# JURONG PIONEER JUNIOR COLLEGE
## JC2 Preliminary Examination 2022

**PHYSICS**
**Higher 2**

**9749/01**
**23 September 2022**

Paper 1 Multiple Choice

**1 hour**

Additional Material: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

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

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 **15** printed pages.

**Data**

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

**Formulae**

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

1 A boat changes its velocity from 8 m s$^{-1}$ due south to 6 m s$^{-1}$ due west.

What is its change in velocity?

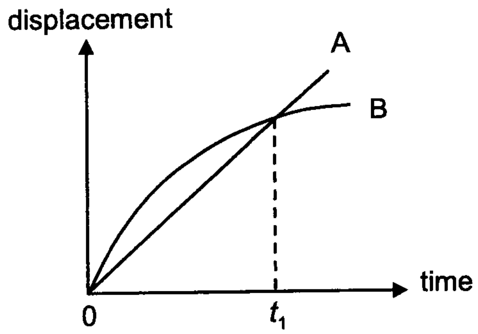
**A** 2 m s$^{-1}$ at a direction of 37° west of south

**B** 2 m s$^{-1}$ at a direction of 53° west of south

**C** 10 m s$^{-1}$ at a direction of 37° west of north

**D** 10 m s$^{-1}$ at a direction of 53° east of north

2 The graph shows the variation with time of the displacement for two trains A and B running on parallel tracks.




Which statement is correct?

**A** Both trains speed up all the time.

**B** Both trains have the same velocity at time $t_1$.

**C** Both trains have the same velocity at some time before $t_1$.

**D** Both trains have the same acceleration at some time before $t_1$.

3 A machine shoots baseballs at a vertical wall at a constant rate of one ball every 5.0 s. The ball hits the wall perpendicularly with a speed of 10.0 m s$^{-1}$ and rebounds with a speed of 7.0 m s$^{-1}$. Each ball has a mass of 300 g.

What is the average force exerted on the wall?

**A** 0.18 N

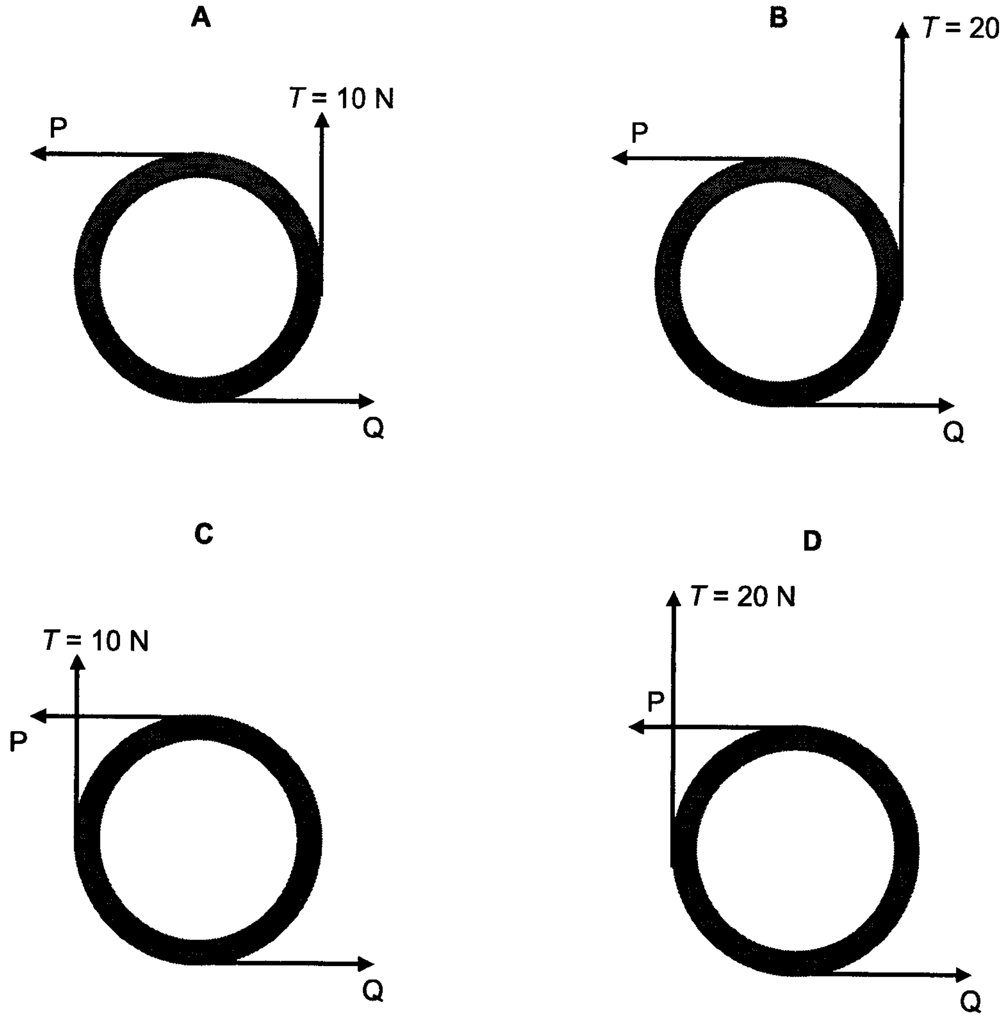
**B** 0.42 N

**C** 0.60 N

**D** 1.0 N

4 A circular ring of weight 20 N is suspended by a string attached to a point on its rim. The magnitude of the tension in the string is $T$. The ring is acted on by two horizontal forces, P and Q, forming a couple. P and Q are each of magnitude 10 N and acts tangentially on the rim of the ring as shown.

Which of the diagram shows the ring in equilibrium?




5 The motor of a small boat has a propeller of diameter 0.200 m. When the boat is starting from rest, the propeller sends a stream of water backwards at a speed of 10.0 m $s^{-1}$. Half of the work done by the motor is transferred to the water as its kinetic energy.

What is the power of the motor, taking density of water to be 1000 kg $m^{-3}$?

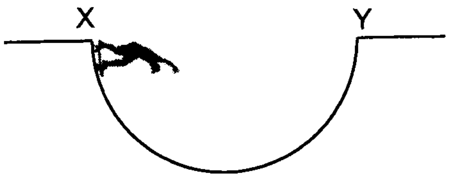
**A** 1.25 kW

**B** 6.50 kW

**C** 15.7 kW

**D** 31.4 kW

6 A skateboarder of mass $m$ skates on a smooth semi-circular half-pipe as shown. He starts from point X from rest and skates towards Y. Assume that air resistance is negligible.




What is the maximum force exerted by the half-pipe on the skateboarder?

**A** $mg$

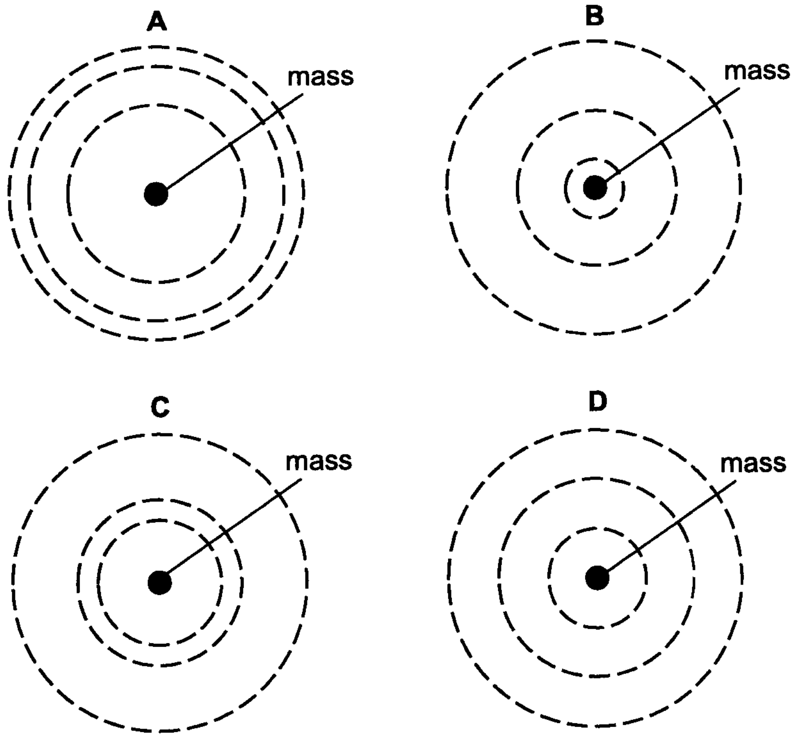
**B** $2mg$

**C** $3mg$

**D** $4mg$

7 The diagrams shows three equipotential lines around a point mass. The dotted lines represent increasing potential of $-15\ \mathrm{J\ kg^{-1}}$, $-10\ \mathrm{J\ kg^{-1}}$ and $-5\ \mathrm{J\ kg^{-1}}$, with the lowest potential being the innermost dotted line.

Which of the following best represents the equipotential lines around the point mass?



**8** A particle is oscillating in simple harmonic motion, with kinetic energy $E_K$, potential energy $E_P$ and total energy $E_T$. The particle is mid-way between the equilibrium position and an amplitude position.

What are the ratios $E_K : E_T$ and $E_P : E_T$?

| | $E_K : E_T$ | $E_P : E_T$ |
|---|---|---|
| **A** | 0.25 | 0.75 |
| **B** | 0.50 | 0.50 |
| **C** | 0.67 | 0.33 |
| **D** | 0.75 | 0.25 |

**9** What is the number of oxygen atoms, in terms of the Avogadro number $N_A$, in one mole of carbon dioxide ($CO_2$)?

**A** $\frac{1}{3}N_A$

**B** $\frac{2}{3}N_A$

**C** $N_A$

**D** $2N_A$

**10** A hot water tank of heat capacity 6500 J $K^{-1}$ contains 14 kg of water at 30 °C.

The specific heat capacity of water is 4200 J $kg^{-1}$ $K^{-1}$ and specific latent heat of vaporisation of water is $2.26 \times 10^6$ J $kg^{-1}$.

What is the time taken to convert all the water to steam using a heater coil of power 5.2 kW?

**A** 800 s

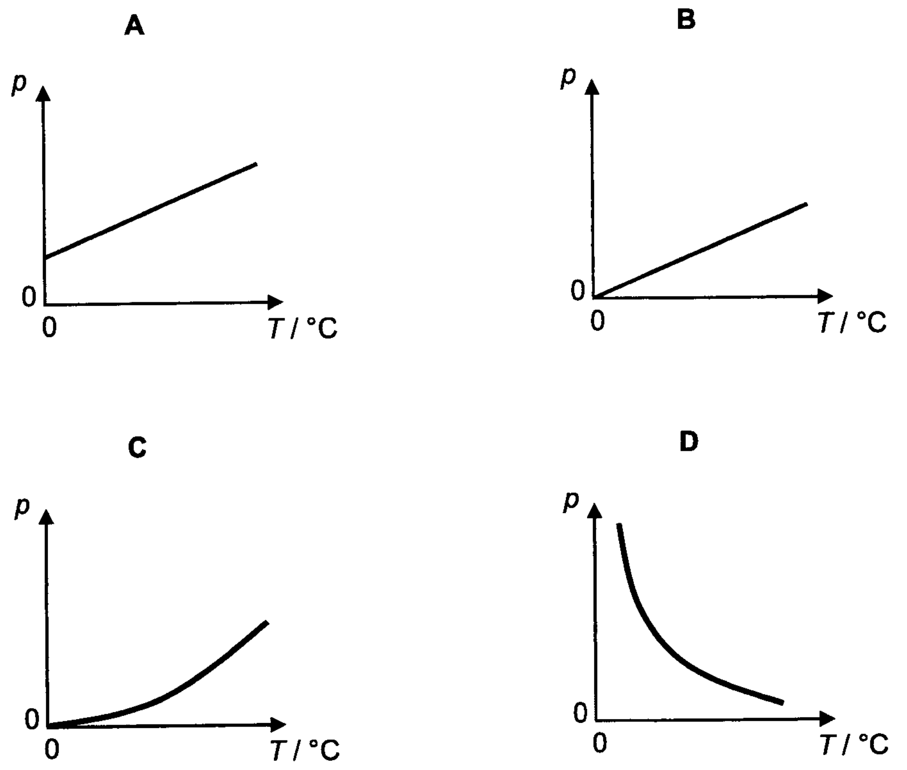
**B** 6000 s

**C** 6200 s

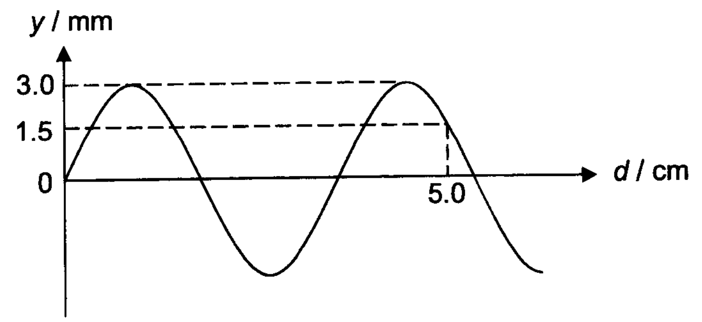
**D** 7000 s

**11** A fixed mass of an ideal gas is heated at constant volume.

Which graph shows the correct variation of pressure with temperature in degrees Celsius?




**12** The variation with distance $d$ along a sinusoidal wave of displacement $y$ of particles in the wave is as shown. When $d$ is 5.0 cm, $y$ is 1.5 mm.




What is the wavelength of the wave?

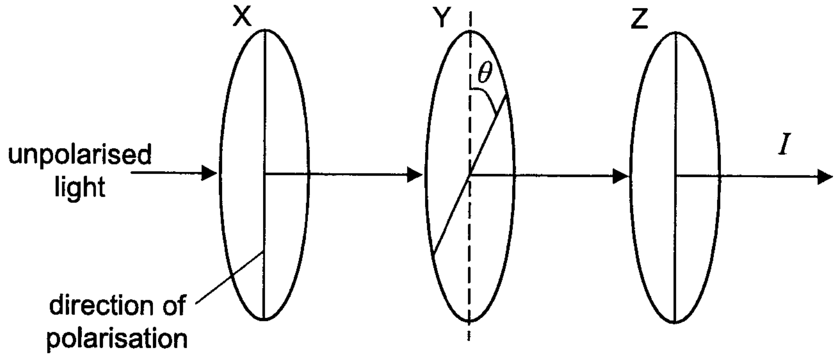
**A** 3.5 cm

**B** 3.8 cm

**C** 4.3 cm

**D** 4.6 cm

**13** Unpolarised light passes through three polaroids X, Y, and Z are arranged as shown. The directions of polarisation of X and of Z are kept vertical, while the angle between the direction of polarisation of X and of Y is $\theta$. The intensity of the light after passing through Z is $I$.




At which of the following $\theta$ is the magnitude of $I$ the largest?

**A** 30°

**B** 45°

**C** 60°

**D** 90°

**14** Monochromatic light of wavelength 600 nm diffracts through a single slit of width 0.1 mm.

What is the width of the central maximum of the diffraction pattern produced on a screen 3.0 m away?

**A** 0.012 m

**B** 0.018 m

**C** 0.036 m

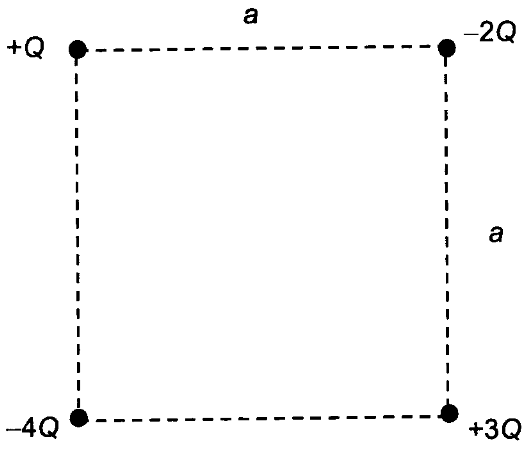
**D** 0.34 m

**15** A thin beam of monochromatic light is incident normally on a diffraction grating. The third order diffracted beam occurs at an angle of 50° to the normal.

What is the highest order visible with this grating at this wavelength?

**A** 3 **B** 4 **C** 5 **D** 6

16 Four point charges are placed at the corners of a square of side $a$ and the magnitude of the charges are as shown.




What is the work done in bringing a unit positive charge from infinity to the centre of the square?

**A** $\dfrac{Q}{4\pi\varepsilon_0 a}$

**B** $\dfrac{5\sqrt{2}Q}{2\pi\varepsilon_0 a}$

**C** $\dfrac{-\sqrt{2}Q}{2\pi\varepsilon_0 a}$

**D** $\dfrac{-5Q}{2\pi\varepsilon_0 a}$

17 Which statement about an electric field is correct?

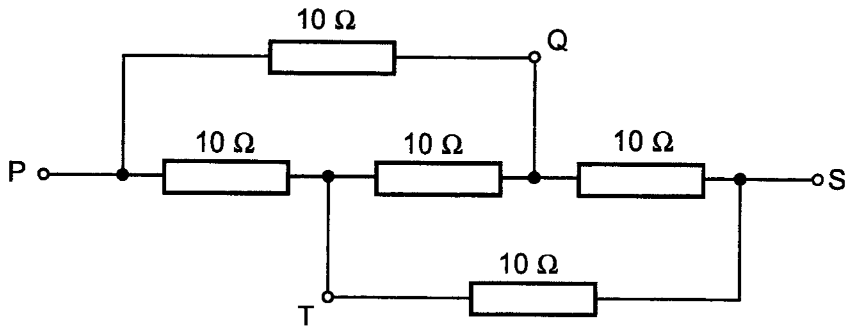
**A** When a positive point charge is brought from infinity into the field of a positively charged sphere, its potential energy decreases.

**B** The direction of an electric field at a point shows the direction in which any charge would move if placed at that point.

**C** When a positive charge moves along the direction of an electric field, its potential energy decreases.

**D** The electric field strength is always proportional to the electrical potential.

**18** A network of resistors each of resistance 10 Ω are shown.




What is the effective resistance between Q and T?

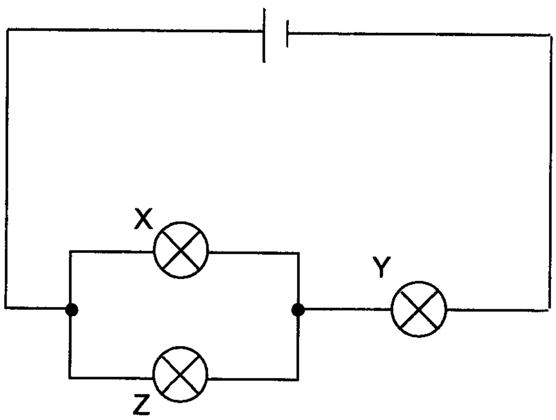
**A** 2.0 Ω

**B** 5.0 Ω

**C** 10 Ω

**D** 12 Ω

**19** The circuit diagram shows a battery of negligible internal resistance connected to three identical bulbs X, Y and Z.

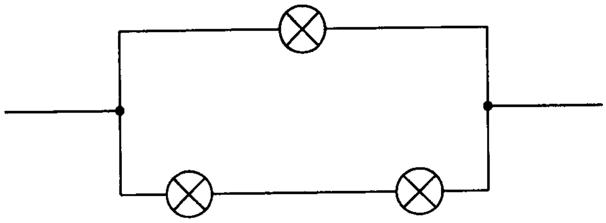



The filament of bulb X broke.

What happens to the brightness of bulb Y and bulb Z?

| | bulb Y | bulb Z |
|---|---|---|
| **A** | brighter | dimmer |
| **B** | dimmer | brighter |
| **C** | remains the same | brighter |
| **D** | brighter | remains the same |

**20** In the diagram below, three identical bulbs are connected to form a circuit. The maximum power produced by a single bulb is 10 W.

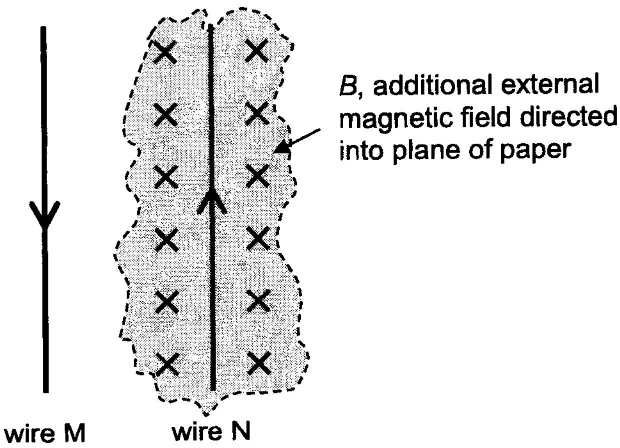


The resistance of the bulbs remains constant when lighted up.

What is the total maximum power that can be attained in this circuit such that all bulbs are lighted up?

**A** 10 W **B** 15 W **C** 20 W **D** 30 W

**21** Two long straight vertical wires run parallel to each other, carrying currents in opposite directions as shown. Wire N is in a region where an additional external magnetic field, *B*, is directed into the plane of the paper.




Which statement is correct?

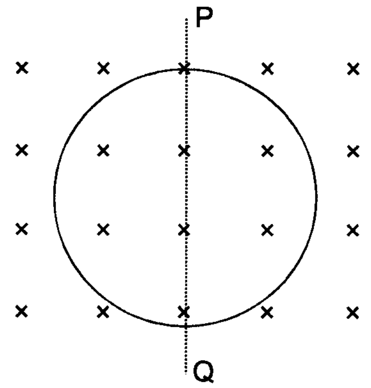
**A** The net force on wire N is zero.

**B** The net force on wire N acts to the right.

**C** The net force on wire N acts out of the plane of the paper.

**D** The net force on wire N acts either to the left or right depending on the magnitude of the currents and the strength of the external magnetic field.

**22** A circular coil has resistance $R$ and area $A$. The coil is placed in a uniform magnetic field of flux density $B$ such that its plane is perpendicular to the magnetic field lines.

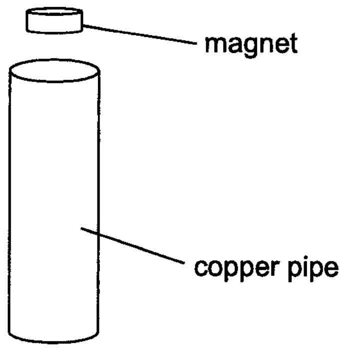



The plane of the coil is now rotated through 90° about the axis PQ.

What is the magnitude of the charge that flows in the coil?

**A** $\dfrac{BA}{R}$ **B** $\dfrac{R}{BA}$ **C** $BAR$ **D** zero

**23** When a small cylindrical magnet is released from rest above a copper pipe, the magnet falls slowly through the pipe.




What change can be made so that the magnet falls slower through the same length of the pipe?

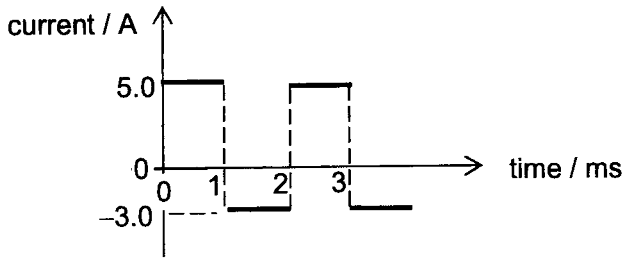
**A** Place the magnet nearer to the top of the pipe before releasing it from rest.

**B** Use a pipe of material with higher resistivity.

**C** Use a weaker magnet of the same mass.

**D** Use a lighter magnet.

**24** An alternating current flowing through a resistor varies with time as shown.




What is the value of the direct current that gives the same heating effect as the alternating current?

**A** 17 A **B** 4.1 A **C** 4.0 A **D** 2.0 A

**25** A 40:1 step down transformer is connected to a 2300 V root-mean-square (r.m.s.) supply and has a 10 A r.m.s. current flowing through it.

If the efficiency of the transformer is 90%, what is the r.m.s. current in the secondary coil?

**A** 0.225 A

**B** 0.275 A

**C** 360 A

**D** 440 A

**26** An electron of mass *m* and charge *e* is accelerated from rest through a potential difference of *V*.

What is the frequency of a photon whose wavelength is equal to the de Broglie wavelength of this electron?

**A** $\dfrac{c\sqrt{2meV}}{h}$

**B** $\dfrac{h}{c\sqrt{2meV}}$

**C** $\dfrac{hc}{eV}$

**D** $\dfrac{eV}{h}$

**27** When a parallel beam of white light passes through a cool vapour, dark lines appear in the spectrum of the emergent light.

This is principally because the energy is absorbed and

**A** is not re-radiated at all.

**B** is re-radiated as ultra-violet radiation.

**C** is re-radiated uniformly in all directions.

**D** is re-radiated gradually over a long period of time.

**28** The accelerating potential difference in an X-ray tube is 20 kV.

What is the shortest wavelength of the X-ray photon emitted from the X-ray tube?

**A** $6.22 \times 10^{-11}$ m

**B** $6.22 \times 10^{-10}$ m

**C** $1.61 \times 10^{-11}$ m

**D** $1.61 \times 10^{-10}$ m

**29** Which of the following is an isotope that decays by β-emission to produce $^{111}_{48}\text{Cd}$?

**A** $^{111}_{47}\text{Ag}$ **B** $^{110}_{47}\text{Ag}$ **C** $^{111}_{49}\text{In}$ **D** $^{112}_{50}\text{Sn}$

**30** A detector is used for monitoring an α-source and a reading of 150 counts per minute is observed. After a time equal to the half-life of the α-source, the reading has fallen to 80 counts per minute. A 10 mm thick lead sheet is then inserted between the α-source and the detector.

What is a possible reading of the detector now?

**A** 0

**B** 10

**C** 20

**D** 25

**End of paper**

Name: ______________________ Class: ____________

# JURONG PIONEER JUNIOR COLLEGE

## JC2 Preliminary Examination 2022

**PHYSICS**
**Higher 2**

**9749/02**
**13 September 2022**

Paper 2 Structured Questions

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

Write your name and class on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

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** | / 5 |
| **2** | / 10 |
| **3** | / 9 |
| **4** | / 8 |
| **5** | / 7 |
| **6** | / 12 |
| **7** | / 9 |
| **8** | / 20 |
| **Total** | / 80 |

This document consists of **22** printed pages. **[Turn over**

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| displacement of particle in s.h.m. | $x = x_0 \sin \omega t$ |
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| | $= \pm\omega\sqrt{x_0{}^2 - x^2}$ |
| electric current | $I = Anvq$ |
| resistors in series | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel | $1/R = 1/R_1 + 1/R_2 + \ldots$ |
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| radioactive decay | $x = x_0 \exp(-\lambda t)$ |
| decay constant | $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$ |

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

1 A smooth pebble, made from uniform rock, has the shape of an elongated sphere as shown in Fig. 1.1.

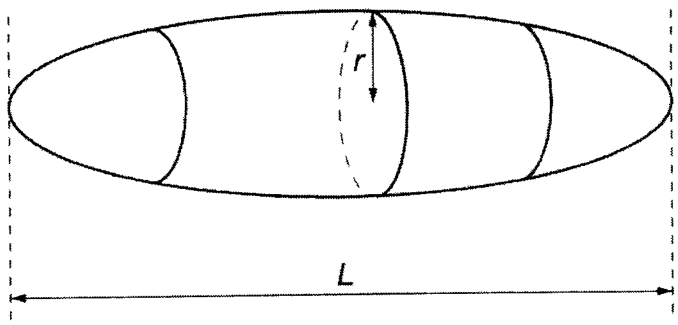



**Fig. 1.1**

The length and the mass of the pebble is $L$ and $M$ respectively. The cross-section of the pebble, in the plane perpendicular to $L$, is circular with a maximum radius $r$.

The density $\rho$ of the rock from which the pebble is composed is given by

$$\rho = \frac{Mr^n}{kL}$$

where $n$ is an integer and $k$ is a constant, with no units, that is equal to 2.094.

**(a)** Use SI base units to show that $n$ is equal to −2.

[1]

**(b)** The mean values, absolute uncertainties and percentage uncertainties of some of the above quantities are listed in Fig. 1.2.

| quantity | mean value | absolute uncertainty | percentage uncertainty |
|---|---|---|---|
| $L$ | 0.1242 m | 0.0002 m | - |
| $M$ | 1072 g | - | 0.18 % |
| $\rho$ | 2340 kg m$^{-3}$ | 50 kg m$^{-3}$ | - |

**Fig. 1.2**

**(i)** Calculate the fractional uncertainty in $r$.

fractional uncertainty = .......................................... [2]

**(ii)** Determine $r$ with its absolute uncertainty. Give your values to the appropriate number of significant figures.

$r$ = (........................ ± .................) m [2]

2 **(a)** State *Newton's third law of motion.*

..........................................................................................................

..........................................................................................................

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

**(b)** In a track and field event, a high jumper jumps over a horizontal bar and lands on a thick mattress. Fig. 2.1 shows the instant where she is just clearing the bar at her maximum height. The high jumper is considered as a point mass labelled P.

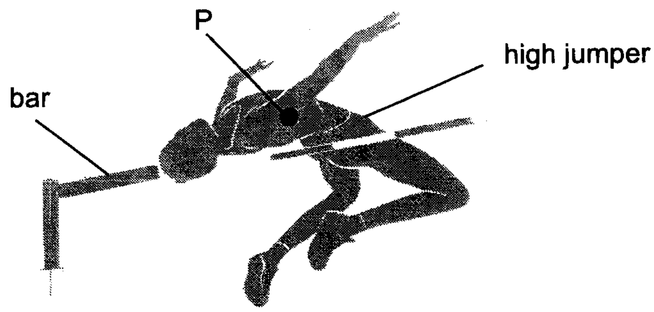



**Fig. 2.1**

**(i)** On Fig. 2.1, draw a labelled force diagram to show the force(s) acting on her at P. Make it clear the difference in magnitude of the force(s) if any. [1]

**(ii)** Fig. 2.2 shows the instant she lands on the mattress.

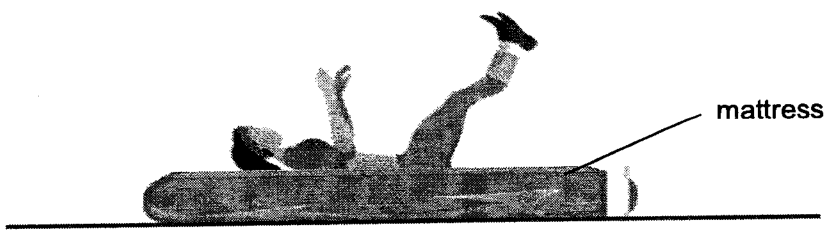



**Fig. 2.2**

On Fig. 2.2, draw labelled force diagrams to show the forces on her and on the mattress for the instant she landed. Make it clear which forces are action-reaction pairs, and which forces are different in magnitude. [3]

**(c)** Fig. 2.3 shows the variation with time $t$ of the impact force $F$ on her upon hitting the mattress. She has a mass of 50 kg and she comes to rest without rebounding at $t = 1.2$ s.

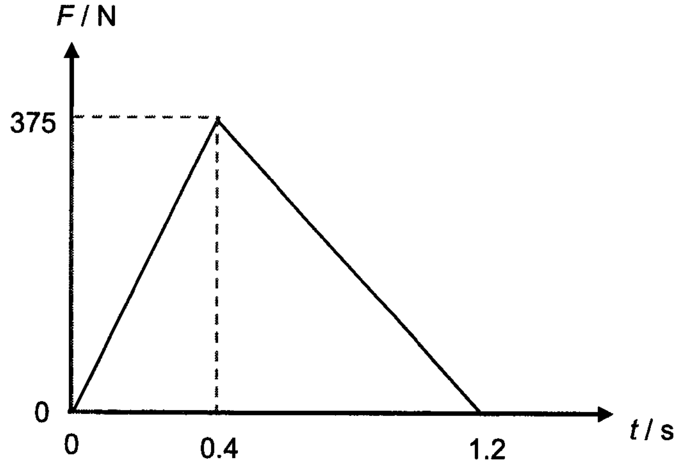



**Fig. 2.3**

**(i)** Determine the speed at which she hits the mattress.

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

**(ii)** In another attempt, she hits the high jump bar horizontally with a speed of 1.5 m s$^{-1}$. The bar has a mass of 3.0 kg and the collision is elastic.

Determine the speed of the bar immediately after collision.

speed = ........................................ m s$^{-1}$ [3]

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

..........................................................................................................................................

..........................................................................................................................................

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

**(b)** A satellite of mass $m$ orbits in a circular path around the Earth, of mass $M$ and radius $R_E$, at a height $h$ above the Earth's surface.

**(i)** On the axes of Fig. 3.1, from $h = R_E$ onwards, sketch and label the variation with $h$ of

**1.** the gravitational potential energy $E_p$, [1]

**2.** the kinetic energy $E_k$ of the satellite. [1]

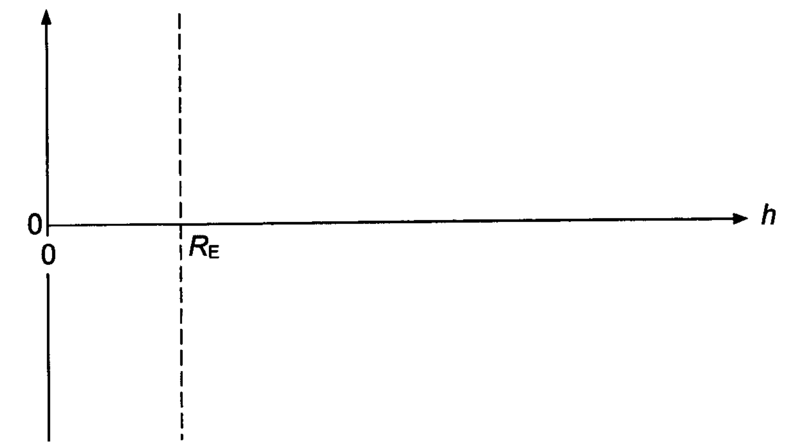



**Fig. 3.1**

**(ii)** The Earth has radius $6.4 \times 10^6$ m and mass $6.0 \times 10^{24}$ kg.

A satellite has mass 1200 kg and an orbital period of 12 hours.

Determine $h$.

$h$ = ........................................ m [3]

**(iii)** State and explain whether work done required on the satellite is positive, negative, or zero, in order for the satellite to orbit at a larger *h*.

..........................................................................................................................

..........................................................................................................................

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

4 (a) Fig. 4.1 shows two coherent sources P and Q producing waves. A wave detector is moved along line AB.

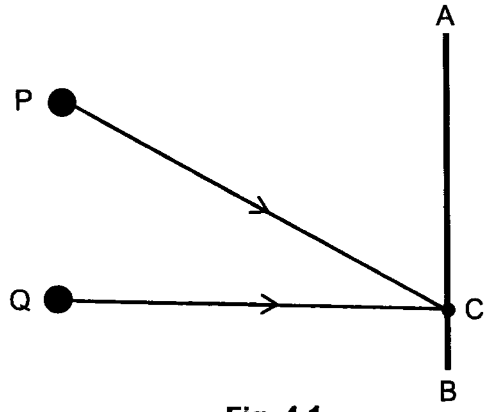



**Fig. 4.1**

(i) Explain how interference fringes are formed along the line AB.

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

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

(ii) The waves from P and Q meet at a point C in phase. Waves from P has an amplitude of 1.5 cm and intensity $I$. The resultant intensity at C is $3I$.

Calculate the amplitude of wave from Q.

amplitude = .......................................... cm [2]

**(b)** The apparatus shown in Fig. 4.2 is used to produce an interference pattern on a screen.

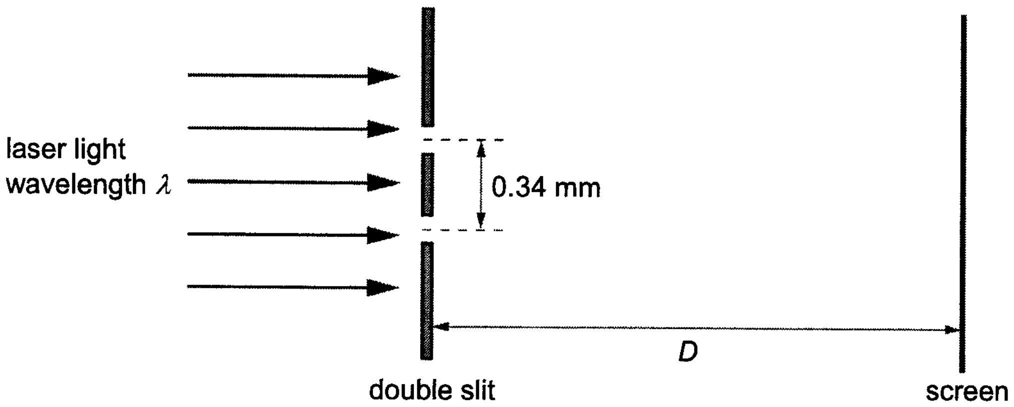



**Fig. 4.2**

Light of wavelength $\lambda$ is incident on a double-slit. The slit separation is 0.34 mm. The separation between adjacent fringes is $x$. Fringes are viewed on a screen at distance $D$ from the double-slit.

Distance $D$ is varied from 2.0 m to 3.5 m. The variation with $D$ of $x$ is shown in Fig. 4.3.

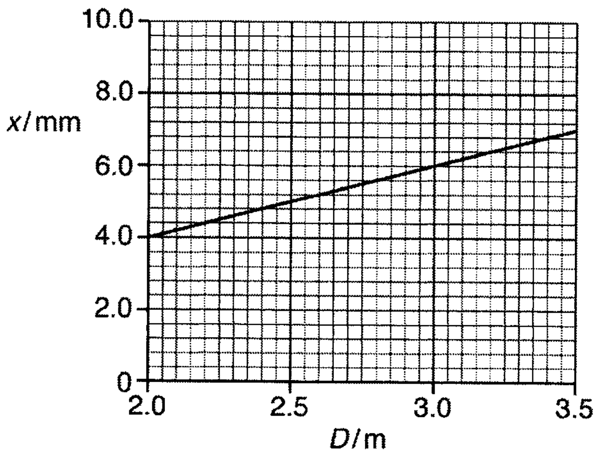



**Fig. 4.3**

**(i)** Use Fig. 4.3 to determine the wavelength $\lambda$.

$\lambda$ = ........................................ nm [3]

**(ii)** The double slit is now replaced by another double slit with a larger slit separation.

On Fig. 4.3, sketch a possible line to show the variation with *D* of *x* for the fringes that are now produced. [1]

**5** **(a)** A student decides to build a temperature probe and sets up the circuit using a thermistor and a 5.00 kΩ resistor as shown in Fig. 5.1. The battery has e.m.f. 9.00 V and negligible resistance.

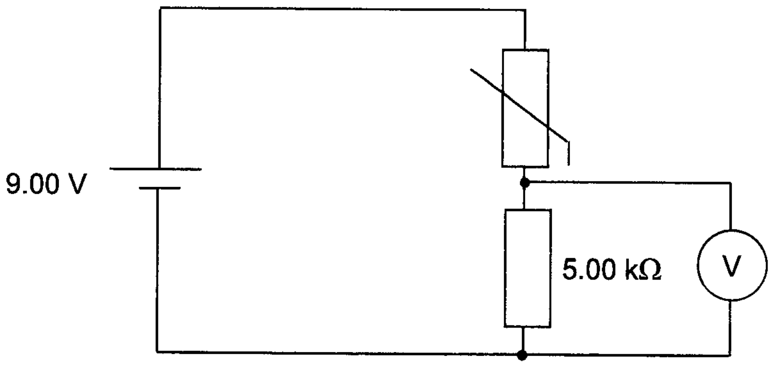



**Fig. 5.1**

**(i)** When the thermistor is at 30.0°C, the thermistor's resistance is 1.25 kΩ.

Calculate the reading on the voltmeter at this temperature.

voltmeter reading = ........................................ V [1]

**(ii)** The student removed the thermistor and voltmeter from the circuit. He added in a light dependent resistor (LDR) and a lamp to build a lighting system which switches on automatically when the surrounding gets dark.

In the space provided below, draw a circuit diagram to show how the electrical components can be connected.

[2]

**(b)** Fig. 5.2 shows a circuit which may be used to compare the resistance $R$ of an unknown resistor with a 100 Ω resistor. The distances $l$ from one end of the potentiometer slide-wire to the balance point are 400 mm and 588 mm when X is connected to Y and to Z respectively. The length of the slide-wire is 1.000 m.

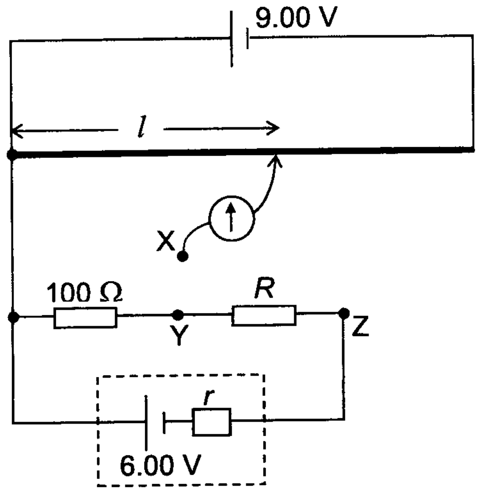



**Fig. 5.2**

Determine

**(i)** the value of resistance $R$,

$R$ = ....................................... Ω [2]

**(ii)** the value of internal resistance $r$.

$r$ = ....................................... Ω [2]

6 (a) By reference to the photoelectric effect, state what is meant by the work function of a surface.

..................................................................................................................

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

(b) Light of wavelength 540 nm is incident on a metal surface having a work function of 2.5 eV.

Determine whether electrons are emitted from the surface.

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

(c) Explain whether your conclusion in **(b)** is affected by the intensity of light incident on the surface.

..................................................................................................................

..................................................................................................................

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

(d) Fig. 6.1 below shows some of the energy levels (in electron-volts) of an atom X.

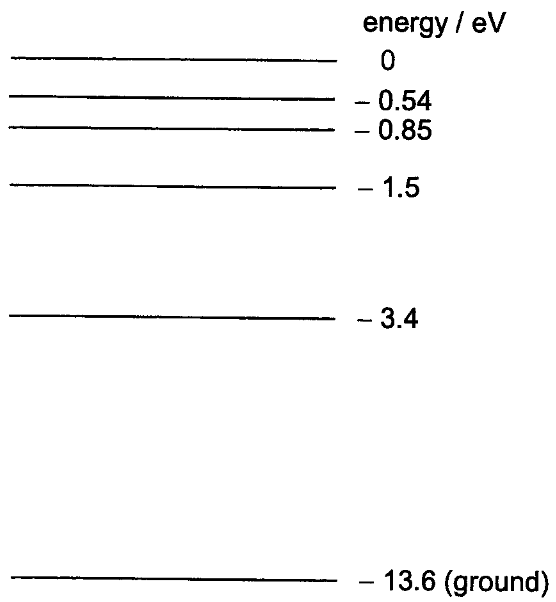



**Fig. 6.1**

Cool vapour of X at low pressure is bombarded with electrons that are accelerated from rest through an accelerating potential of 12.8 V.

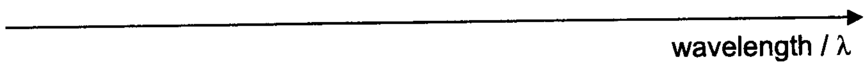
**(i)** State the ionisation energy of X.

ionisation energy = ....................................... eV [1]

**(ii)** Determine the number of different wavelengths of radiation that will be emitted.

number of different wavelengths = ....................................... [2]

**(iii)** On Fig. 6.2, draw the spectral lines. Label the line corresponding to the highest energy radiation.




[2]

**Fig. 6.2**

**(iv)** Determine the wavelength of the highest energy radiation.

wavelength = ....................................... m [1]

7 A transformer has 3000 turns in its primary coil. It is used to convert a main supply of root-mean-square value of 250 V to an alternating voltage having a peak value of 14 V.

(a) Explain what is meant by the *root-mean-square* value of an alternating current.

.............................................................................................................

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

(b) Calculate the number of turns in the secondary coil. State an assumption made in your calculation.

number of turns = ....................................... [2]

Assumption: .............................................................................................

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

(c) The secondary coil is connected in series with a resistor R. The variation with time $t$, in seconds, of the potential difference in the secondary coil is given by the expression

$$V = 14\sin(475t)$$

(i) To prevent overheating, the mean power dissipated in R must not exceed 340 W.

Calculate the minimum resistance of R.

resistance = ....................................... Ω [2]

(ii) On Fig. 7.1, sketch the variation with time $t$ of the power $P$ dissipated in R for a time interval of one period. Numerical values are not required.

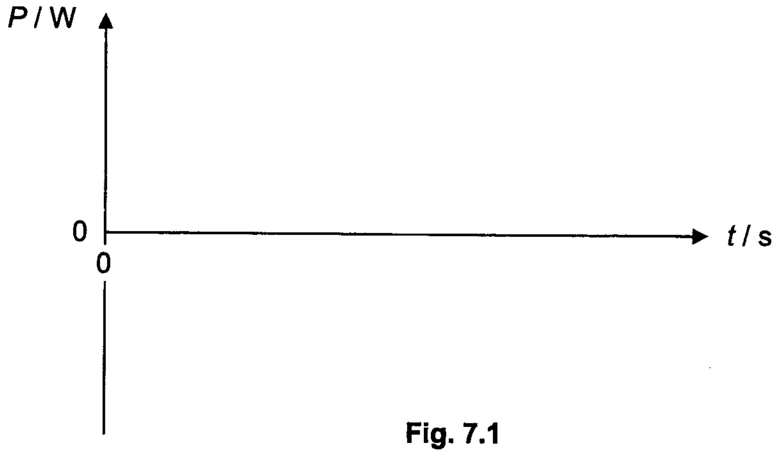



Fig. 7.1

[2]

8 Read the passage below and answer the questions that follows.

When an earthquake occurs, two different types of seismic waves could be generated: P-waves (primary waves) and S-waves (secondary waves). The speed of the waves depends on wave type and the properties of the rock; the denser the rock, the faster the waves travel.

P-waves travel the fastest. They consist of successive contractions and rarefactions, just like sound waves in air. The motion of the particles in the rocks that the waves travel through is parallel to the direction of the wave. S-waves are slower than P-waves. They are transverse waves, which means that the particle motion is at right angles to the direction of travel. S-waves cannot travel through air or liquids.

By studying the propagation characteristics of seismic waves, scientists have learned much about the detailed nature of Earth's interior. Inner core of Earth consists of solid iron and nickel. Outer core of Earth consists of liquid iron and nickel.

Fig. 8.1 shows the velocity and density variations within Earth (from the surface to the centre) based on seismic observations. The main regions of Earth and important boundaries are labelled.

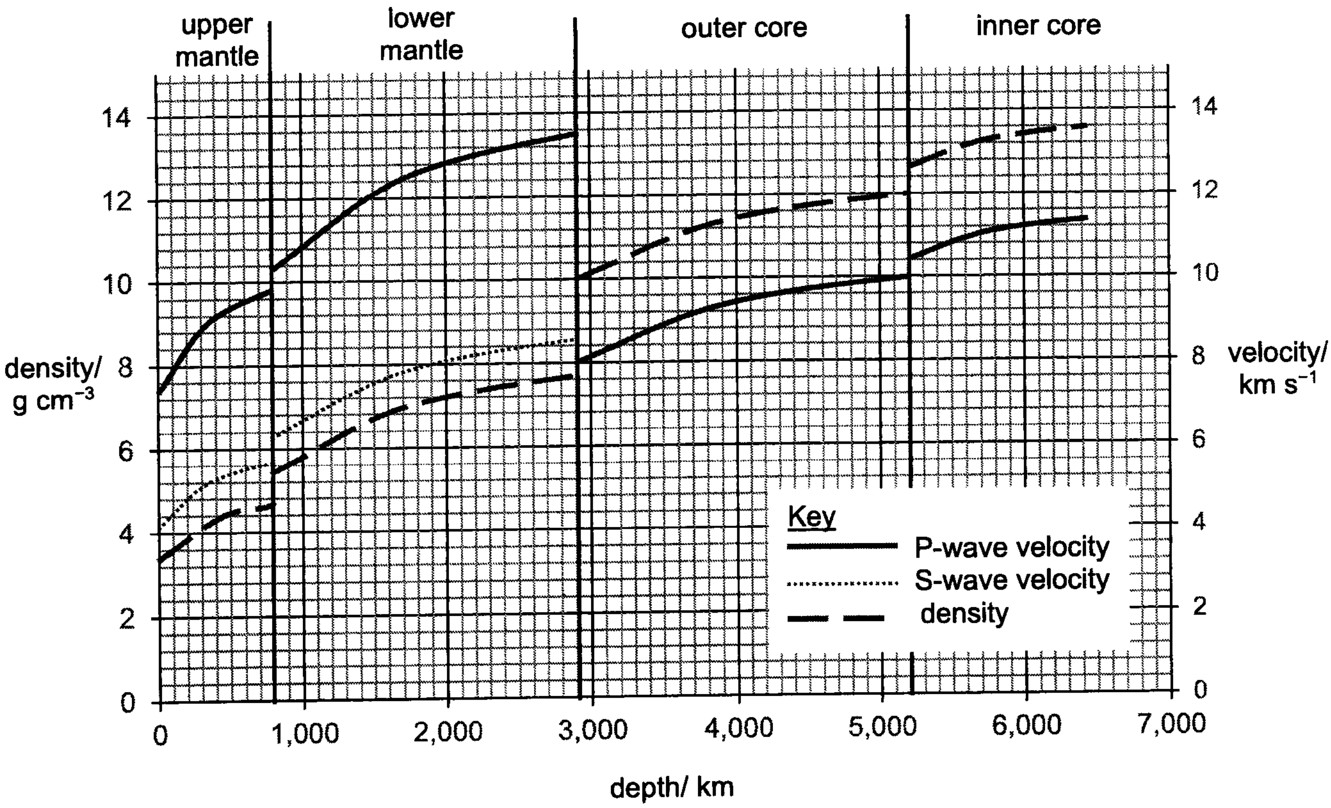



**Fig. 8.1**

**(a)** A large earthquake occurs at a depth of 200 km from the surface of the Earth at a particular location and both seismic P-waves and S-waves are produced. The P-waves and S-waves travel through the Earth away from the epicentre of the earthquake.

A seismograph at a different location detects the arrival of the S-waves 2 minutes 50 seconds after the arrival of the P-waves.

**(i)** Estimate the time taken for the S-waves to travel from the epicentre of the earthquake to the seismograph.

time = .......................................... s [3]

**(ii)** Calculate the distance of the epicentre of the earthquake from the seismograph.

distance = .......................................... km [1]

**(iii)** Seismic waves produced by the earthquake are detected by seismographs in many different countries. In certain parts of the world, however, seismographs do not detect any of the S-waves produced by the earthquake.

Using Fig. 8.1 and other information, explain why these seismographs do not detect the S-waves.

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

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

**(b)** The waves from earthquake cause surface vibrations. Surface waves travel along the outer surface of the Earth. These are the slowest and often produce the worst damage. The vibrations can damage buildings far from the epicentre (source) of the earthquake.

Over the past 30 years, it was observed that the vertical component was a likely contributor, along with severe horizontal ground motion, to the mass destructive structural effects observed during extreme earthquakes. It was reported that the magnitude of vertical ground motion exceeded the magnitude of horizontal ground motion especially in strong earthquakes such as Loma prieta 1989, Northridge 1994, Kobe 1995, Kocaeli 1999, and Duzce 1999.

The vertical ground vibrations 50 km from a particular earthquake can be modelled by the equation:

$$s = 0.014\cos(12t)$$

where $s$ is the vertical displacement in metres and $t$ is the time in seconds.

**(i)** State the amplitude and frequency of these vibrations

amplitude = ....................................... m

frequency = ....................................... Hz [2]

**(ii)** Using differentiation, derive expressions for

**1.** the vertical velocity $v$ of the ground as these waves pass,

[1]

**2.** the vertical acceleration $a$ of the ground as these waves pass.

[1]

**(iii)** The U.S. Geological Survey measures Peak Ground Acceleration (PGA) to create an instrumental intensity scale for the effects of earthquakes. This scale is shown in Fig. 8.2.

| instrumental intensity scale | PGA / m $s^{-2}$ | maximum ground velocity, $v_o$ / m $s^{-1}$ | perceived shaking | potential damage |
|---|---|---|---|---|
| I | < 0.017 | < 0.001 | not felt | none |
| II –III | 0.017 – 0.14 | 0.001 – 0.011 | weak | none |
| IV | 0.14 – 0.38 | 0.011 – 0.034 | light | none |
| V | 0.38 – 0.90 | 0.034 – 0.081 | moderate | very light |
| VI | 0.90 – 1.8 | 0.081 – 0.16 | strong | light |
| VII | 1.8 – 3.3 | 0.16 – 0.31 | very strong | moderate |
| VIII | 3.3 – 6.4 | 0.31 – 0.60 | severe | moderate to heavy |
| IX | 6.4 – 12.2 | 0.60 – 1.16 | violent | heavy |
| X + | > 12.2 | > 1.16 | extreme | very heavy |

**Fig. 8.2**

Peak Ground Acceleration (PGA) is the magnitude of maximum acceleration of the ground during an earthquake.

**1.** Assuming that the ground movements can be modelled as simple harmonic oscillations, show that

$$\text{PGA} = 2\pi f \times v_o$$

where $f$ is its frequency and $v_o$ is its maximum ground velocity.

[2]

**2.** Calculate the frequency and the amplitude of the strongest earthquake causing an instrumental intensity scale of V.

frequency = ........................................ Hz

amplitude = ........................................ m [3]

3. When a building is shaken by an earthquake, it vibrates at the same frequency as the ground vibration. However, the amplitude of the building's oscillation can be much larger than the amplitude of the movements of the ground.

Explain why the building can oscillate with such a large amplitude.

..................................................................................................................................

..................................................................................................................................

..................................................................................................................................

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

(iv) It is suggested that the Peak Ground Acceleration is inversely proportional to the distance $r$ from the epicenter.

Fig. 8.3 gives some data from an earthquake.

| distance $r$ from epicenter/ km | 56 | 84 | 120 | 220 |
|---|---|---|---|---|
| PGA/ m $s^{-2}$ | 1.20 | 0.78 | 0.53 | 0.30 |

**Fig. 8.3**

Use the data in Fig. 8.3 to explain whether the suggested equation is valid.

[3]

**End of paper**

Name: ____________________ Class: ________

# JURONG PIONEER JUNIOR COLLEGE
## JC2 Preliminary Examination 2022

**PHYSICS**
**Higher 2**

**9749/03**
**21 September 2022**

Paper 3 Longer Structured Questions

**2 hours**

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

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index number on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.

**Section A**
Answer **all** questions.

**Section B**
Answer any **one** question only.

You are advised to spend about one and 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** | / 7 |
| **2** | / 8 |
| **3** | / 7 |
| **4** | / 8 |
| **5** | / 8 |
| **6** | / 7 |
| **7** | / 7 |
| **8** | / 8 |
| **9** | / 20 |
| **10** | / 20 |
| **Total** | / 80 |

This document consists of **27** printed pages. **[Turn over**

**Data**

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

**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 | $\varphi = -\frac{GM}{r}$ |
| temperature | $T / \mathrm{K} = T / {}^\circ\mathrm{C} + 273.15$ |
| pressure of an ideal gas | $p = \frac{1}{3}\frac{Nm}{V}\langle c^2 \rangle$ |
| mean translational kinetic energy of an ideal gas molecule | $E = \frac{3}{2}kT$ |
| displacement of particle in s.h.m. | $x = x_0 \sin \omega t$ |
| velocity of particle in s.h.m. | $v = v_0 \cos \omega t$ |
| | $= \pm \omega \sqrt{{x_0}^2 - x^2}$ |
| electric current | $I = Anvq$ |
| resistors in series | $R = R_1 + R_2 + \ldots$ |
| resistors in parallel | $1/R = 1/R_1 + 1/R_2 + \ldots$ |
| electric potential | $V = \frac{Q}{4\pi\varepsilon_0 r}$ |
| alternating current/voltage | $x = x_0 \sin \omega t$ |
| magnetic flux density due to a long straight wire | $B = \frac{\mu_0 I}{2\pi d}$ |
| magnetic flux density due to a flat circular coil | $B = \frac{\mu_0 N I}{2r}$ |
| magnetic flux density due to a long solenoid | $B = \mu_0 n I$ |
| radioactive decay | $x = x_0 \exp(-\lambda t)$ |
| decay constant | $\lambda = \frac{\ln 2}{t_{\frac{1}{2}}}$ |

## Section A

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

1 A student takes measurements to determine the acceleration of free fall. He throws a ball of mass 0.010 kg vertically upwards with a velocity of 25 $m\,s^{-1}$ from ground level.

The variation with time $t$ of the vertical velocity $v$ of the ball is shown in Fig. 1.1.

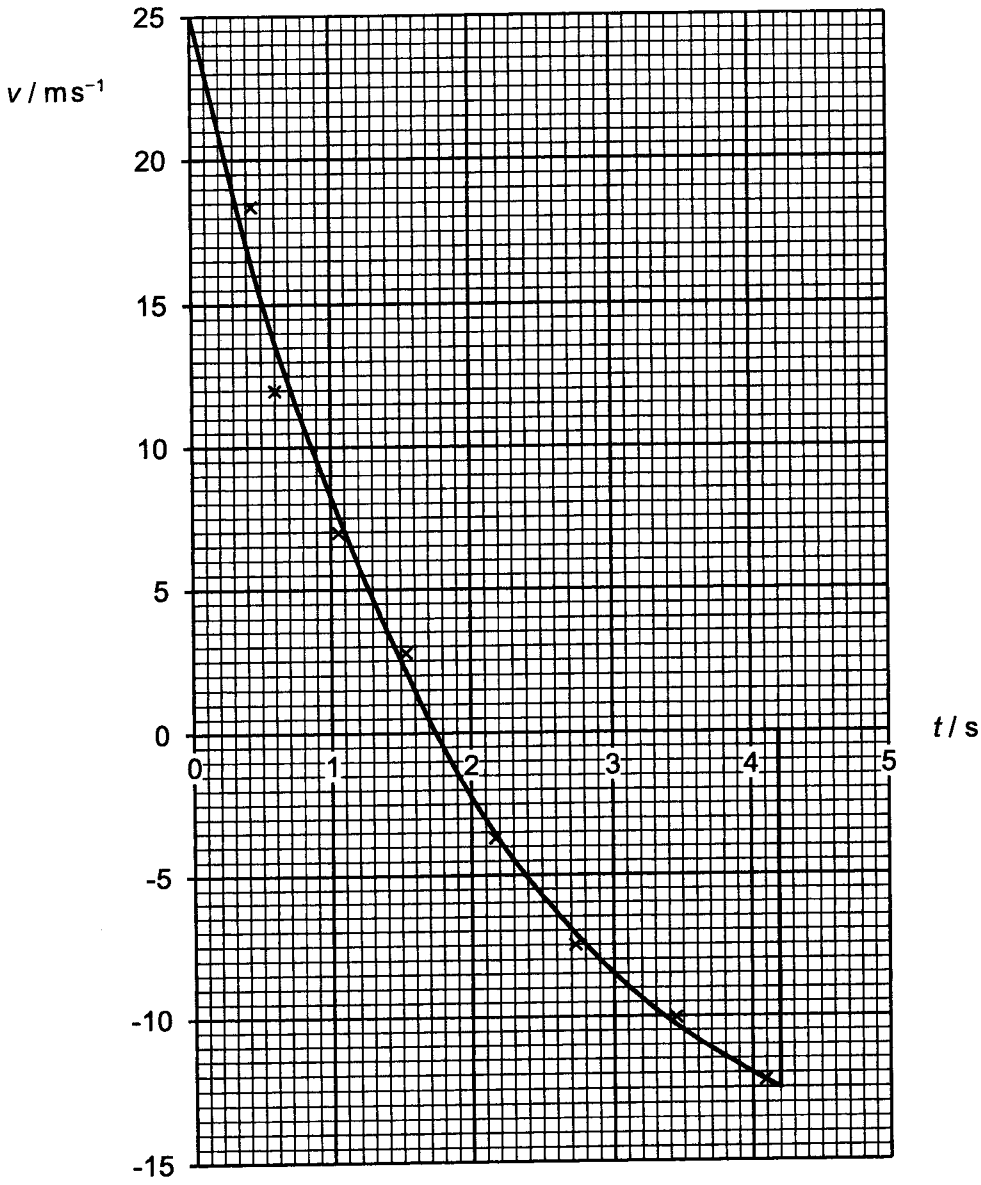



**Fig. 1.1**

**(a)** Using Fig. 1.1, explain

**(i)** how it can be deduced that air resistance is present in this experiment,

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

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

**(ii)** how the magnitude of the acceleration of free fall can be determined.

..........................................................................................................................

..........................................................................................................................

..........................................................................................................................

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

**(b)** Calculate the magnitude of the maximum force due to air resistance on the ball.

Explain your working.

force = ........................................ N [3]

2 Fig. 2.1 shows the variation with displacement $d$ of the force $F$ applied to an object at rest.

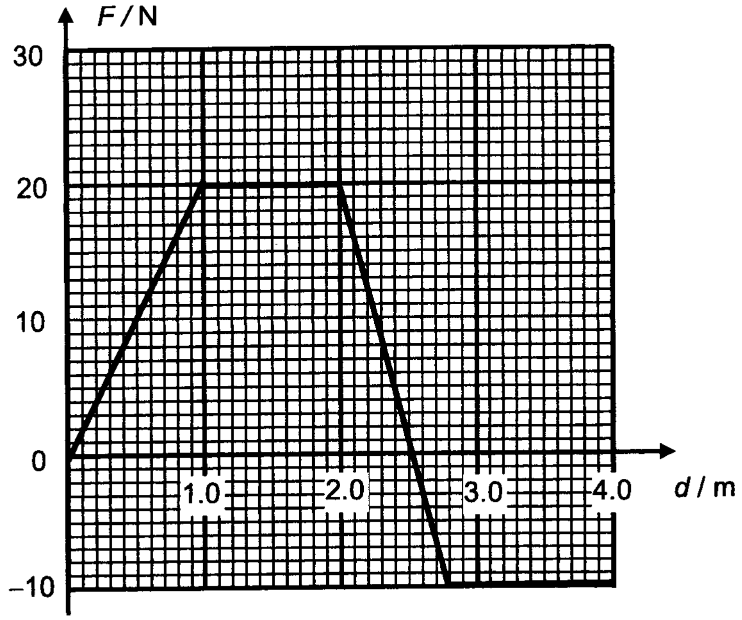



**Fig. 2.1**

**(a)** On Fig. 2.2, draw a graph showing the variation with $d$ of the work done.

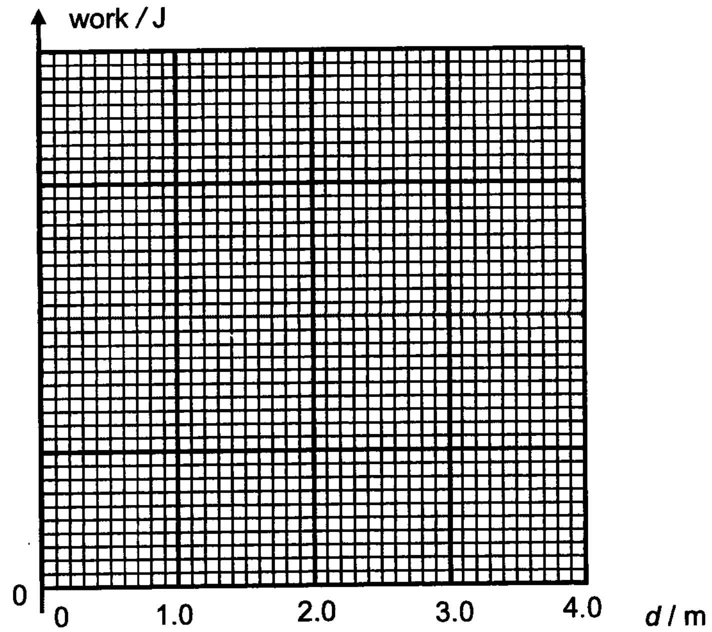



**Fig. 2.2**

[4]

**(b)** Fig. 2.3 shows the object moving from rest up a slope of 30° as a result of the force $F$ applied in Fig. 2.1. A constant frictional force of 3.0 N acts on the object and the object has a mass of 0.50 kg.

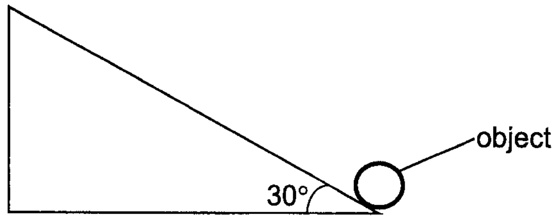



**Fig. 2.3**

For a displacement $d$ of 2.0 m up the slope, determine for the object

**(i)** its gain in gravitational potential energy,

gain = ........................................ J [1]

**(ii)** its final kinetic energy.

kinetic energy = ........................................ J [3]

3 A bob of mass 100 g is tied to a brass weight of mass 400 g using an inelastic string passed through a smooth vertical tube. The bob is made to move in a circular motion in the horizontal plane as shown in Fig. 3.1, such that the part of the string from the top of the tube to the bob is kept at 30 cm long and is at an angle $\theta$ to the vertical.

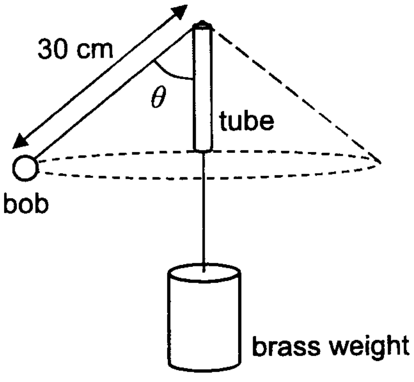



**Fig. 3.1**

**(a)** The bob moves at a constant speed $v$.

Explain why it has an acceleration.

..............................................................................................................................

..............................................................................................................................

..............................................................................................................................

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

**(b)** Calculate $\theta$. Explain your working.

$\theta$ = .......................................... ° [3]

**(c)** Determine *v*.

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

4 (a) Explain what is meant by the *internal energy* of a gas.

..........................................................................................................

..........................................................................................................

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

(b) An ideal gas has a volume of $1.8 \times 10^{-3}$ m$^3$ at a pressure of $3.3 \times 10^5$ Pa and a temperature of 37 °C.

(i) Show that the number of molecules in the gas is $1.4 \times 10^{23}$.

[1]

(ii) The gas expands so that its volume increases to $2.4 \times 10^{-3}$ m$^3$ at a pressure of $2.3 \times 10^5$ Pa and a temperature of 15 °C. The work done by the gas during the expansion is 85 J.

Calculate

1. the change in internal energy of the gas,

change = ........................................ J [2]

2. the thermal energy required by the gas,

energy = ........................................ J [2]

**3.** the ratio

$$\frac{\text{r.m.s. speed of the gas molecules at 15 °C}}{\text{r.m.s. speed of the gas molecules at 37 °C}}.$$

ratio = ........................................ [2]

5 **(a)** Explain what is meant by a progressive transverse wave.

progressive ..........................................................................................................

..........................................................................................................

transverse ..........................................................................................................

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

**(b)** A 30 W light bulb, connected to a power source, emits light radially in all directions.

**(i)** Determine the intensity of the light of the bulb at a point 3.0 m away.

intensity = ........................................ W m$^{-2}$ [2]

**(ii)** Determine the ratio

$$\frac{\text{amplitude of light at a point 2.0 m away}}{\text{amplitude of light at a point 3.0 m away}}.$$

ratio = ........................................ [2]

**(iii)** A similar bulb is used in a torchlight, where there is a concave mirror placed around the bulb.

Explain how the intensity of the light from the torchlight at 3.0 m away differs from your answer in **(b)(i)**.

..........................................................................................................

..........................................................................................................

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

6 Fig. 6.1 shows three equally spaced equipotential lines between two charged parallel plates. The plates are 0.12 m apart and has a potential difference of 50 V across them.

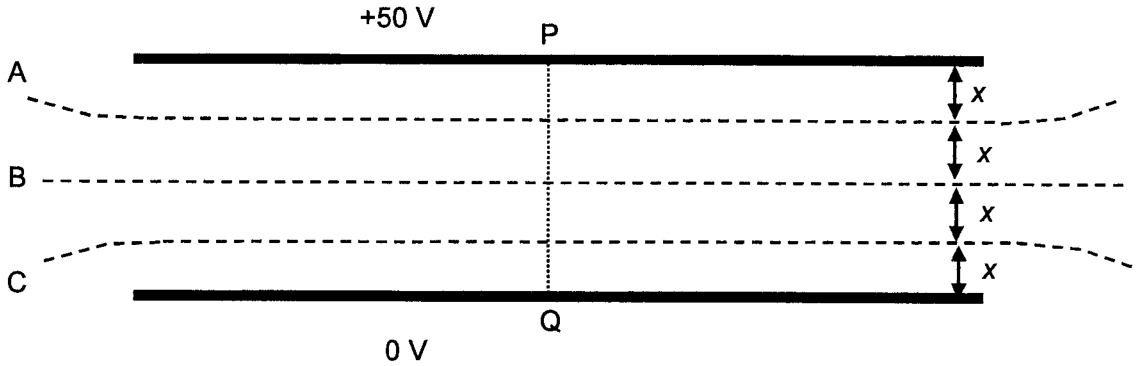



**Fig. 6.1**

**(a)** On Fig. 6.1, draw six lines to show the electric field between the plates. [1]

**(b)** On Fig. 6.2, sketch the variation of the electric potential $V$ with $x$ where $x$ is the distance from P along the line PQ. Label clearly the values for the electric potential corresponding to the lines A, B and C.

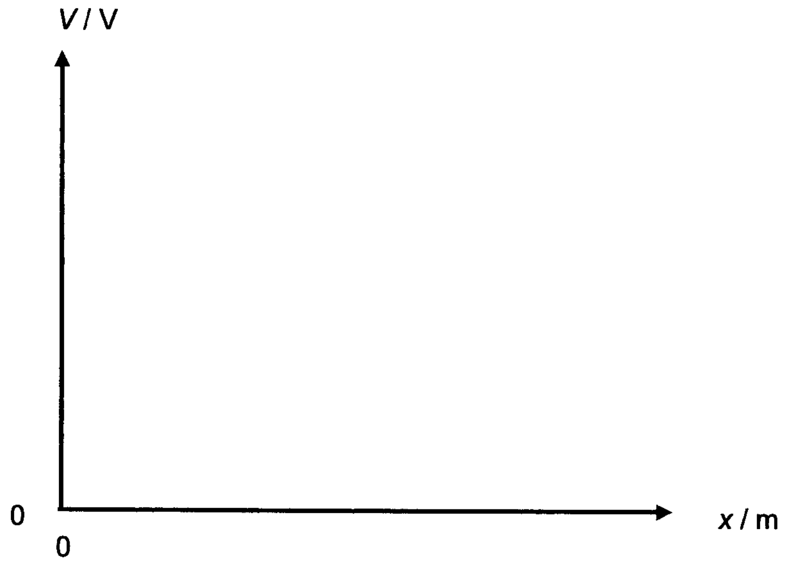



**Fig. 6.2**

[2]

**(c)** A proton is placed at a point along the equipotential line A.

Determine the electric force acting on it.

force = ........................................ N [2]

**(d)** The proton is now projected vertically downwards with initial velocity of $2\times10^{4}$ m s$^{-1}$ towards the lower plate.

Determine the speed at which the proton will hit the lower plate.

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

7 A piece of wire X and a negative temperature coefficient (NTC) thermistor are connected in series with a 9.0 V battery, as shown in Fig. 7.1.

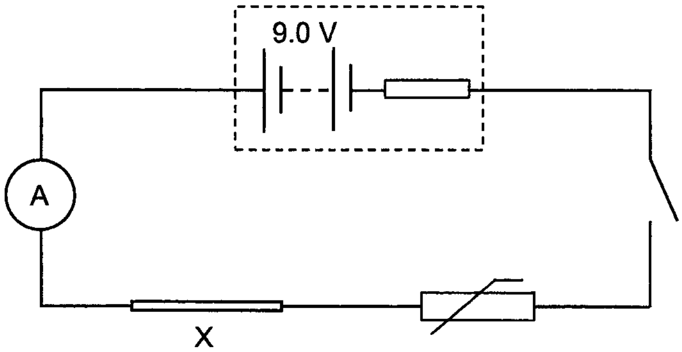



**Fig. 7.1**

**(a)** When the switch is closed, the reading on the ammeter is 0.52 A.

**(i)** Show that electrons are passing through any point in the circuit at a rate of $3.3 \times 10^{18}\ s^{-1}$.

[1]

**(ii)** Wire X has a diameter of 0.36 mm, and has a charge carrier number density of $5.9 \times 10^{28}\ m^{-3}$.

Calculate the drift velocity of electrons in wire X.

drift velocity = ........................................ $m\ s^{-1}$ [2]

(iii) When the switch is closed, the current in the circuit flows almost immediately.

Explain this in the context of your answer to **(ii)**.

..........................................................................................................................

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

**(b)** The $I$-$V$ characteristics of wire X and the NTC thermistor are shown in Fig. 7.2.

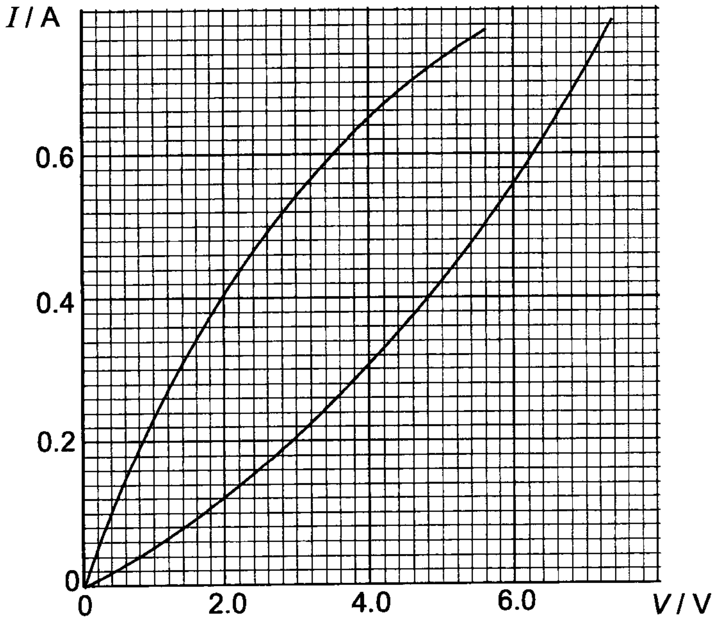


**Fig. 7.2**

Calculate the internal resistance of the battery.

internal resistance = ........................................ Ω [2]

8 **(a)** In a nuclear reaction, a uranium-235 $\left({}^{235}_{92}\text{U}\right)$ nuclide is transformed into an unstable uranium-236 nuclide $\left({}^{236}_{92}\text{U}\right)$ through bombardment by a slow-moving neutron. The unstable uranium-236 nuclide undergoes nuclear fission to form stable products of a lanthanum-139 nuclide $\left({}^{139}_{57}\text{La}\right)$ and a nuclide of bromine $\left({}^{A}_{Z}\text{Br}\right)$.

$$ {}^{235}_{92}\text{U} + {}^{1}_{0}\text{n} \rightarrow {}^{236}_{92}\text{U} \rightarrow {}^{139}_{57}\text{La} + {}^{A}_{Z}\text{Br} + 3\,{}^{1}_{0}\text{n} + \gamma $$

Data for the nuclei in the reaction are given in Fig. 8.1.

| nucleus | mass / $u$ |
|---|---|
| proton ${}^{1}_{1}\text{p}$ | 1.00728 |
| neutron ${}^{1}_{0}\text{n}$ | 1.00866 |
| lanthanum ${}^{139}_{57}\text{La}$ | 138.906 |
| Uranium ${}^{235}_{92}\text{U}$ | 235.044 |

**Fig. 8.1**

**(i)** Determine the nucleon number $A$ and proton number $Z$ of the bromine nuclide.

$A$ = ........................................

$Z$ = ........................................ [1]

**(ii)** Calculate the binding energy of the uranium-235 nuclide to 4 significant figures.

binding energy = ........................................ MeV [3]

(iii) State the feature of this equation that indicates a chain reaction may be possible.

..........................................................................................................

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

**(b)** In a laboratory source of strontium-90, the number of atoms present in the year 2013 was $2.36 \times 10^{13}$. Strontium-90 decays by emission of a β-particle and this nuclide has a half-life of 28 years.

**(i)** State what is a β-particle.

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

**(ii)** Calculate the activity of the source in the year 2113.

activity = ........................................ Bq [2]

## Section B

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

**9** **(a)** Define *simple harmonic motion.*

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

**(b)** A flat horizontal plate is made to vibrate in a vertical plane as shown in Fig. 9.1

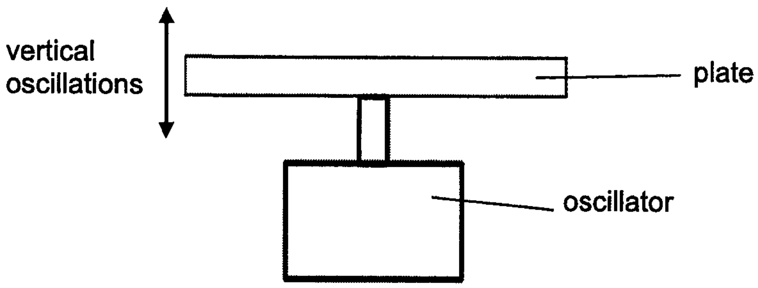


**Fig. 9.1**

Some sand is sprinkled onto the plate and the variation with displacement $x$ of the acceleration $a$ of the plate is shown in Fig. 9.2. Upward displacement of the plate is taken to be positive. At time $t$ = 0, the plate is at equilibrium position and it is moving upwards.

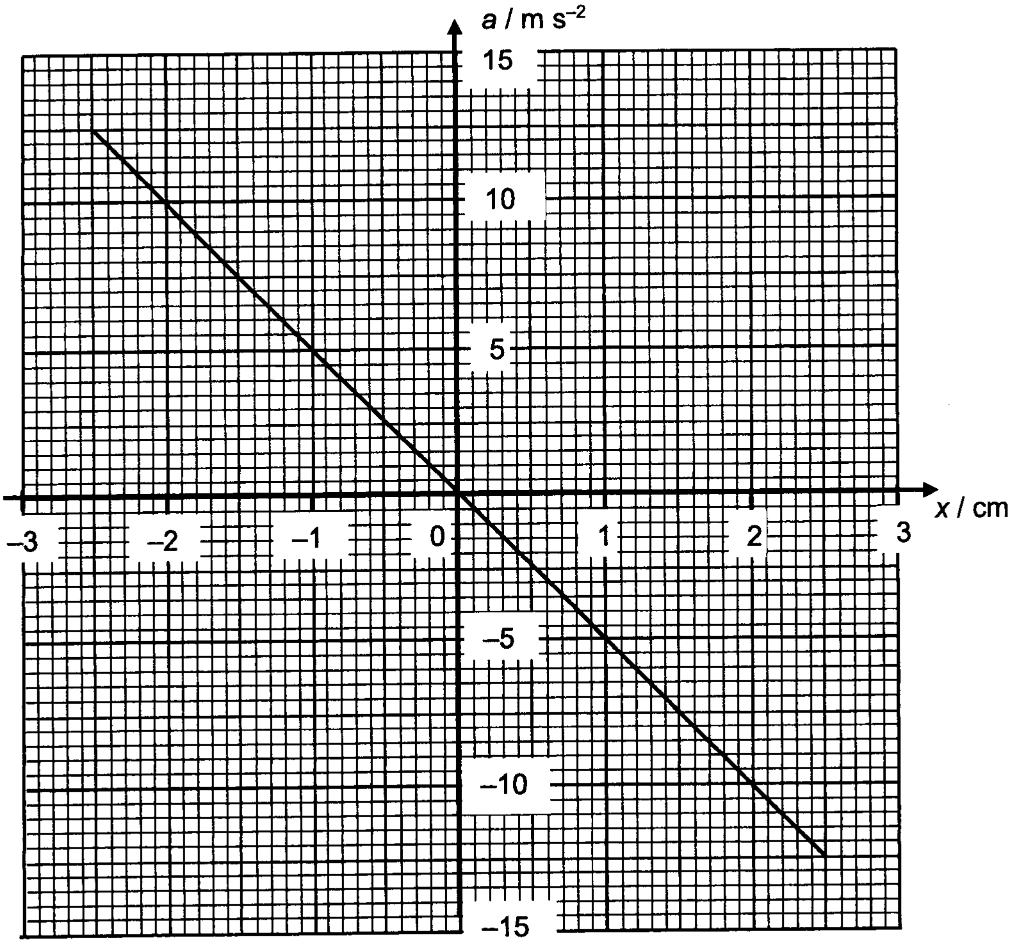


**Fig. 9.2**

**(i)** State the acceleration of the plate at which the sand first loses contact with the plate. Explain your reasoning.

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

**(ii)** Assume the mass of each sand particle is $1.2 \times 10^{-5}$ kg.

Using appropriate values from Fig. 9.2, calculate the

**1.** frequency of vibration of the oscillation plate,

frequency = ........................................ Hz [3]

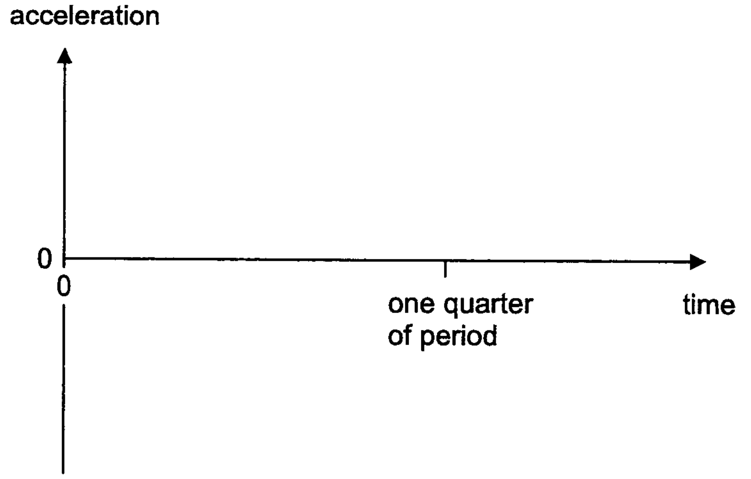
**2.** kinetic energy of one sand particle at $x = -1.0$ cm,

kinetic energy = ........................................ J [2]

**3.** time when sand particle first loses contact with plate.

time = ........................................ s [2]

**(iii)** On Fig. 9.3, sketch a graph to show the variation with time of the acceleration of one sand particle for a duration of one quarter of the period of the vibrating plate. Numerical values are not required.




[2]

**Fig. 9.3**

(c) The bob of a simple pendulum undergoes simple harmonic motion as illustrated in Fig. 9.4.

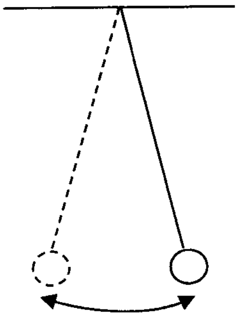


**Fig. 9.4**

A block of wood, floating in water, undergoes vertical oscillations, as illustrated in Fig. 9.5.

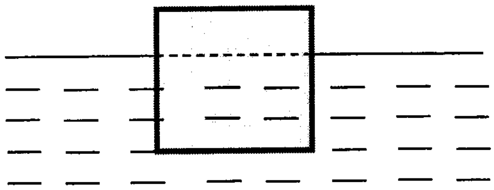


**Fig. 9.5**

(i) For each system, describe the restoring force that gives rise to the oscillations.

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.......................................................................................................... [4]

(ii) For the system in Fig. 9.5, an oscillator is placed in the water and created a wave of variable frequency. At one particular frequency, the block oscillates with a large amplitude.

State the phenomenon as illustrated above and a condition in order for the phenomenon to occur.

..........................................................................................................

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

**10 (a)** A stiff metal wire is used to form a rectangular frame PQRS measuring 8.7 cm by 7.2 cm. The frame is open at the top, and is suspended from a sensitive newton meter as shown in Fig. 10.1.

XY is a vertical axis passing through the newton meter and frame PQRS.

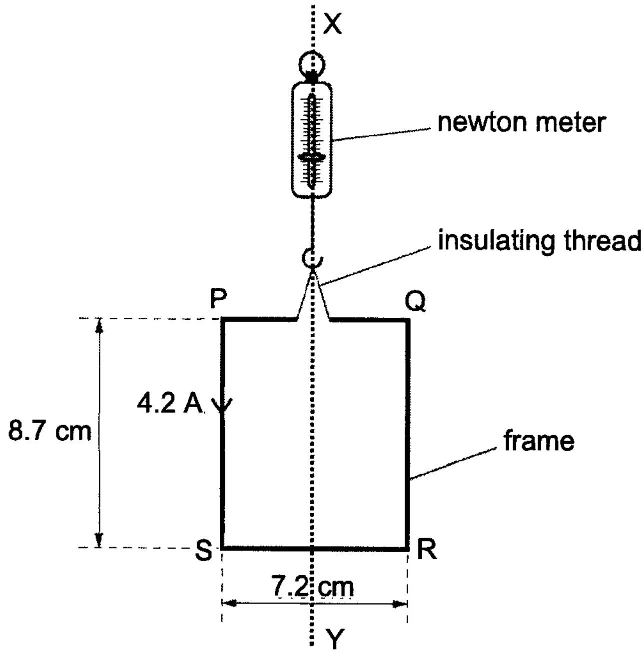


**Fig. 10.1**

The open ends of the frame are connected to a power supply so that there is a current of 4.2 A in the frame in the direction indicated in Fig. 10.1.

The frame is slowly lowered into a uniform magnetic field of flux density *B* so that side SR is in the field. The magnetic field lines are horizontal and at an angle of 53° to the frame as shown in Fig. 10.2.

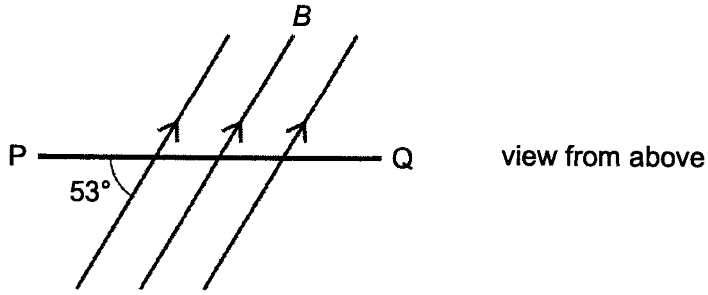


**Fig. 10.2**

When side SR of the frame first enters the magnetic field, the reading on the newton meter changes by 6.0 mN.

**(i)** Calculate *B*.

$B$ = ........................................ T [2]

**(ii)** State and explain whether the change in the reading on the newton meter is an increase or a decrease.

..........................................................................................................................

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

**(iii)** The frame is lowered further so that the vertical sides start to enter the magnetic field.

**1.** On Fig. 10.2, draw arrows to show the direction of the forces acting on sides PS and QR. [2]

**2.** The frame is rotated through 90° about the XY axis.

Calculate the magnitude of the torque exerted on the frame in the new orientation when the whole frame is in the magnetic field.

torque = ........................................ N m [3]

**3.** Suggest what effect the forces will have on the frame eventually.

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

**(b)** A small solenoid of cross-sectional area $1.4 \times 10^{-3}$ m$^2$ is placed inside a larger solenoid of cross-sectional area $4.2 \times 10^{-3}$ m$^2$ as shown in Fig. 10.3.

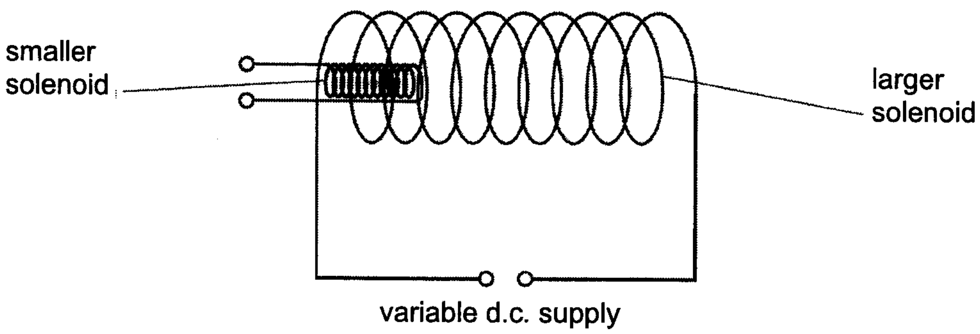


**Fig. 10.3**

The larger solenoid has 40 turns and is attached to a variable d.c. power supply. The smaller solenoid has 320 turns.

**(i)** Compare quantitatively the magnetic flux linkage in the two solenoids.

..........................................................................................................................

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

**(ii)** The variation with time $t$ of the magnetic flux density $B$ of the larger solenoid is shown in Fig. 10.4.

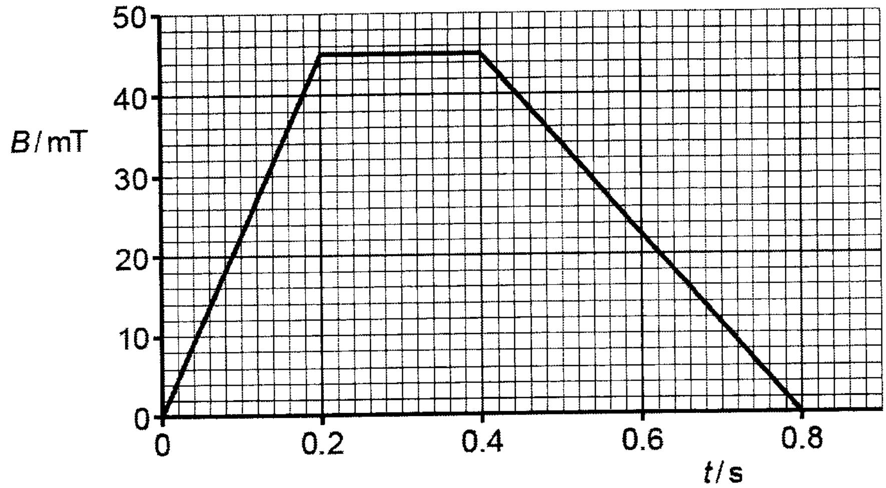


**Fig. 10.4**

**1.** Calculate the magnitude of the e.m.f. induced in the smaller solenoid from $t = 0$ to $t = 0.20$ s.

e.m.f. = ........................................ V [2]

**2.** On Fig. 10.5, sketch a graph to show the variation with time $t$ of the e.m.f. induced $E$ in the smaller solenoid for $t = 0$ to $t = 0.80$ s.

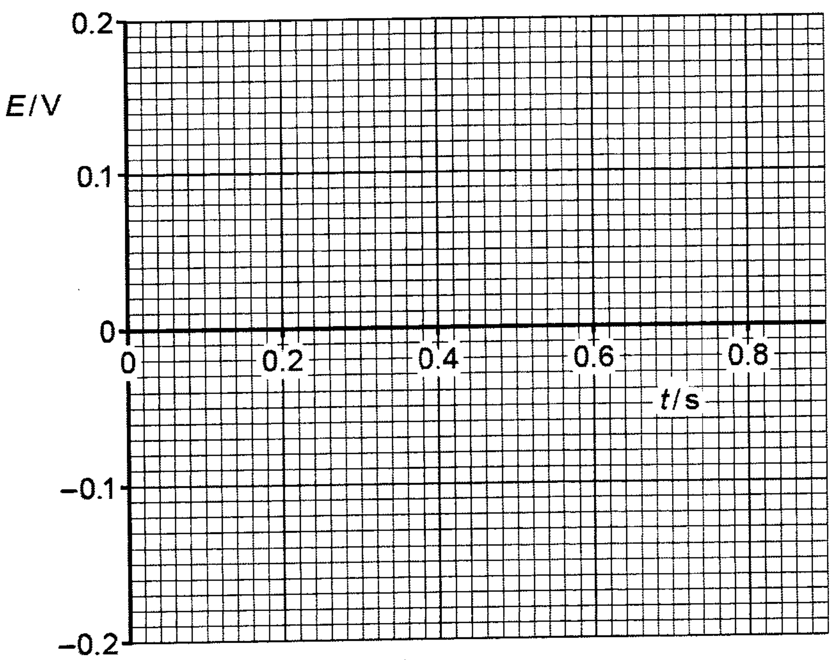


**Fig. 10.5** [3]

**(iii)** The flux density $B$ is now kept constant. The terminals of the smaller solenoid are connected together. The smaller solenoid is then removed from inside the larger solenoid.

Using laws of electromagnetic induction, explain why a force is needed to remove the smaller solenoid.

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

**End of paper**

| Name | Class | Index Number |
|---|---|---|
| | | |

**JURONG PIONEER JUNIOR COLLEGE**
**JC2 Preliminary Examination**

**PHYSICS** **9749/04**
**Higher 2**

Paper 4 Practical

18 August 2022

**2 hours 30 minutes**

**READ THESE INSTRUCTIONS FIRST**

Write your name, class and index 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, graphs or rough working.
Do not use staples, paper clips, glue or correction fluid.

Answer **all** questions.

You will be allowed a maximum of one hour to work with the apparatus for Questions 1 and 2, and a maximum of one hour for Question 3. You are advised to spend approximately 30 minutes on Question 4.

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.

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.

| Shift |
|---|
| |
| **Laboratory** |
| |

| For Examiner's Use | |
|---|---|
| 1 | / 17 |
| 2 | / 5 |
| 3 | / 21 |
| 4 | / 12 |
| Total | / 55 |

This document consists of **18** printed pages.

1 In this experiment, you will investigate an electrical circuit.

**(a) (i)** You have been provided with a length of constantan wire attached to a metre rule, and a resistor Y of unknown resistance.

Connect the circuit as shown in Fig. 1.1.

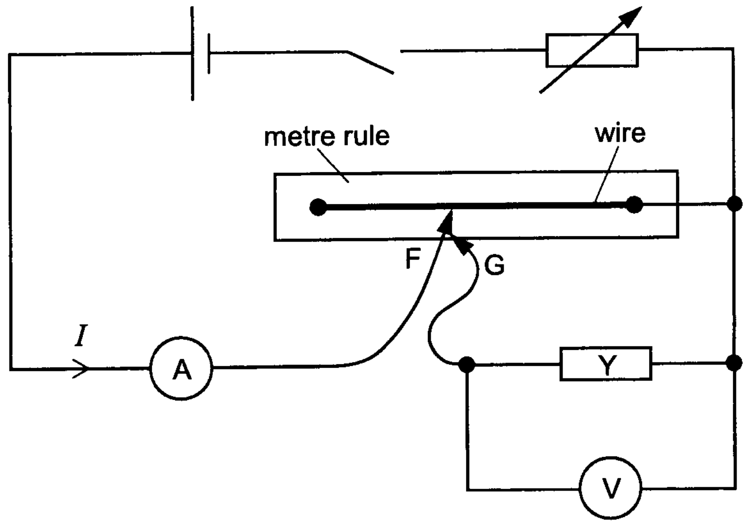


**Fig. 1.1**

F and G are crocodile clips.

**(ii)** Connect F to a point half-way along the wire. Connect G to F.

**(iii)** Place the slider of the rheostat at its mid-point.

**(iv)** Close the switch and record the voltmeter reading $V_0$ to the nearest 0.01 V.

$V_0$ = ....................................... [1]

**(v) 1.** Adjust the slider of the rheostat until the voltmeter reading just changes to $(V_0 + 0.01)$ V.

Record the ammeter reading.

ammeter reading = .......................................

**2.** Adjust the slider of the rheostat until the voltmeter reading just changes to $(V_0 - 0.01)$ V.

Record the ammeter reading.

ammeter reading = .......................................
[1]

**(vi)** Open the switch.

**(b)** The distance $x$ between the end of the wire and F is shown in Fig. 1.2.

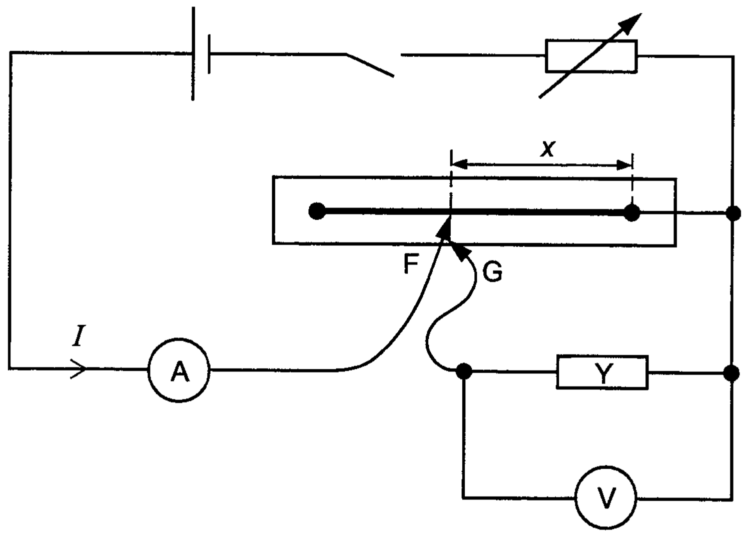


**Fig. 1.2**

**(i)** Move F so that $x$ is approximately 30 cm.

**(ii)** Close the switch and adjust the slider of the rheostat until the voltmeter reading is equal to $V_0$.

**(iii)** Record $x$ and the ammeter reading $I$.

$x$ = ......................................

$I$ = ...................................... [1]

**(iv)** Open the switch.

**(c)** Vary $x$ and repeat **(b)(ii)**, **(b)(iii)** and **(b)(iv)** keeping the voltmeter reading equal to $V_0$ throughout.

[5]

**(d)** $I$ and $x$ are related by the expression

$$I = \frac{P}{x} + Q$$

where $P$ and $Q$ are constants.

Plot a suitable graph to determine the values of $P$ and $Q$.

$P$ = ......................................

$Q$ = ......................................
[6]

**(e)** Theory suggests that

$$\frac{P}{Q} = L$$

where $L$ is the length of wire that has the same resistance as resistor Y.

Calculate $L$.

$L$ = ........................................ [1]

**(f)** **(i)** Remove Y from the circuit and replace it with a wire of length $L$ from the wire wound on the card. **Do not cut the wire.**

**(ii)** Connect F to a point half-way along the wire on the metre rule.

Repeat **(b)(ii)**, **(b)(iii)** and **(b)(iv)**.

$x$ = ........................................

$I$ = ........................................

**(iii)** Use your values in **(f)(ii)** to plot another point on your graph.

Label this point Z.

**(iv)** State whether this point agrees with the pattern of the other points on your graph.

Use your values in **(a)(v)** to justify your statement.

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

**[Total: 17]**

2 In this experiment, you will determine the spring constant of a spring.

(a) You have been provided with three identical springs, attached to a ring.

The length of an unstretched spring is $S$, as shown in Fig. 2.1.

Without disconnecting the springs, measure and record $S$ for **one** of the springs.

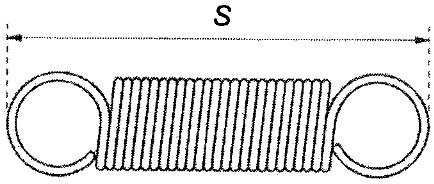


**Fig. 2.1**

$S$ = ........................................

**(b) (i)** Set up the apparatus as shown in Fig. 2.2.

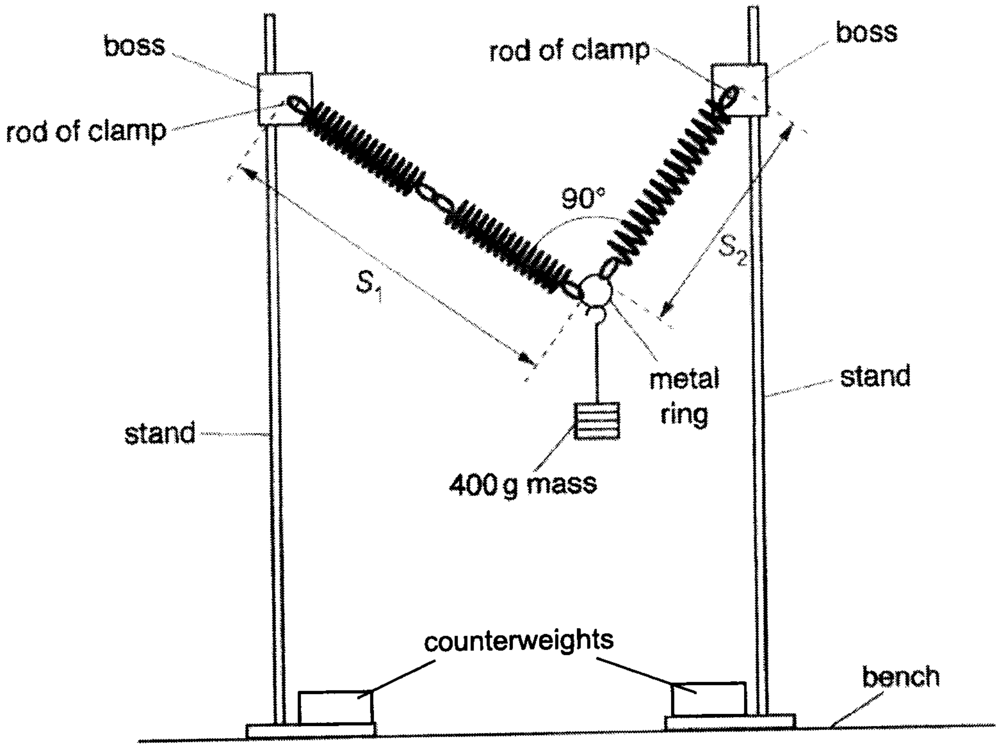


**Fig. 2.2**

Adjust the apparatus so that the angle between the springs is 90°.

The extended length of the double spring is $S_1$ and the extended length of the single spring is $S_2$.

Measure and record $S_1$ and $S_2$.

$S_1$ = ........................................

$S_2$ = ........................................ [1]

**(ii)** The extensions are $p$ and $q$ where

$$p = S_1 - 2S \text{ and } q = S_2 - S.$$

Calculate $p$ and $q$.

$p$ = ........................................

$q$ = ........................................ [1]

**(c)** Theory suggests that

$$m^2g^2 = \frac{k^2p^2}{4} + k^2q^2$$

where $m$ = 400 g, $k$ is the spring constant of one of the springs and $g$ = 9.81 m s$^{-2}$.

**(i)** Calculate $k$.

$k$ = ...................................... N m$^{-1}$ [1]

**(ii)** If you were to repeat this experiment with other masses, describe the graph that you would plot to determine $k$.

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

**[Total: 5]**

3 A ride in a playground consists of a plank of wood supported by two loops of ropes.

In this experiment, you will investigate a model of this ride.

You have been provided with two sets of string loops and two half-metre rules.

**(a) (i)** Use the shorter loops of string to set up the apparatus as shown in Fig. 3.1.

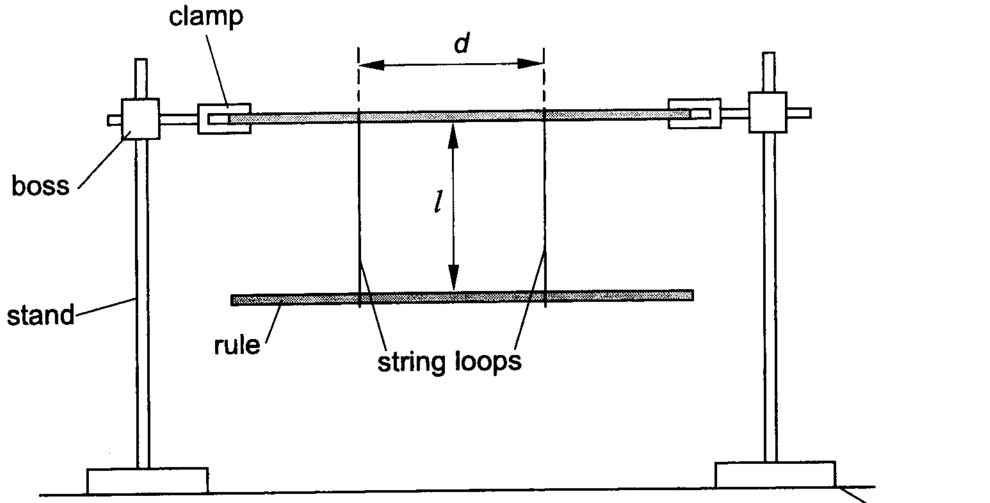


**Fig. 3.1**

Adjust the heights of the bosses until the top rule is parallel to the bench and both rules have their scales facing upwards.

The distance between the string loops is $d$.

Adjust the position of the string loops until $d$ is approximately 40 cm.

The string loops should be vertical and the same distance from the centre of the bottom rule.

Measure and record $d$.

$d$ = ...................................... [1]

**(ii)** Estimate the percentage uncertainty in your value of $d$.

percentage uncertainty in $d$ = ...................................... [1]

**(iii)** The distance between the bottom face of the top rule and the top face of the bottom rule is *l*, as shown in Fig. 3.1.

Measure and record *l*.

*l* = ........................................ [1]

**(iv)** Estimate the percentage uncertainty in your value of *l*.

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

**(b)** Move one end of the bottom rule towards you. Move the other end of the rule away from you. Release the rule. The rule will oscillate about a vertical axis.

Determine the period *T* of these oscillations.

*T* = ........................................ [1]

**(c)** Set up the apparatus using the larger loops of string and a smaller value of *d*. Repeat **(a)(i)**, **(a)(iii)** and **(b)**.

*d* = ........................................

*l* = ........................................

*T* = ........................................

[2]

(d) It is suggested that

$$T^2 = \frac{kl}{d^2}$$

where $k$ is a constant.

(i) Use your values in **(a)(i)**, **(a)(iii)**, **(b)** and **(c)** to determine two values of $k$.

first value of $k$ = ........................................

second value of $k$ = ........................................

[2]

(ii) State whether or not the results of your experiment support the suggested relationship. Justify your conclusion by referring to your values in **(a)(ii)** and **(a)(iv)**.

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

**(e)** Using the **larger** loop of string, add two 50 g masses to the bottom rule, as shown in Fig. 3.2. Each mass represents a child on the ride.

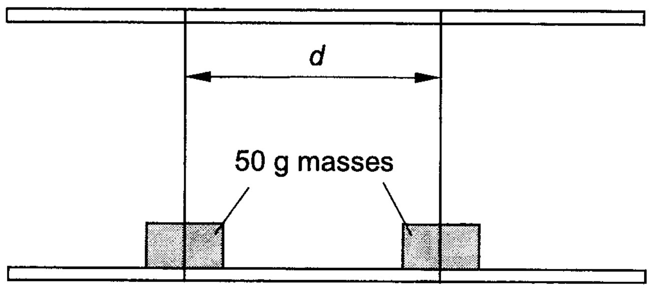


**Fig. 3.2**

Vary $d$ and find values of $T$ with and without the masses in place.

Present your results clearly.

Use your results to estimate a value for $d$ where the value of $T$ is the same with and without the masses.

$d$ = ....................................... [3]

(f) You have been provided with some other masses. Use these masses to determine the effect on $T$ of one or more children sitting at the **centre** of the ride while a child is seated at each string.

Present your results and conclusion clearly.

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..........................................................................................................................................

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

**(g)** The behaviour of the oscillating system depends on the length of the bottom plank.

It is suggested that the period *T* is directly proportional to the length *L* of the plank.

Explain how you would investigate this relationship.

Your account should include:

- your experimental procedure
- control of variables
- how you would use your results to show direct proportionality
- why you might have difficulties using planks of very small lengths and very large lengths.

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.................................................................................................................. [5]

[Total: 21]

4 Some of the radiation from a radioactive source will be absorbed as it passes through a material.

The amount of radiation absorbed will depend on the density $\rho$ and the thickness $t$ of the material.

The count rate $C$ detected from a source after absorption is given by the equation

$$C = k\rho^n t^m$$

where $k$, $n$ and $m$ are constants.

Design an experiment to determine the values of $n$ and $m$.

Assume that you have sheets of different materials. For each material there would be sheets of different thicknesses.

Draw a diagram to show the arrangement of your apparatus. You should pay particular attention to

**(a)** the equipment you would use
**(b)** the procedure to be followed
**(c)** how the density and thickness of the materials are measured
**(d)** the control of variables
**(e)** any precautions that should be taken to improve the accuracy and safety of the experiment.

**Diagram**

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[Total: 12]

**End of paper**