fig. 3.4

(iii) Determine the work done by the electric field to completely separate the 3 point charges in Fig 3.3.

work done = ……………………………. J [3]

4 **(a)** State the *First Law of Thermodynamics*.

....

....

.... [1]

(b) 0.050 moles of an ideal gas is contained within an uninsulated cylinder with a movable piston as shown in Fig. 4.1.

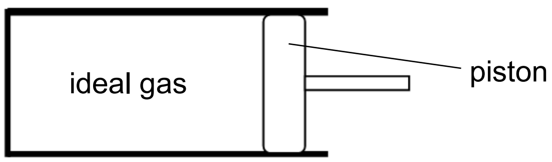


Fig. 4.1

The piston moves slowly outwards, resulting in the variation of pressure shown in Fig. 4.2

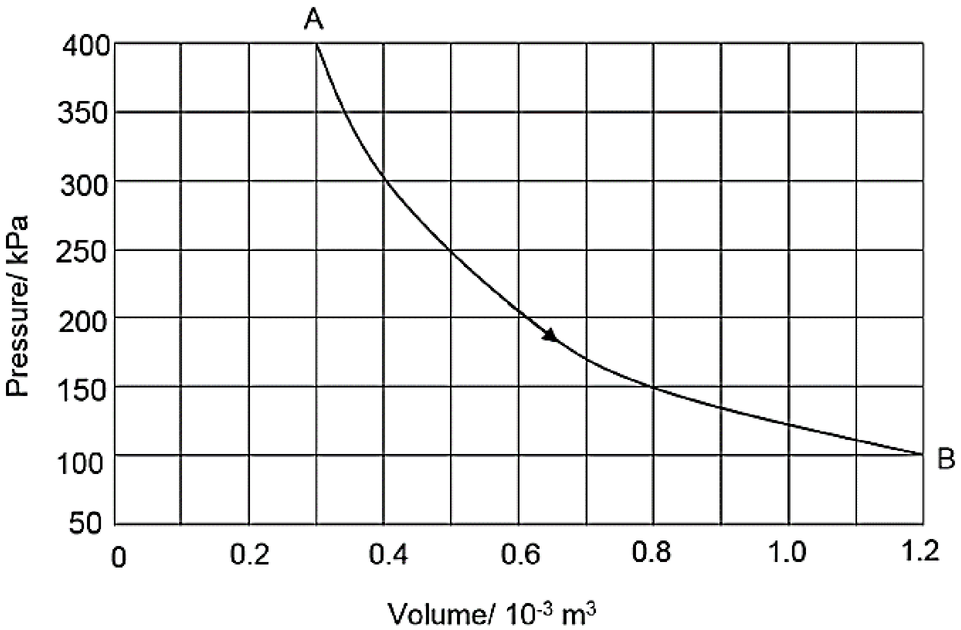


Fig. 4.2

(i) The process A to B occurs along an isotherm.

Determine the temperature along this isotherm.

temperature = ……………………………… K [2]

(ii) Calculate the total kinetic energy as a result of the random motion of the gas molecules in the cylinder.

total kinetic energy = …………………………… J [1]

(iii) Estimate the amount of work done by gas as it expands from A to B

work done = …………………………… J [2]

(iv) A student states that no heat flows into or out of the gas during the process A to B as the temperature of the gas did not change.

State and explain the validity of his statement.

....

....

....

.... [3]

(c) In another set up with the same starting point as the one shown in Fig. 4.1, the piston is moved very quickly outwards expanding the gas to a volume of 1.2×10^{-3} m^3. As a result, the temperature of the gas decreases to 144 K.

On Fig. 4.2, sketch the variation with volume of the pressure of the gas. [2]

5 Fig. 5.1 shows the structure of a geophone which is used by geophysicists to determine the speed of seismic waves traveling within the ground layer.

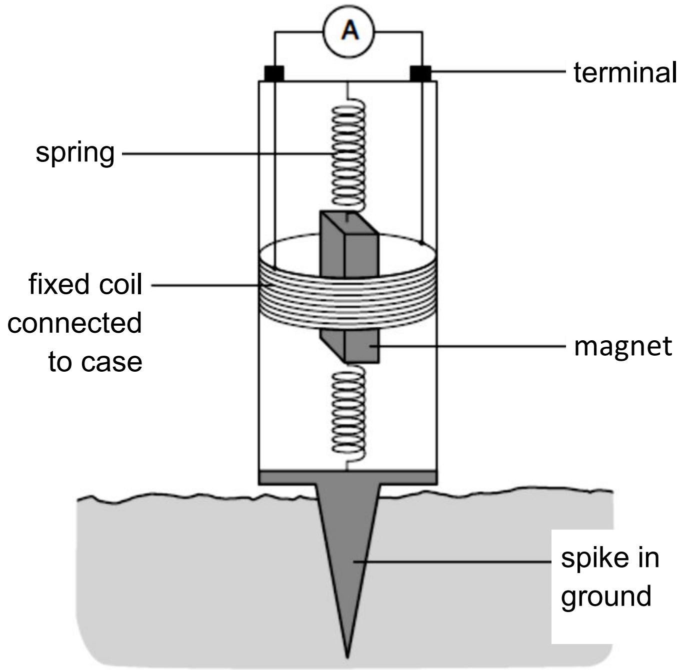


Fig. 5.1

The spike of the geophone is inserted into the ground. When a seismic vibration moves the case and coil, the magnet remains stationary due to its inertia.

(a) State Faraday's law of electromagnetic induction.

....

.... [1]

(b) Using Faraday's law, explain how an e.m.f. is generated between the terminals when seismic waves pass through the ground.

....

....

....

.... [2]

(c) A coil of 50 turns generates a maximum e.m.f. of 85 mV in a geophone.

Calculate the rate of change of magnetic flux needed to generate this e.m.f.

rate of change of magnetic flux = ………………………… Wb s^{-1} [2]

(d) Suggest 2 changes to the geophone which will make it more sensitive to the seismic vibrations.

1. .... [1]

2. .... [1]

6 In the hairdryer shown in Fig. 6.1, an alternating current passes through the heating coil when the switch is closed.

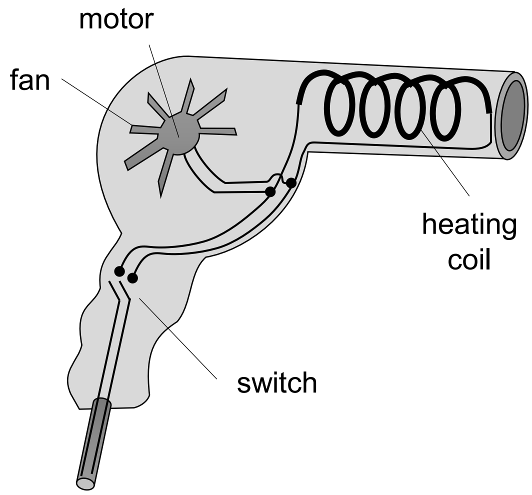


Fig. 6.1

(a) By reference to heating effect, explain what is meant by the root-mean-square (r.m.s) value of an alternating current.

....

.... [1]

(b) The hair dryer is connected to the mains supply of 120 V r.m.s. and frequency 50 Hz. The heating coil delivers a power of 1200 W.

(i) Calculate the peak current through the heating coil.

peak current = …………………………… A [2]

(ii) Write an equation, in terms of the elapsed time *t*, for the current that passes through the heating coil, given that the instantaneous power output is zero at *t* = 0 s. [1]

(c) The primary coil of a transformer is connected to a 2.4 kV r.m.s. supply. The secondary coil is connected to the hair dryer and the current flowing through the heating coil has the same value as that calculated in **(b)(i)**.

The transformer is non-ideal and electrical energy is converted to thermal energy in the transformer at a rate of 600 W.

Determine the r.m.s. current in the primary coil.

r.m.s. current = …………………………… A [2]

Section B

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

7 (a) (i) Explain what is meant by an *alternating current*.

....

....

.... [1]

(ii) Fig. 7.1. shows a metal wire held taut between a knife edge X and a smooth pulley P. The wire passes between opposing poles of permanent bar magnets.

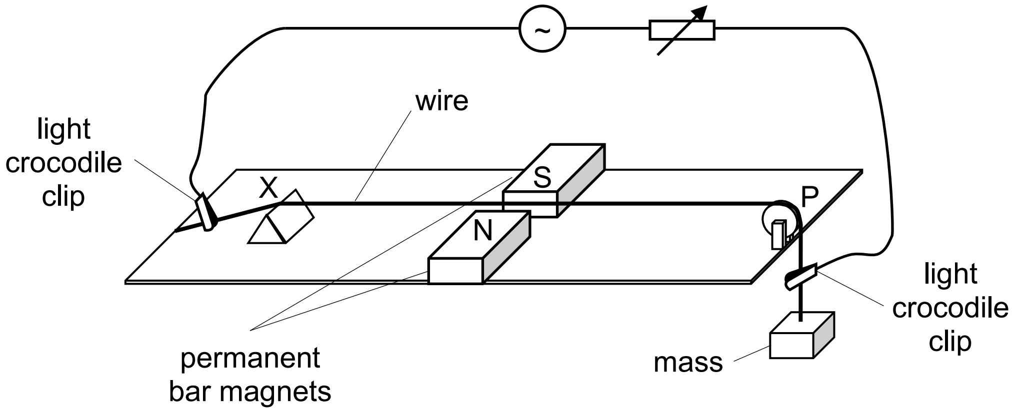


Fig. 7.1

The wire vibrates when a sinusoidal alternating source is connected across the wire. Explain how these vibrations are created. Describe the properties of these vibrations.

....

....

....

....

....

....

....

....

.... [4]

(iii) When the frequency of the alternating source is 120 Hz, a standing wave wire in its fundamental mode is observed in the wire. XP is 2.0 m in length.

1. Calculate the speed of the wave in the wire.

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

2. Explain, with reference to the formation of a stationary wave, what is meant by the speed calculated in **(a)(iii)1**.

....

....

....

....

....

....

....

....

....

.... [4]

(iv) When the mass hanging below pulley P is doubled, the fundamental mode standing wave is observed to occur when the frequency of the alternating source is 170 Hz. When the mass was triple that of the original set up, the fundamental mode frequency is 208 Hz.

Suggest if the relationship

$$v \propto \sqrt{T}$$

is valid, where v is the wave velocity in the metal wire, and
T is the tension in the metal wire. [3]

(b) (i) State what is meant by the *diffraction* of a wave.

....

.... [1]

(ii) Light of wavelength 633 nm from a laser is directed normally at a diffraction grating, as illustrated in Fig. 7.2.

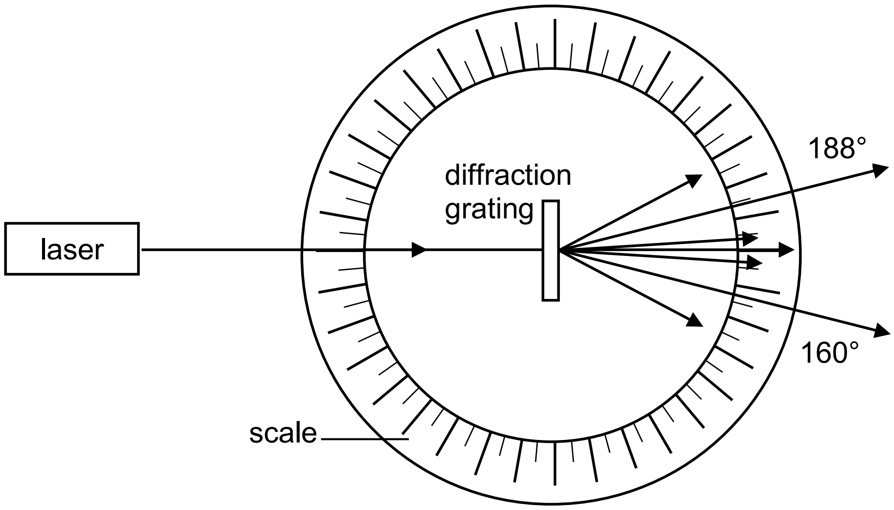


Fig. 7.2

The diffraction grating is situated at the centre of a circular scale, marked in degrees. The readings on the scale for the second order diffracted beams are 160° and 188°.

Calculate the number of lines per unit length of the slits in the diffraction grating.

number of lines per unit length = …………………………… m^{-1} [4]

(iii) Suggest why the non-central fringes produced by light passing through a diffraction grating is brighter than that from the same source with a double slit.

....

.... [1]

8 **(a)** In an α-particle scattering experiment, an α-particle is travelling in a vacuum towards the centre of a gold nucleus, as illustrated in Fig. 8.1.

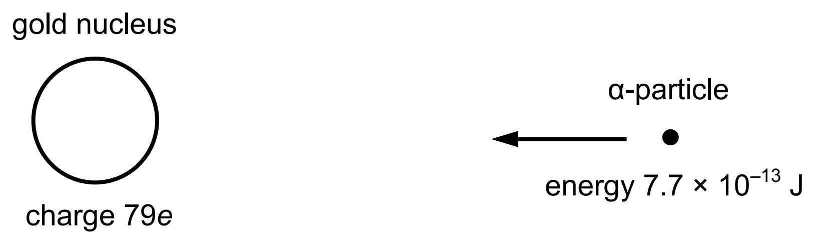


Fig. 8.1

The gold nucleus has a charge 79*e*. At a large distance from the gold nucleus, the α-particle has energy 7.7×10^{-13} J.

(i) The α-particle does not collide with the gold nucleus.

Show that the radius of the gold nucleus must be less than 4.7×10^{-14} m. [2]

(ii) The results of the α-particle scattering experiment provide evidence for the structure of the atom.

result 1: The vast majority of α-particles pass straight through the metal foil or are deviated by small angles.

result 2: A very small minority of α-particles are scattered through angles greater than 90^o and up to 180^o.

State what may be inferred from

1. result 1,

....

.... [1]

2. result 2.

....

....

....

.... [2]

(b) One nuclear reaction that can take place in a nuclear reactor may be represented, in part, by the equation

$$^{235}_{92}U + ^{1}_{0}n \rightarrow ^{95}_{42}Mo + ^{139}_{57}La + 2^{1}_{0}n + \text{..........} + \text{ energy}$$

Data for a nucleus and some particles are given in Fig. 8.2

nucleus or particle	mass / u
$^{139}_{57}La$	138.955
$^{1}_{0}n$	1.00863
$^{1}_{1}p$	1.00728
$^{0}_{-1}e$	0.000549

Fig. 8.2

(i) Complete the nuclear reaction shown above. [1]

(ii) Calculate the binding energy per nucleon, in MeV, of lanthanum-139 $\left(^{139}_{57}La\right)$.

binding energy per nucleon = ……………………………. MeV [3]

(iii) State and explain whether the binding energy per nucleon of uranium-235 $\left({}^{235}_{92}U\right)$ will be greater, equal to or less than your answer to **(b)(ii)**.

....

....

....

.... [2]

(c) A radiation detector is placed close to a radioactive source as shown in Fig. 8.3.

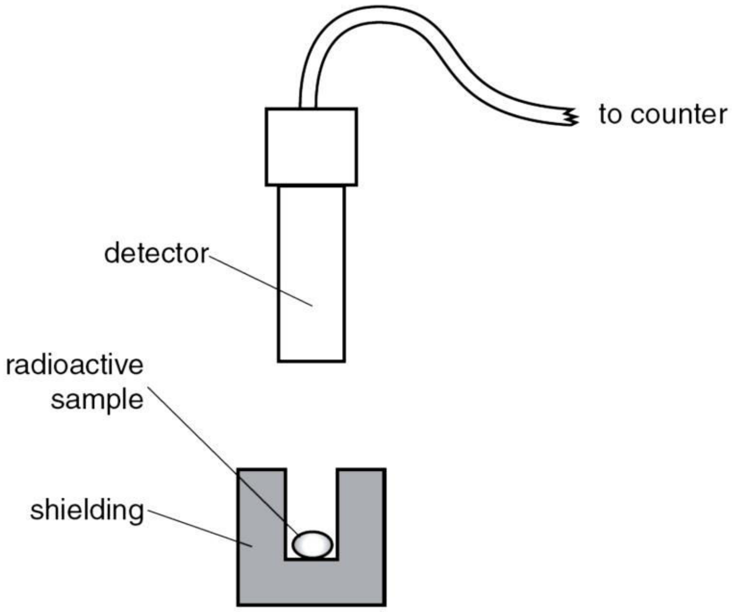


Fig. 8.3

The emissions from the radioactive source include both β-particles and γ-ray photons.
The β-particles emitted have energies up to a maximum of 0.61 MeV.

(i) Suggest two reasons why the activity of the source and the measured count rate may be different.

1. ....

.... [1]

2. ....

.... [1]

(ii) Explain why the emitted β-particles have a range of energies.

....

.... [1]

(iii) The γ-ray photons emitted have specific energies. Suggest why this is so.

....

.... [1]

(d) The variation with time *t* of the measured count rate in **(c)** is as shown in Fig. 8.4.

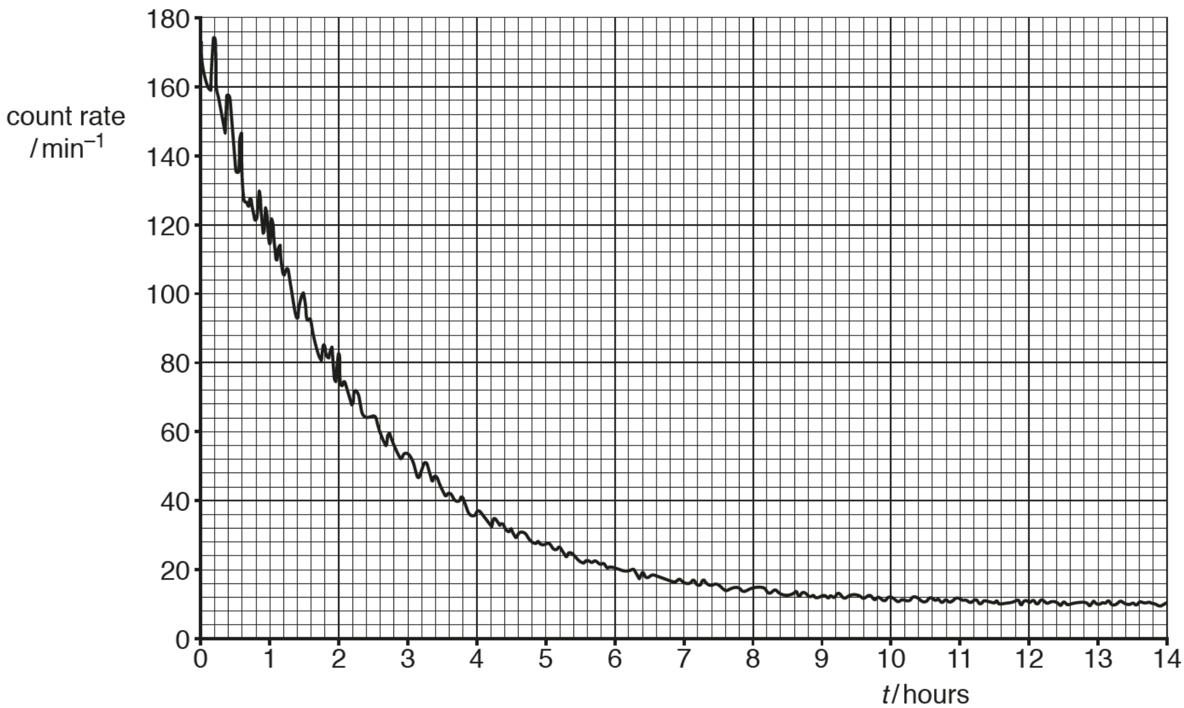


Fig. 8.4

(i) Use Fig. 8.4 to determine the half-life of the radioactive source.

half-life = ... hours [3]

(ii) The readings in Fig. 8.4 were obtained at room temperature.

A second sample of this radioactive source is heated to a temperature of 500 °C. The initial count rate at time t = 0 is the same as that in Fig. 8.4. The variation with time t of the measured count rate from the heated source is determined.

State and explain if there are any differences in

1. the half-life,

....

.... [1]

2. the measured count rate for any specific time.

....

.... [1]

END OF PAPER

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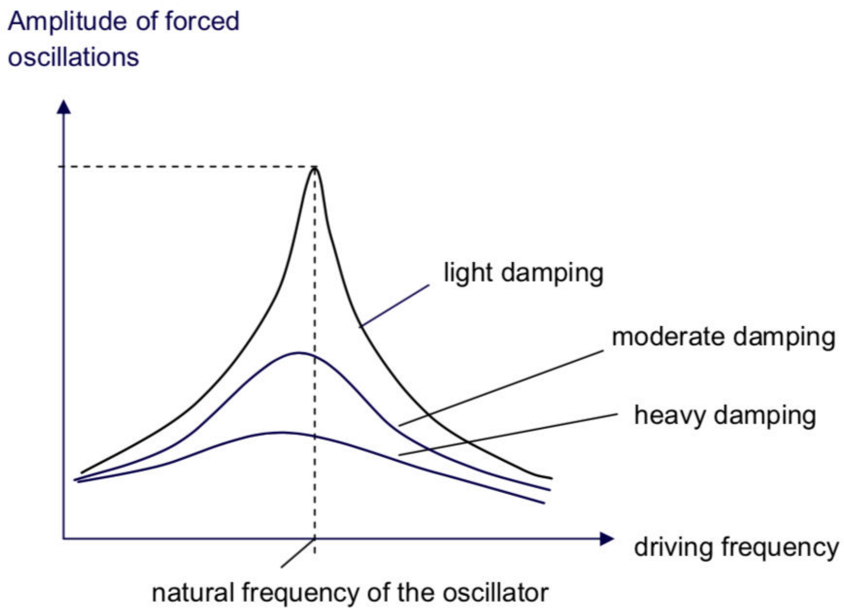
EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

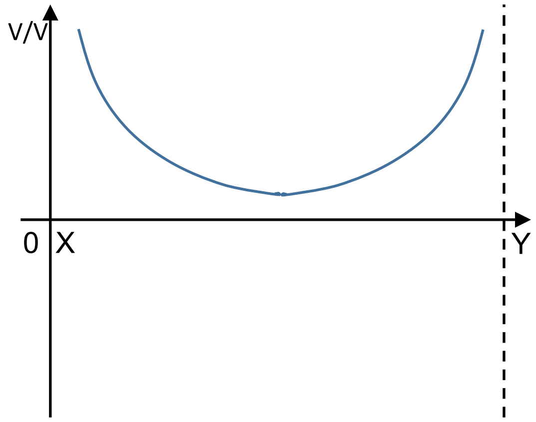
PHYSICS — 9749/03

Paper 3 Longer Structured Questions
MARK SCHEME
Maximum Mark: 80

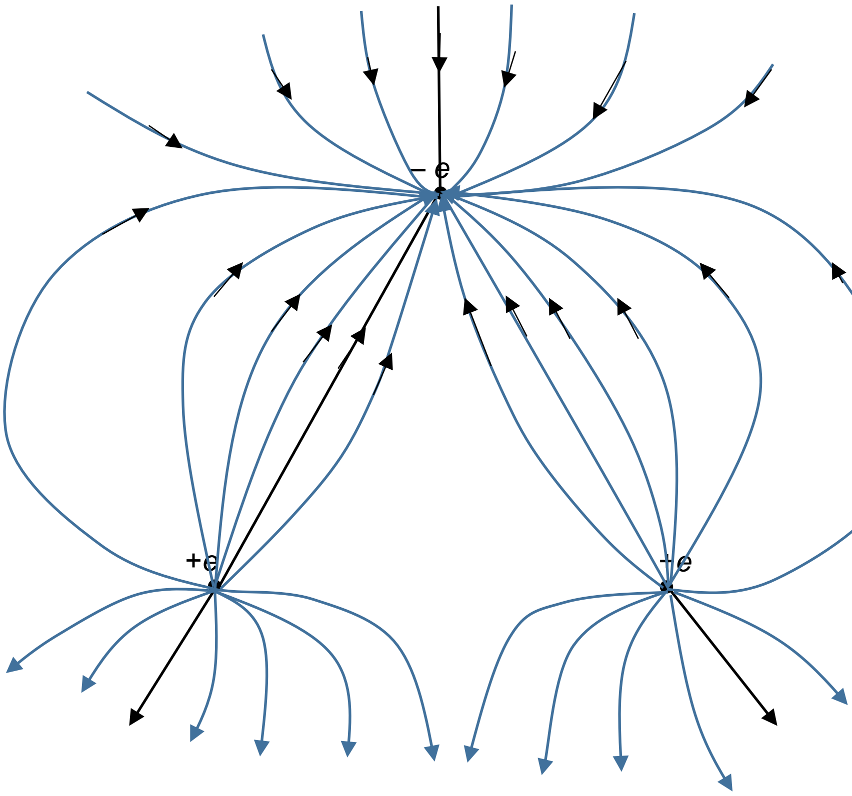
18 September 2018

Question		Marks
1(a)	Difference in pressure **Δp** = **$\rho g \Delta h$**	
	= 1000 x 9.81 x 0.051	M1
	= 500.31 Pa	
	= 500 Pa	A1
1(b)	Upthrust U = **Δp x 5.1 x 5.1 x 10^{-4}**	M1
	= 1.3005 = 1.3 N	A0
1(c)	U + T = W	M1
	1.3 + T = 4.0	
	T = 2.7 N	
	By N3L Force on spring by cube is 2.7 N downwards.	A1
1(d)	Let the extension of the spring be x.	
	T = k x	
	2.7 = 30 x	M1
	x = 0.090 m = 9.0 cm	A0
	initial height above surface, h = 9.0 – 7.0	M1
	= 2.0 cm	
	= 0.020 m	A1
1(e)(i)	2.7 = 4.0/9.81 x a	M1
	a = 6.62 m s^{-2} (Downwards)	A1
1(e)(ii)	Viscous force is proportional to speed. Resultant force downwards = Weight – Viscous Force (- Upthrust if considered not negligible) ***a*** decreases as velocity increases.	B1
	When viscous force = weight, ***a*** = 0 m s^{-2}	B1

Question		Marks
2(a)	acceleration / force proportional to displacement (from a fixed point)	B1
	either acceleration and displacement in opposite directions or acceleration always directed towards a fixed point	B1
2(b)(i)1.	0.1 s, 0.3 s, 0.5 s, etc (any two)	B1
2(b)(i)2.	either **0 s, 0.4 s, 0.8 s, 1.2 s** or **0.2 s, 0.6 s, 1.0 s** (any two)	B1
2(b)(ii)	period = 0.4 s frequency = 2.5 Hz	B1
2(b)(iii)	phase difference = 90^o	B1
2(c)	free: (body oscillates) without any loss of energy / no resistive forces / no external forces applied	B1
	forced: continuous energy input (required) / body is made to vibrate by an (external) periodic force / driving oscillator	B1
2(d)(i)		
	Any of these shapes and max peak at natural frequency	B1
2(d)(ii)	frequency = 2.4 - 2.5 Hz	B1
2(d)(iii)	e.g. (1) attach sheet of card to trolley bigger than the cross section of the trolley	M1
	increases damping / frictional force	A1
	e.g. (2) reduce oscillator amplitude	M1
	reduce power / energy input to system	A1

Question		Marks
3(a)	the work done per unit positive charge by an external agent in bringing a small test charge from infinity to that point, without any change in the kinetic energy of the charge.	
3(b)(i)		B1 B1
3(b)(ii)	The electric field strength (*E*) at a point between X and Y can be found finding the negative of the gradient of the tangent drawn at that point on the graph in 3(b)(i).	B1
	The electric force acting on the known charge q can be found by multiplying the electric strength *E* at that point with the known charge *q*.	B1
3(c)(i)	Zero	

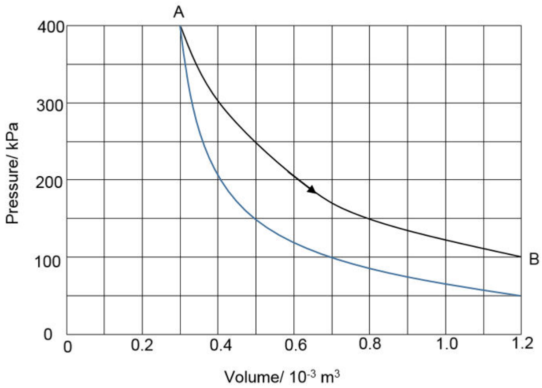
Question	Marks
3(c)(ii)	



Electric field lines from positive charge to negative charge shown with arrows. B1

- Lines do not intersect B1
- Line start and end with charge
- Line are closer near the centre line B1
- Symmetrical in shape

Question		Marks
3(c)(iii)	<u>To move the positive charge q at X to infinity:</u> Total electric potential at X due to the charges at Z and Y, Vx = 0	B1
	Work done by external agent to move +e from X to infinity, Wx = e.(0-Vx) = e.0 = 0	
	<u>To move – e at Z to infinity:</u> Total electric potential at Z (Vz) is due to the electric charge at Y = $+e/4\pi\varepsilon_o(0.06)$	B1
	Work done by external agent to move -e from Z to infinity, Wz = -e.(0-Vz) = $-e.\ (0 - e/4\pi\varepsilon_o(0.06))$ = $e^2/4\pi\varepsilon_o(0.06)$ = 3.837×10^{-27} J	
	No work is needed to move the last charge at Y to infinity.	
	Hence total work done by external agent to separate the 3 charges completely = $0+3.837 \times 10^{-27} +0$ = 3.84×10^{-27} J	B1
	Work done by electric field to separate the 3 charges totally from one another = $- 3.84 \times 10^{-27}$ J	
	OR	
	Other variation of method	
	Work done by external agent to assemble charges one at a time = - work done by external agent to separate the 3 charges totally from one another = work done by electric field to separate the 3 charges totally from one another.	
4(a)	The <u>increase in the internal energy</u> of a system is the sum of the external <u>work done on</u> the system and the <u>heat supplied to</u> the system.	B1
4(b)(i)	Using $T = \dfrac{pV}{nR}$	M1
	Taking any point: Point A: $T_A = \frac{(400\times10^3)(0.3\times10^{-3})}{(0.050)(8.31)} = 289\ K$ Point B: $T_B = \frac{(100\times10^3)(1.2\times10^{-3})}{(0.050)(8.31)} = 289\ K$	
	Therefore, temperature is 289 K.	A1
4(b)(ii)	Kinetic energy = $\frac{3}{2}nRT = \left(\frac{3}{2}\right)(0.050)(8.31)(289) = 180\ J$ -	M1 A0

Question		Marks
4(b) (iii)	Work done by gas = area under the *p*-*V* graph = (25 squares+9 missing squares) (50×10^3) (0.10×10^{-3}) = 170 J (allow 165 to 175J)	M1 A1
4(b) (iv)	temperature unchanged, no increase in the internal energy. ΔU = 0J	
	When the gas expands from A to B, work done on the gas is w = - 170 J.	M1
	Using 1st Law of Thermodynamics: ΔU = w + q 0 = - 170 + q Heat supplied, q = +170 J	 A1
	q is positive → heat is supplied to the gas during the expansion of the gas to ensure that there is no increase in the internal energy of the gas. Therefore, the student claim is false.	
4(c)		
	Downwards sloping curve below AB Ends at (1.2, 50)	B1 B1

5(a)	The induced e.m.f. is directly proportional to the rate of change of magnetic flux linkage.	B1
5(b)	As the seismic waves passes, the vibrations moves the case (and coil) and causes the movement of the case (and coil) relative to the magnet.	B1
	This results in a change of magnetic flux linkage through the coil, and by Faraday's law, an e.m.f. will be induced across the coil.	B1
5(c)	$\varepsilon = \frac{dN\phi}{dt} \Rightarrow \frac{d\phi}{dt} = \frac{\varepsilon}{N}$ $= \frac{85 \times 10^{-3}}{50}$ $= 1.7 \times 10^{-3}$ -	C1 A1
5(d)	✓ magnet with stronger magnetic field ✓ coil with many turns ✓ spring with a lower spring constant. (any two of the above)	B1 B1

Question		Marks
6(a)	The r.m.s value of an a.c. will give the same heating effect on a resistor as due to a d.c. current of the same value.	B1
6(b)(i)	Power = VI = 1200 W r.m.s current I = 1200 / 120 = 10 A Peak Current $I_o = 10\sqrt{(2)} = 14.1$ A	 C1 A1
6(b) (ii)	$I = I_o \sin(2\pi f\, t)$ $= 14.1 \sin(2\pi\times 0.50t)$ $= 14.1 \sin(100\,\pi t)$	 B1
6(c)	Secondary power = 600 + 1200 = 1800 W By conservation of energy, Input power = 1800 W $I_pV_p = 1800$ $I_p = 1800/(2.4\times10^3)$ $= 0.75$ A	 C1 A1

7(a)(i)	an electric current that periodically reverses its direction in a circuit (with a frequency)	B1
7(a)(ii)	- wire carries a current that is perpendicular to the magnetic field between the magnet poles - (by Fleming's LHR) wire experiences a force that is normal to both the current and magnetic field - force experienced is directed up and down vertically - since current reverses direction periodically, vibration is the same frequency as the AC	B1 B1 B1 B1
7(a)(iii)1.	recognising $\lambda = 2(L_{XP})$ $v = f\lambda = (120)(4) = 480$ m s^{-1}	M1 A1
7(a) (iii)2.	- meeting of (waves) - waves of same type, same frequency, opposite direction (characteristics) - incident waves from force on AC-carrying wire in magnetic field reflected off X and P (Origin of standing waves) - speed of incident / reflected wave in wire (concluding with correct answer)	B1 B1 B1 B1

Question		Marks
7(a) (iv)	$v = f\lambda$, therefore $v \propto f$ because λ is fixed by length of XP	B1
	tension is provided by weight, $T = mg$ therefore $T \propto m$	B1
	Need to show that $f \propto \sqrt{m}$ Take ratio:	
	$\frac{f_1}{f_0} = \frac{170}{120} \approx 1.42$, $\sqrt{\frac{2m}{m}} = \sqrt{2} \approx 1.41$ $\frac{f_2}{f_0} = \frac{208}{120} \approx 1.73$, $\sqrt{\frac{3m}{m}} = \sqrt{3} \approx 1.73$	M1
	Likely valid	A0
7(b)(i)	waves spread at edge or slit changes direction and spreads into geometric shadow	B1
7(b)(ii)	$\theta = \frac{1}{2}(188 - 160) = 14°$	C1
	$d\sin\theta = n\lambda \rightarrow d\sin(14°) = 2(633 \times 10^{-9})$	M1
	$d = 5.23 \times 10^{-6}$ m	C1
	$d = \frac{1}{N} \rightarrow N = \frac{1}{d} = 1.91 \times 10^{5}$	A1
7(b) (iii)	each bright fringe is constructive interference from multiple points of diffracted waves (vs two points in double slit)	B1

8(a) (i)	loss in E_K = gain in electric E_P	M1
	$7.7 \times 10^{-13} = \frac{Qq}{4\pi\varepsilon_o r}$	
	$= \frac{(79 \times 1.60 \times 10^{-19})(2 \times 1.60 \times 10^{-19})}{4\pi(8.85 \times 10^{-12})r}$	M1
	$r = 4.72 \times 10^{-14}$ m Since *r* is the distance of closest approach, the radius of gold must be less than this.	
8(a) (ii)	**1.** most of the atom is empty space **or** the size of the nucleus is very small compared to the size of the atom	B1
	2. the nucleus is positively charged	B1
	the mass is concentrated in the nucleus	B1
8(b)(i)	$7\ {}^{0}_{-1}e$	A1

Question		Marks
8(b)(ii)	mass defect = [(82 × 1.00863) + (57 × 1.00728) – 138.955]*u*	C1
	= 1.16762*u*	
	binding energy per nucleon	
	$$= \frac{1.16762 \times 1.66 \times 10^{-27} \times \left(3.0 \times 10^{8}\right)^{2}}{139 \times \left(1.60 \times 10^{-19}\right)}$$	M1
	$= 7.84$ MeV	A1
8(b)(iii)	Since the fission reaction releases energy,	M1
	the binding energy of uranium must be lower than for the products	A1
	OR	M1
	Above A = 56, binding energy per nucleon decreases as A increases. Since U-235 has a larger nucleon number (compared to La-139), it must have a higher binding energy per nucleon.	A1
8(c)(i)	✓ radiation emitted in all directions ✓ background radiation ✓ emission from radioactive daughter products ✓ window of detector may absorb some radiation ✓ self-absorption in source	Any 2 B1 each
8(c)(ii)	the energy is shared with a(n) (anti)neutrino	B1
8(c)(iii)	energy levels in the nuclei are discrete	B1
8(d)(i)	Background count = 10 min^{-1}	B1
	After 3 T_{half}, count rate will be 30 min^{-1}	M1
	Hence 3 T_{half} = 4.5 hours	
	T_{half} = 1.5 hours (1.4 to 1.6 hours)	A1
8(d)(ii)	1. <u>no change</u> as radioactive <u>decay is spontaneous</u> / independent of environment.	B1
	2. likely to be <u>different</u> as radioactive <u>decay is random</u> (and cannot be predicted).	B1

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS
General Certificate of Education Advanced Level
Higher 2

CANDIDATE NAME								
CIVICS GROUP	1	7	-			REGISTRATION NUMBER		

PHYSICS

9749/04

Paper 4 Practical

24 August 2018

2 hours 30 minutes

Candidates answer on the Question Paper.
Additional Materials: as listed in the Confidential Instructions

READ THESE INSTRUCTIONS FIRST

Write your name, civics group and registration number 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 an HB pencil for any diagrams or graphs.
Do not use paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers in the spaces provided on the question paper.
The use of an approved scientific calculator is expected, where appropriate.
You may lose marks if you do not show your working or if you do not use appropriate units.

Give details of the practical shift and laboratory, where appropriate, in the boxes provided.

Shift
Laboratory

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	
2	
3	
4	
Total	

This document consists of **17** printed pages and **1** blank page.

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1 In this experiment you will investigate how the motion of a paper strip depends on its width.

(a) (i) Measure and record the width *x* of the paper strip, as shown in Fig. 1.1.

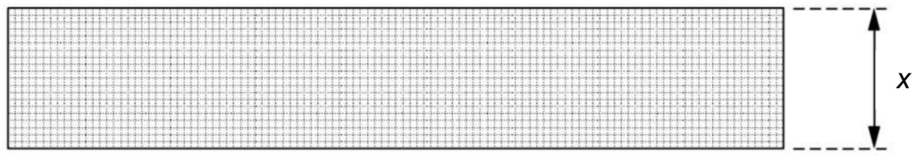

Fig. 1.1

x = ………………………… [1]

(ii) Connect the clips to the strip as shown in Fig. 1.2.

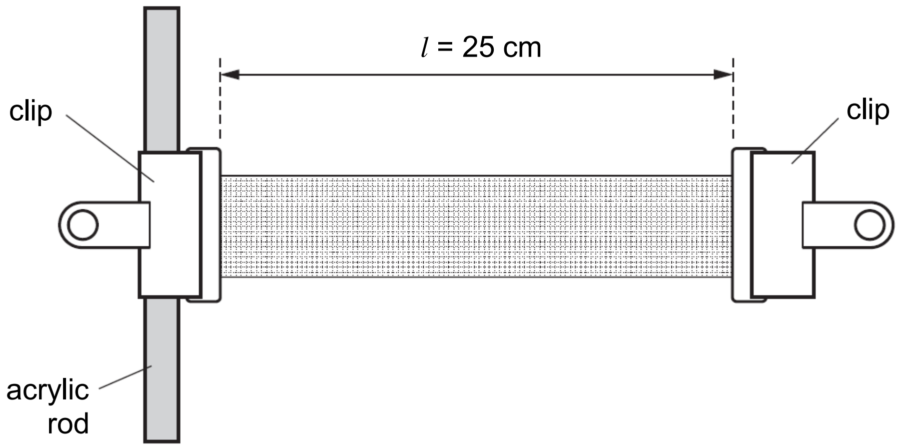

Fig. 1.2

(iii) Measure and record the length *l* of the paper strip between the 2 clips.

l = …………………………

(b) (i) Set up the apparatus with the top clip supported on the nail, as shown in Fig. 1.3.

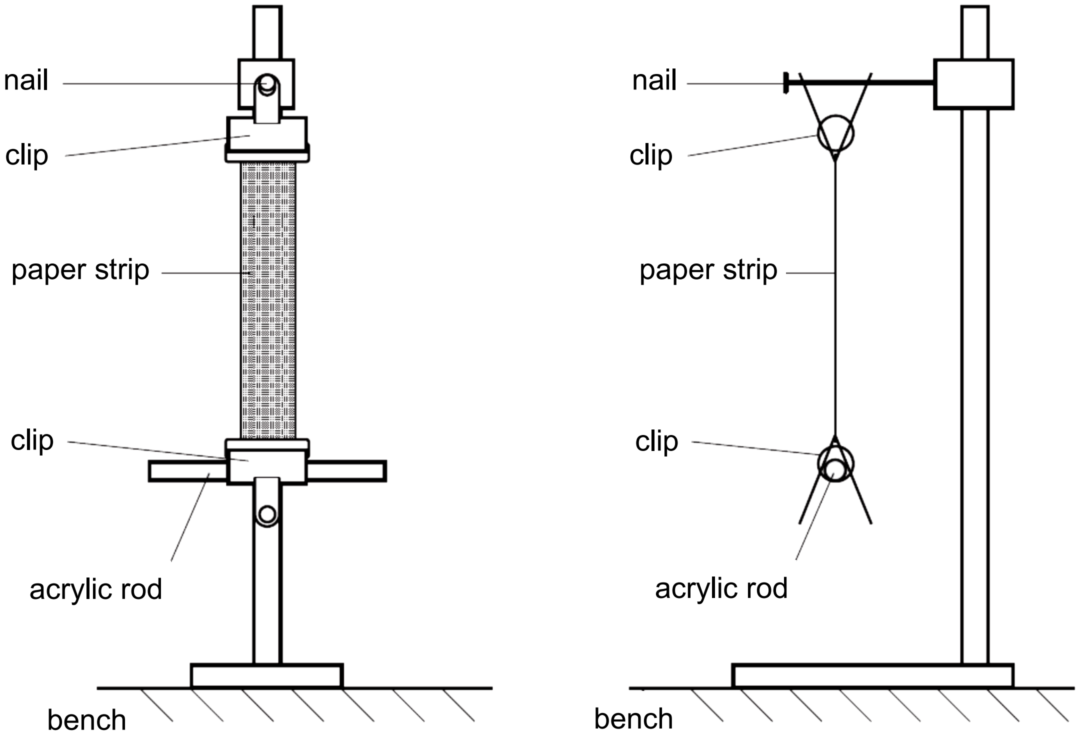

Fig. 1.3

(ii) Twist the acrylic rod through an angle of approximately 45° in a horizontal plane, as shown in Fig. 1.4.

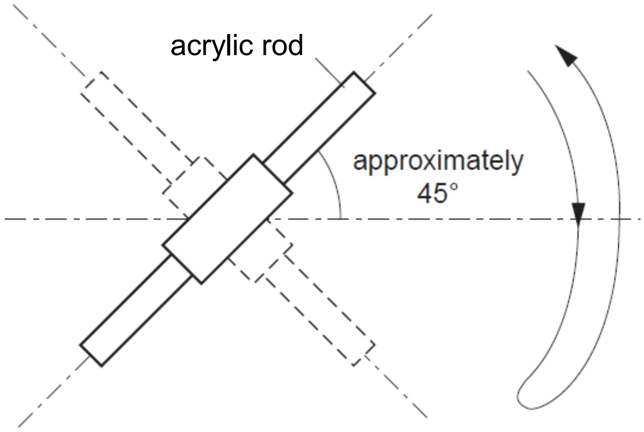

Fig. 1.4 (top view)

Release the rod and observe its movement.
The rod completes one swing by twisting one way and then back the other way, as shown in Fig. 1.4.
The time taken for each complete swing is *T*.
By timing several of these complete swings, determine an accurate value for *T*.

T = ………………………… [2]

(c) By cutting the given strip, repeat **(a)** and **(b)** until you have six sets of values of x and T. Values of x should be in the range 1 cm ≤ x ≤ 6 cm.

[9]

(d) **(i)** Plot a graph of T against $\frac{1}{x}$. [3]

(ii) Determine the gradient and y-intercept of this line.

gradient = ………………………………… [1]

y-intercept = ………………………………… [1]

(e) It is suggested that the relationship between T and x is

$$T = \frac{a}{x} + b$$

where a and b are constants.

Using your answers from **(d)(ii)**, determine the values of a and b.

a = ……………………………………

b = ……………………………………

[1]

(f) State one problem with determining an experimental value of T for x = 15 cm

....

....

....

.... [1]

(g) Paper manufacturers uses a similar setup and set of procedures to determine the quality of their products.

Other than the length l of the paper, suggest two other quantities of the paper that will affect the values of a or b.

1. ....

2. .... [2]

[Total: 21 marks]

2 In this experiment, you will measure the potential difference across a resistor R_2 as the resistance of the circuit is varied.

(a) (i) Connect the circuit shown in Fig. 2.1 using one of the resistors in the chain.

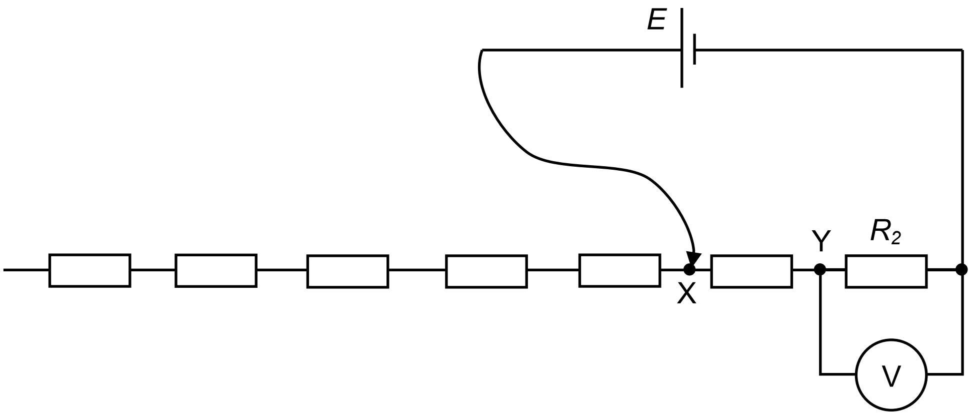

Fig. 2.1

(ii) Record the value of the potential difference V across R_2.

V = ...

(b) Change the number n of resistors between X and Y and repeat **(a)(ii)** until you have six sets of readings for V and n.

[4]

(c) V and n are related by the equation

$$\frac{1}{V} = \frac{nR_1}{ER_2} + \frac{1}{E}$$

where R_1 is the resistance of each of the resistors in the chain and E is the e.m.f. of the battery.

Suggest how you would use the data collected in **(b)** to determine values of E and the ratio of $\frac{R_1}{R_2}$

[3]

[Total: 7 marks]

3 When an object falls in air, it experiences a drag force which opposes the motion of the object. Larger objects experience greater drag forces. In this experiment, you will investigate how the terminal velocity of a paper cone falling in air depends on the diameter of the cone.

(a) Cut a sector of a piece of filter paper as shown in Fig. 3.1.

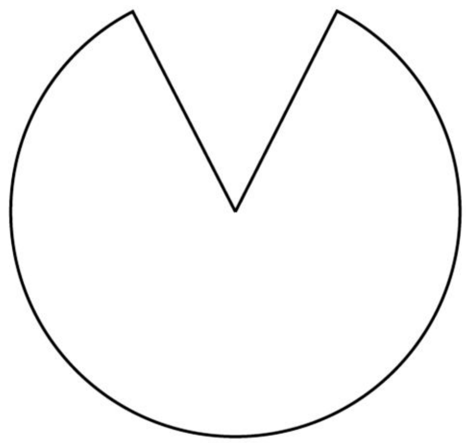

Fig. 3.1

(b) **(i)** Tape the straight edges of the paper together to produce a cone, as shown in Fig. 3.3.

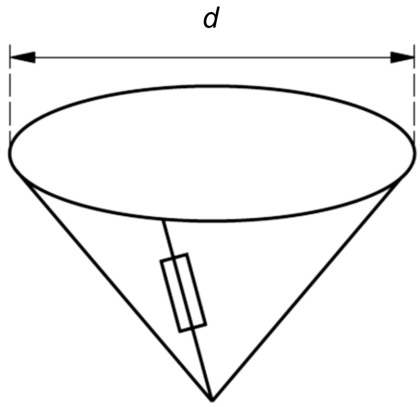

Fig. 3.2

(ii) Measure and record the diameter d of the cone.

d = ………………………………….. [1]

(c) (i) Mount a metre rule vertically using a retort stand, boss and clamp.

Explain how you ensured that the metre rule was mounted vertically.

....

....

.... [1]

(ii) Release the cone from a short distance above the top of the metre rule, as shown in Fig. 3.3.

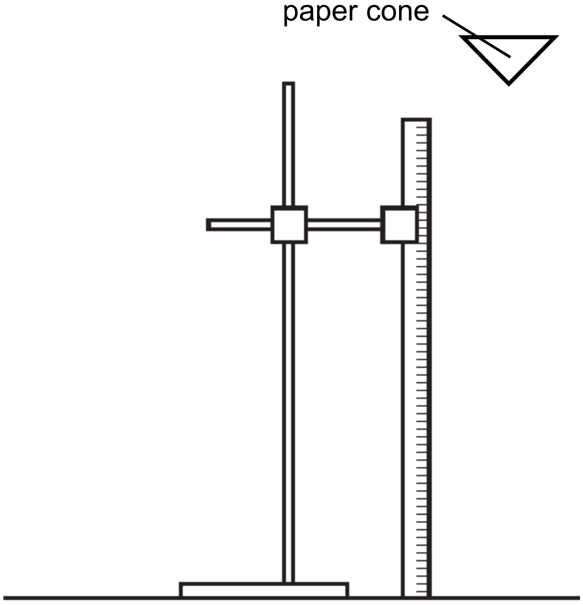

Fig. 3.3

Make and record measurements to determine the time *t* for the cone to fall through a distance *h* from the top of the metre rule.

h = ... [1]

t = ... [1]

(d) Estimate the percentage uncertainty in *t*, showing your working.

percentage uncertainty in *t* = ... [1]

(e) Calculate the terminal velocity *v* of the cone.

v = ………………………………….. [1]

(f) **(i)** Remove the tape from the paper and cut away a larger sector as shown in Fig. 3.4.

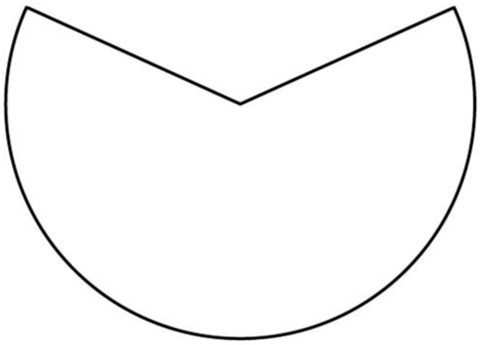

Fig. 3.4

(ii) Repeat **(b)**, **(c)(ii)** and **(e)**, recording your results below.

d = …………………………………..

h = …………………………………..

t = …………………………………..

v = …………………………………..

[2]

(g) It is suggested that *v* is inversely proportional to *d*. Explain clearly if the results of your experiment support this suggestion.

....

....

....

.... [2]

(h) **(i)** State three significant sources of error or limitations of the procedure in this experiment.

1. ....

....

....

2. ....

....

....

3. ....

....

.... [3]

(ii) Suggest three improvements that could be made to the experiment to address the errors identified in **(h)(i)**. You may suggest the use of other apparatus or a different procedure.

1. ....

....

....

2. ....

....

....

3. ....

....

.... [3]

[Total: 16 marks]

4 A student is investigating the absorption of sound by foam.

It is suggested that the absorption *A* of the sound is related to the density *d* and thickness *t* of the foam by the relationship

$$A = K\ d^p t^q$$

where *K*, *p* and *q* are constants.

You are provided with rectangular foam boards of different thicknesses and unknown densities.

Design a laboratory experiment to determine the values of *p* and *q*.

You should draw a diagram to show the arrangement of your apparatus and you should pay particular attention to

(a) the equipment to be used,

(b) the procedure to be followed,

(c) the measurements to be taken,

(d) the control of variables,

(e) the analysis of the data,

(f) any precautions that should be taken to improve the accuracy and safety of the experiment.

Diagram

[11]

[Total: 11 marks]

EUNOIA JUNIOR COLLEGE
JC2 PRELIMINARY EXAMINATIONS 2018
General Certificate of Education Advanced Level
Higher 2

PHYSICS 9749/04

Paper 4 Practical
MARK SCHEME
Maximum Mark: 55

24 August 2018

Question		Marks
1(a)(i)	Evidence of averaging of *x* (along the length of the strip) seen.	[1]
1(b)(ii)	Calculation of *T* from raw readings of *t* seen.	[1]
	Value of *T* within 1.3 s ± 0.2 s.	[1]
1(c)	**Data Collection** If candidate successfully collected: 6 sets of readings – award 3 marks 5 sets of readings – award 2 marks 4 sets of readings – award 1 mark If substantial assistance was rendered by supervisor – deduct 1 mark. If data trend is incorrect – deduct 1 mark.	max [3] min [0]
	Range of *x* To include 1 cm and 6 cm	[1]
	Column Headings Each column heading must contain a quantity and a unit. There must be some distinguishing mark between the quantity and the unit. Ignore POT errors. Ignore units in the body of the table.	[1]
	Presentation of Raw Readings All values of *x* must be to nearest 1 mm. All values of *t* must be to nearest 0.1 s and ≥ 10 s	[1]
	Raw Readings of *t* (or *T*) Evidence of repeated measurements seen.	[1]
	Significant Figures of Calculated Readings Significant fig. for every row of 1/*x* same as, or one more than, raw *x*. (Significant fig. for every row of *T* same as, or one more than, raw *t*. Number of oscillations needs to be recorded)	[1]
	Calculation 1/*x* (and *T*) calculated correctly. Tick if correct.	[1]

Question		Marks
1(d)(i)	**Axes** Sensible scales must be used. Awkward scales (e.g. 3:10) are not allowed. Scales must be chosen so that the plotted points on the grid occupy at least half the graph grid in both *x* and *y* directions. Scales must be labelled with the quantity (and unit) which is being plotted. Scale markings should not be more than three large squares apart.	[1]
	Plotting of Points All observations in table must be plotted. Check first and last points are plotted correctly. Tick if correct. Points are plotted to an accuracy of half a small square. Do not accept 'blobs' (points with diameter greater than half a small square).	[1]
	Line of Best Fit Judge by the balance of all the points (at least five) about candidate's line. (Point(s) not considered by candidates need to be clearly labelled as anomalous) There must be an even distribution of points either side of the line along the whole length. If mark is not awarded indicate rotation or direction of best fit line. Lines must not be kinked.	[1]
1(d)(ii)	**Gradient** The hypotenuse of the triangle must be at least 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 $\Delta x/\Delta y$). If incorrect, write in the correct value(s).	[1]
	***y*-intercept** *Either* Correct read-off from a point on the line and substitute into straight line equation $y = mx + c$. Read-off must be **accurate** to half a small square. Allow ecf of gradient value. *Or* Read-off of intercept directly from graph. Read off must be **accurate** to half a small square.	[1]
1(e)	*a* is the value of candidate's gradient with consistent unit (mm s or cm s or m s). *b* is the value of candidate's y-intercept with consistent unit (s).	[1]
1(f)	✓ strip too wide (for the clips / causes significant drag / tear paper) ✓ time for 1 oscillation too short for clear observation.	Max [1]
1(g)	✓ thickness of paper ✓ density of paper or mass per unit area (**not** mass / weight) ✓ Young's modulus ✓ Shear modulus	Max [2]

[Total: 21 Marks]

Question		Marks
2(b)	**Data Collection** If candidate successfully collected: 6 sets of readings – award 2 marks 5 sets of readings – award 1 marks If substantial assistance was rendered by supervisor – deduct 1 mark. If data trend (i.e. *V* decreases as *n* increases) is incorrect – deduct 1 mark.	max [2] min [0]
	Column Headings Each column heading must contain a quantity and a unit. There must be some distinguishing mark between the quantity and the unit. Ignore Power-of-Ten errors. Ignore units in the body of the table.	[1]
	Presentation of Raw Readings All values of *V* must be to nearest 0.001 V.	[1]
2(c)	Stated appropriate graph (1/*V* against *n*) to be plotted.	[1]
	E is determined by the inverse of the *y*-intercept	[1]
	Ratio R_1/R_2 is determined by dividing the gradient with the *y*-intercept	[1]
		[Total: 7 Marks]
3(b)(ii)	Value of *d* to nearest 0.1 cm or 1 mm	[1]
3(c)(i)	Use the set square to align metre rule to benchtop in 2 perpendicular directions.	[1]
3(c)(ii)	Value of *h* in range of 50 cm to 100 cm	[1]
	Averaging of at least 3 measurements of *t* seen.	[1]
3(d)	Absolute uncertainty must be in the range of 0.1 s to 0.3 s. Correct calculation. Final answer to 1 or 2 significant figures.	[1]
3(e)	First value of *v* calculated correctly. Calculations must be checked. Write in correct value if wrong.	[1]
3(f)(ii)	Smaller *d* gives greater *v*.	[1]
	Second value of *v* calculated correctly. Calculations must be checked. Write in correct value if wrong.	[1]
3(g)	Correct calculation to check proportionality. Possibilities include: ✓ Two calculations of *vd*. Ratio of *v* values and inverse ratio of *d* values both calculated.	[1]
	Sensible comments relating to proportionality calculations and percentage uncertainty calculated in **(d)**.	[1]

Question		Marks
3(h)(i)	Relevant points can include: a) Two sets of readings insufficient to draw valid conclusion. b) Cone may have not reached terminal velocity. c) Hard to see when cone strikes floor. d) Cone falls at an angle due to imbalance of cone. e) Human error in timing/reaction time. f) Difficult to measure diameter because cone flexible. g) Parallax error in reading positions of the cone.	Max [3]
3(h)(ii)	Corresponding points to **(h)(i)** can include: a) Take more readings and plot a graph. b) Ensure terminal velocity by increasing release height or measure velocity at two intervals to check terminal velocity reached. c) Use a pressure (or other appropriate) sensor placed on the floor to stop timer. d) Balance the cone using extra strip of tape. e) Use light gate to trigger stopwatch or use video camera / high speed camera placed in front of the apparatus or measure time over greater distance. f) Measure diameter of cone in two directions and average or use a string to measure the circumference and calculate the diameter g) Drop in front of rule/read at eye level.	Max [3]

[Total: 16 Marks]

4	**Basic Procedure**	
	Diagram shows in-line placement of apparatus, including foam board (not “floating”)	[1]
	Viable selection of sound source (eg signal generator connected to a loudspeaker) and corresponding sensor (eg microphone connected to a pre-amplifier to a CRO, or microphone connected to a data-logger, or a decibel meter). Speaker must be switched on.	[1]
	Repeats experiment by changing foam boards of the <u>same *d*</u> but <u>different *t*</u>. Mention how t is changed (board with different thickness) AND by changing foam boards of the <u>same *t*</u> but <u>different *d*</u>. (need to see eg different materials)	[1]
	Measuring and Quantifying Dependent Variable	
	Defines absorption appropriately ($1 – x/x_o$). x_o is measured without any foam boards in place	[1]
	Measuring and Quantifying Independent Variable(s)	
	t is measured using metre rule / vernier calipers / micrometer screw gauge.	[1]
	Length and width of foam boards measured using metre rule. Mass of foam boards is measured using a pan / spring balance. Density of foam board is calculated appropriately.	[1]

Question		Marks
	Processing and Analysing Experimental Data	
	Appropriate graph of *A* against *t* to be plotted (i.e. lg *A* against lg *t*) If a straight line graph is obtained, the gradient of the graph is *q*.	[1]
	Appropriate graph of *A* against *d* to be plotted (i.e. lg *A* against lg *d*) If a straight line graph is obtained, gradient of the graph is *p*.	[1]
	Safety Any suitable precautions to mitigate effects of loud sounds.	1
	Additional Details ✓ *t* is measured at least twice at different positions to find average ✓ Sound source of same frequency and/or amplitude is used ✓ Distance between sound source and sensor is kept constant by making measurements and placing markers. ✓ Repeat measurements by flipping the foam boards. ✓ Any suitable precautions to reduce effects of diffraction of sound (i.e. frequency of sound to be significant different from dimensions of foam board / placing microphone right behind foam board, surface area of foam board significantly larger than loudspeaker) ✓ Any suitable method to reduce reflection of sound. (i.e. use of barrier or tube) ✓ Carries out experiment in room with low ambient sound to reduce external effects. ✓ Preliminary trials for suitable initial loudness so that appreciable signal can be detected even when using thickest, most dense foam board	Max [2]
		[Total: 11 Marks]