| NAME: | CLASS: | INDEX NO: |
|---|---|---|

# QUEENSWAY SECONDARY SCHOOL

## PRELIMINARY EXAMINATION 2022

## SECONDARY 4 EXPRESS

Parent's Signature:

**PHYSICS** **6091/01**

Paper 1 Multiple Choice **15 September 2022**

**1 hour**

Additional Materials: Multiple Choice Answer Sheet

**READ THESE INSTRUCTIONS FIRST**

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

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

**Read the instructions on the Answer Sheet very carefully.**

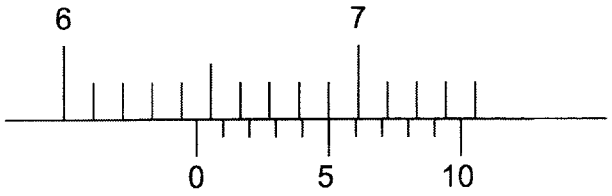
Each correct answer will score one mark. A mark will not be deducted for a wrong answer.
Any rough working should be done in this booklet.
The use of an approved scientific calculator is expected, where appropriate.

This document consists of **20** printed pages.

Setters: Mrs Pang FH, Ms Tan YN

**[Turn over**

1 The diagram shows a vernier calipers scale.




Which reading is shown?

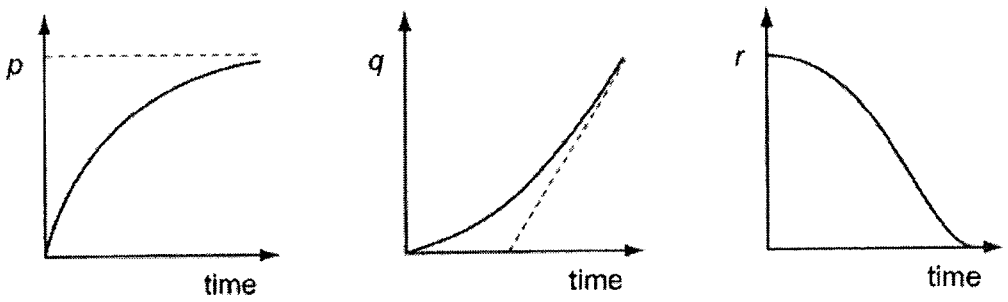
**A** 6.40 cm
**B** 6.45 cm
**C** 6.50 cm
**D** 7.35 cm

2 A motorcyclist accelerates from rest at 2.0 m $s^{-2}$ along a level road until he reaches and maintains a steady speed of 40 m $s^{-1}$.

How much time will elapse before the motorcyclist covers a distance of 1.0 km from his starting point?

**A** 20 s
**B** 25 s
**C** 35 s
**D** 50 s

3 A stone is released from rest at a great height in air and falls vertically. Each of the three graphs represents the variation with time of one of the three variables *p*, *q* or *r*.

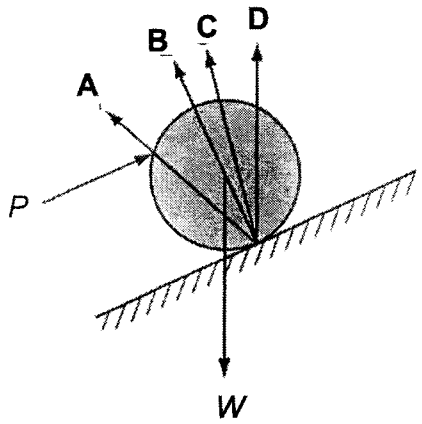



Which row correctly identifies the three variables *p*, *q* and *r*?

| | *p* | *q* | *r* |
|---|---|---|---|
| **A** | velocity | displacement | acceleration |
| **B** | velocity | acceleration | displacement |
| **C** | displacement | velocity | acceleration |
| **D** | acceleration | displacement | velocity |

4 A force $P$ is required to hold a barrel of weight $W$ at rest on a ramp. Friction between the barrel and the ramp stops the barrel from slipping.

Which arrow represents the resultant force the ramp exerts on the barrel?

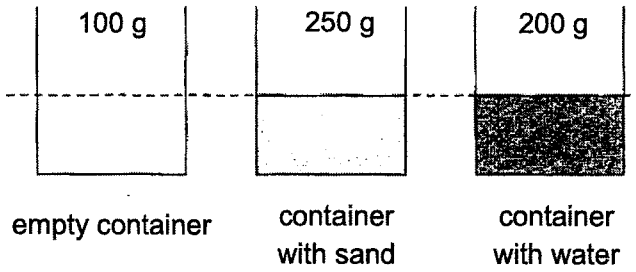



5 When a block of wood of mass 1 kg is pushed with a force of 5 N along the horizontal flat surface of a bench, the block moves with a constant speed of 2 m $s^{-1}$.

When the block is pushed along the same bench with a force of 10 N, it moves with a constant

**A** speed of 4 m $s^{-1}$.
**B** speed of 5 m $s^{-1}$.
**C** acceleration of 4 m $s^{-2}$.
**D** acceleration of 5 m $s^{-2}$.

6 The diagrams show three containers. One container is empty and the other two contain sand and water respectively. The density of water is known to be 1.0 g $cm^{-3}$.




What is the density of the sand?

**A** 1.25 g $cm^{-3}$
**B** 1.50 g $cm^{-3}$
**C** 2.00 g $cm^{-3}$
**D** 2.40 g $cm^{-3}$

7 The weights of two objects measured on two different planets are listed below.

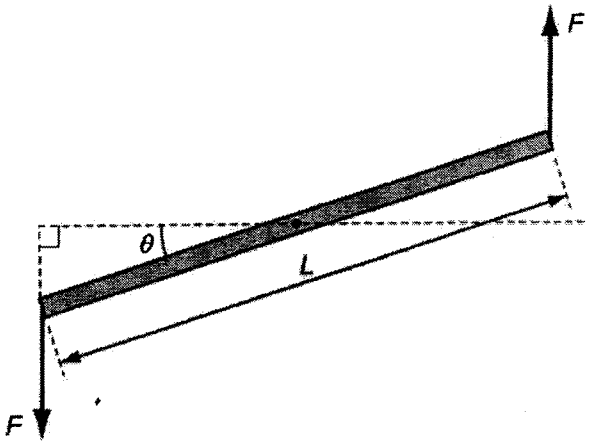
Weight of object M on Mercury = 2000 N
Weight of object J on Jupiter = 6000 N

The gravitational field strength of Mercury and Jupiter are 3.8 N $kg^{-1}$ and 25.4 N $kg^{-1}$ respectively.

Which of the following statements describing the mass and/or weight of the objects is correct?

**A** Object M has a smaller mass than object J because object M has a smaller weight than object J.
**B** Object M has a smaller mass than object J because the gravitational field strength of Mercury is smaller than that of Jupiter.
**C** Object M has a smaller weight than object J because the gravitational field strength of Mercury is smaller than that of Jupiter.
**D** Object M has a mass one-third of the mass of object J because the weight of object M is one-third of the weight of object J.

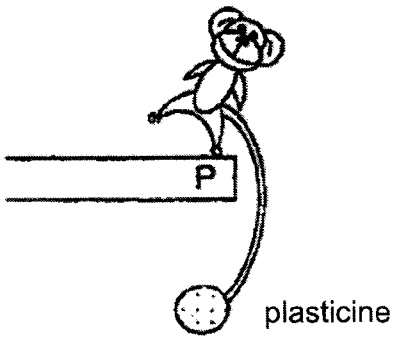
8 The diagram shows two equal and opposite forces applied to the ends of a pivoted bar of length *L*.




What is the magnitude of the moment exerted by these forces on the bar?

**A** $FL$
**B** $FL\sin\theta$
**C** $FL\cos\theta$
**D** $2FL\cos\theta$

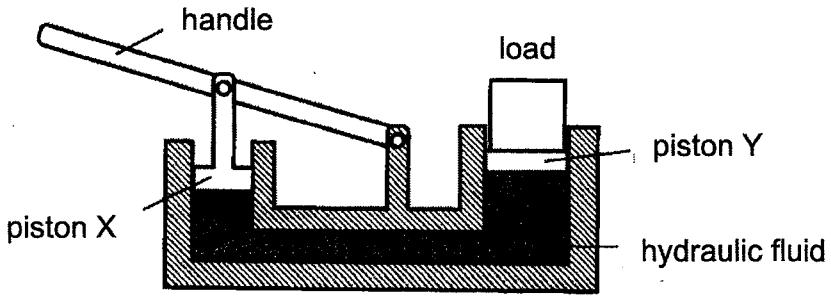
9 The diagram shows a toy monkey with a lump of plasticine placed at the end of its tail. When displaced about point P, it oscillates and eventually comes to rest at this same position.




How does the plasticine help the toy in maintaining its state of equilibrium?

**A** It increases the weight of the toy.
**B** It moves the centre of gravity to be directly above P.
**C** It moves the centre of gravity to be directly below P.
**D** It moves the centre of gravity to be exactly at P.

10 The diagram shows a simple hydraulic jack.

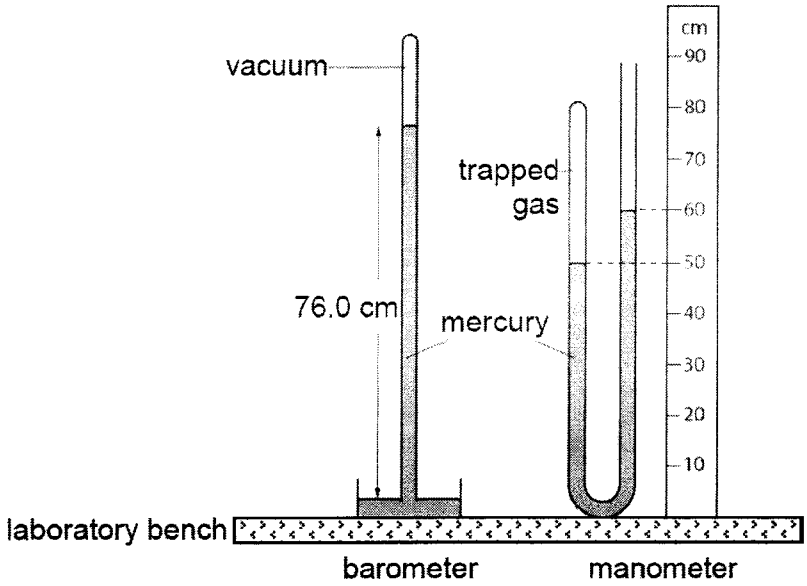



The base areas of both pistons X and Y in contact with the hydraulic fluid are circular in shape.

Which of the following changes should be made in order for heavier loads to be lifted?

| | radius of piston X | radius of piston Y |
|---|---|---|
| **A** | halved | doubled |
| **B** | doubled | halved |
| **C** | doubled | remains the same |
| **D** | remains the same | halved |

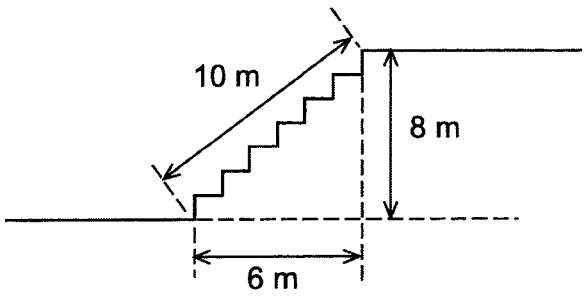
**11** A mercury barometer and a mercury manometer are placed side by side on a laboratory bench.




What is the pressure of the trapped gas?

**A** 10 cm Hg
**B** 50 cm Hg
**C** 66 cm Hg
**D** 86 cm Hg

**12** A boy weighing 800 N runs up a flight of stairs.

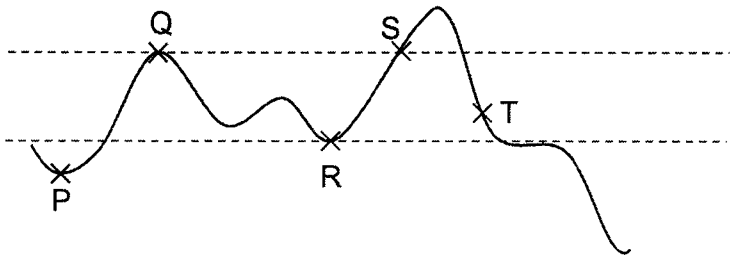



How long does he take to run up the flight of stairs with an average power of 400 W?

**A** 12 s
**B** 16 s
**C** 20 s
**D** 32 s

13 A marble is allowed to roll along an undulating plane from left to right. It is in motion at P and at rest at Q.

Neglect air resistance and assume the plane is smooth.




Which of the following statement(s) is/are correct?

I The marble has zero gravitational potential energy at P.
II The speed of the marble at R is less than that at P.
III The marble will only roll up to S and return.

**A** I only
**B** I and II only
**C** II and III only
**D** I, II and III

14 In a Brownian motion experiment involving smoke particles in air, larger smoke particles are seen to be less agitated in their motion as compared to the smaller smoke particles.

Which statement(s) explain(s) the motion of the larger smoke particles?

I The larger smoke particles have greater weight than the smaller smoke particles.
II The larger smoke particles have greater density than the air molecules.
III There is less bombardment by air molecules on the larger smoke particles.

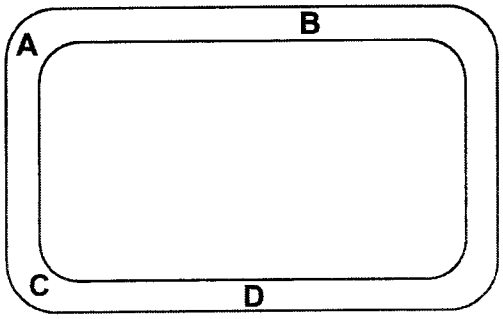
**A** I only
**B** III only
**C** I, II and III
**D** None of the statements

15 A fixed mass of gas is cooled down while its pressure is kept constant.

How do the properties of the molecules of the gas change?

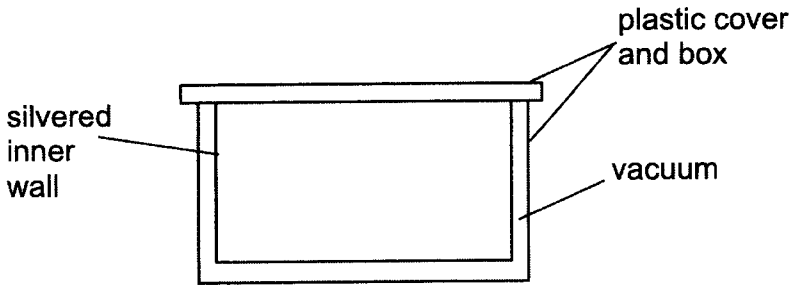
| | average speed | frequency of collisions with walls | average distance apart |
|---|---|---|---|
| **A** | decreases | decreases | decreases |
| **B** | decreases | increases | decreases |
| **C** | decreases | increases | unchanged |
| **D** | unchanged | decreases | increases |

16 A heating element is to be positioned in a narrow sealed tube of liquid.




Which would be the best position, **A**, **B**, **C** or **D**, to place the heating element in order to obtain the best circulation of the liquid throughout the tube?

17 The diagram shows the cross-section of a plastic container that a manufacturing company has created.




The company claims that the container can keep food warm or cold for a duration that surpasses other brands of containers. It offers the following explanations to justify its claims.

I The plastic cover will reduce heat gain or heat loss through conduction as plastic is a poor conductor of thermal energy.
II The vacuum between the interior and exterior walls of the container will reduce heat gain or heat loss through conduction, convection and radiation.
III The silvered inner walls will reflect hotness or coldness back to the food as silver surfaces are good reflectors.

Which of the above explanation(s) is/are correct?

**A** I only
**B** I and II only
**C** I and III only
**D** II and III only

18 One of the steps required to calibrate a thermometer is the selection and determination of the two fixed points.

Which of the following statement(s) about the fixed points is/are correct?

I The fixed points must be easily obtainable and reproducible.
II The fixed points should be based on the physical property of the substance of the thermometer.
III The lower fixed point is the melting point of a substance and the upper fixed point is the boiling point of the substance.

**A** I only
**B** I and II only
**C** II and III only
**D** I, II and III

19 When one junction of a thermocouple is placed in pure melting ice at 0 °C and the other junction in steam at 100 °C, the e.m.f. is 8.0 mV. The cold junction is then removed from the melting ice and placed in a liquid at constant temperature. The e.m.f. is now 2.0 mV.

What is the temperature of the liquid?

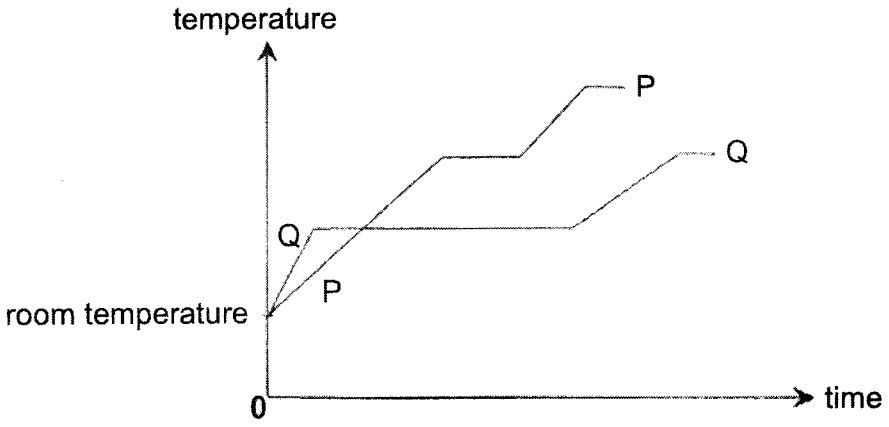
**A** 20 °C
**B** 25 °C
**C** 55 °C
**D** 75 °C

20 The characteristic of certain cooking pots is that when they are removed from the source of heat, the contents in the pots may continue to boil for some time.

What may be the reason for this?

**A** The material of the pot has high specific heat capacity.
**B** The material of the pot has low specific heat capacity.
**C** The pot is made of a very poor conductor of thermal energy.
**D** The pot is made of a poor radiator of thermal energy.

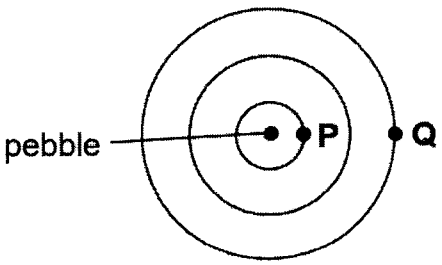
21 The graph shows the variation in temperature with time of two equal masses of substances P and Q, when they are separately heated by identical heaters.




Which of the following deductions is correct?

**A** The boiling point of P is lower than Q.
**B** The specific latent heat of fusion of P is larger than that of Q.
**C** The specific heat capacity of P in the solid state is smaller than that of Q.
**D** Less energy is required to raise the temperature of P from room temperature to its boiling point than Q.

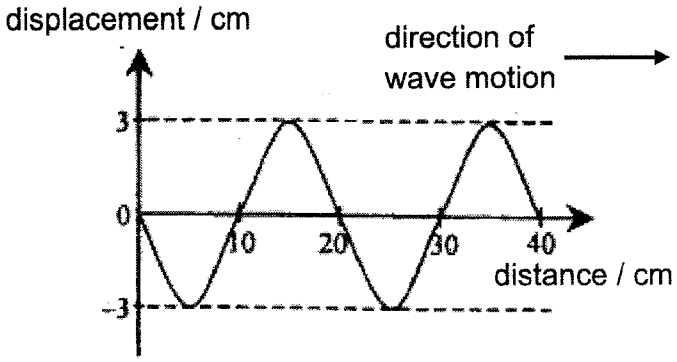
22 A pebble is dropped into still water and circular wavefronts are seen to travel outwards with a speed of $v$.




If the wavelength is $\lambda$, what is the time taken for the wave to travel from P to Q?

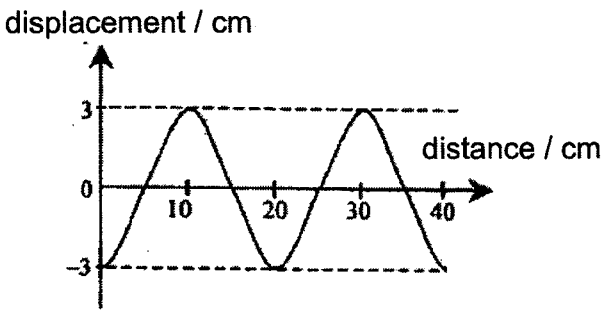
**A** $\lambda / 2v$
**B** $\lambda / v$
**C** $2\lambda / v$
**D** $3\lambda / 2v$

**23** A transverse wave travels along a string with a speed of 0.5 m $s^{-1}$. The graph shows the shape of the string at a certain instant.

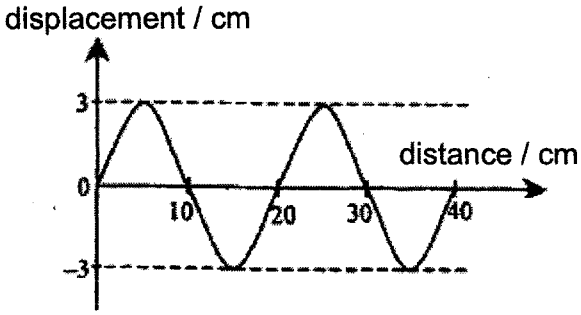



Which of the following graphs shows the shape of the string 0.7 s later?

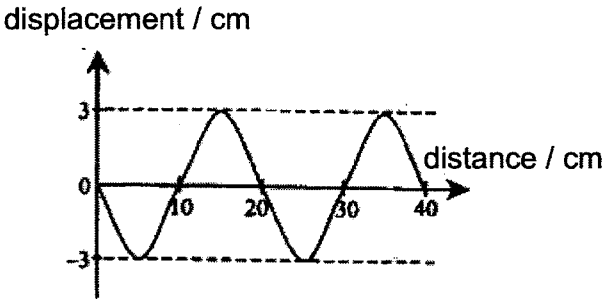
**A**



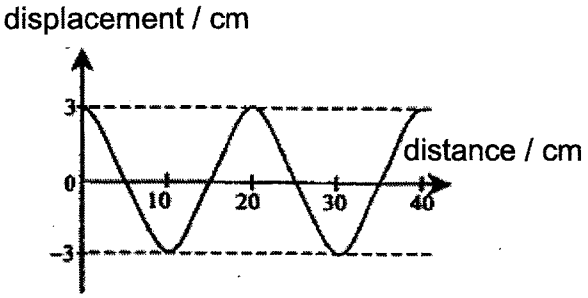

**B**



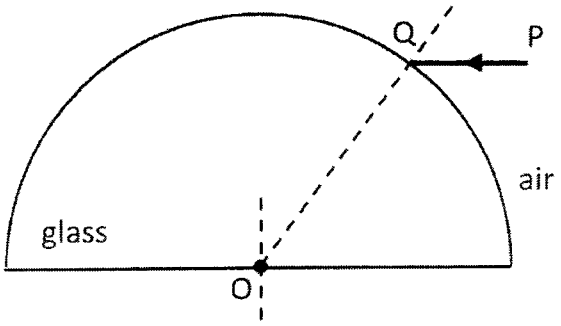

**C**




**D**

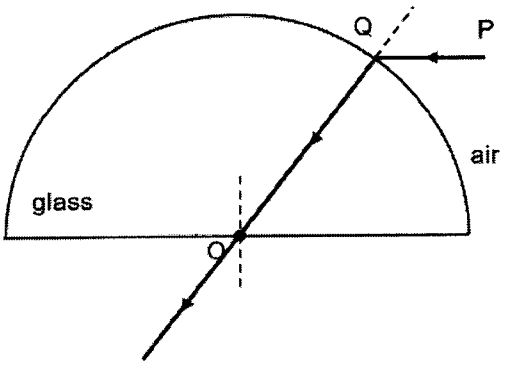


**24** A ray of light in air is incident on a semi-circular block of glass at point Q. OQ is the radius of the semicircle.

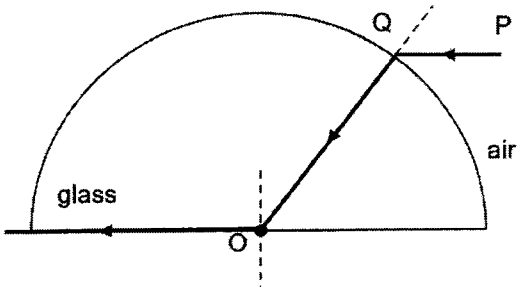



Which of the following ray diagrams shows how the ray will pass through the block and into the air again?

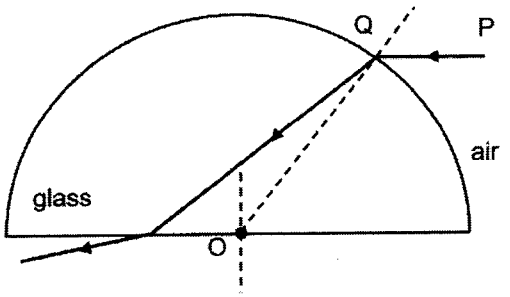
**A**



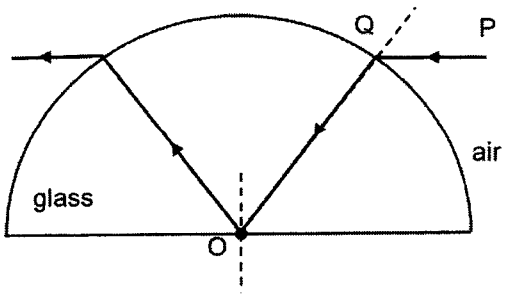

**B**




**C**




**D**




**25** The human eye has a converging lens system that produces an image at the back of the eye.

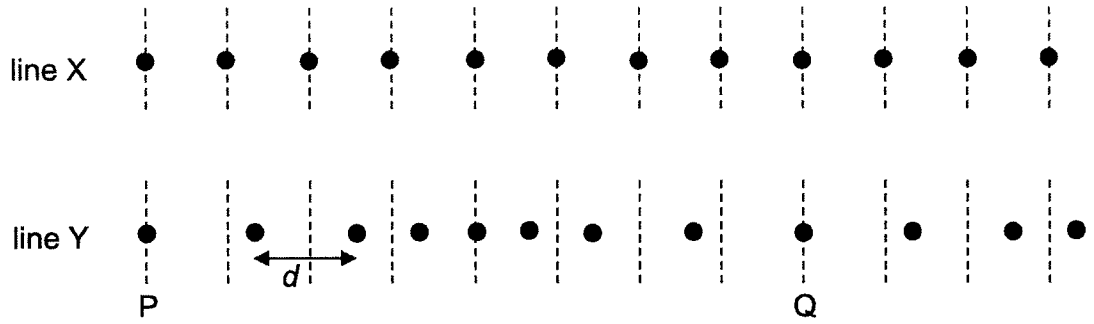
If the eye views a distant object, which type of image is produced?

**A** real, inverted, diminished
**B** real, upright, same size
**C** virtual, upright, diminished
**D** virtual, upright, same size

**26** Which of the following is true about gamma rays?

**A** Gamma rays travel at the highest speed in any medium.
**B** Only gamma rays are used to kill cancer cells in radiation therapy.
**C** Gamma rays are the most energetic in the electromagnetic spectrum.
**D** Gamma rays are the only electromagnetic waves that have ionising effect.

**27** The diagram shows a sound wave passing through a medium. The dots on line X represent the equilibrium positions of the air molecules and the dots on line Y represent the positions of the same air molecules at a particular time.

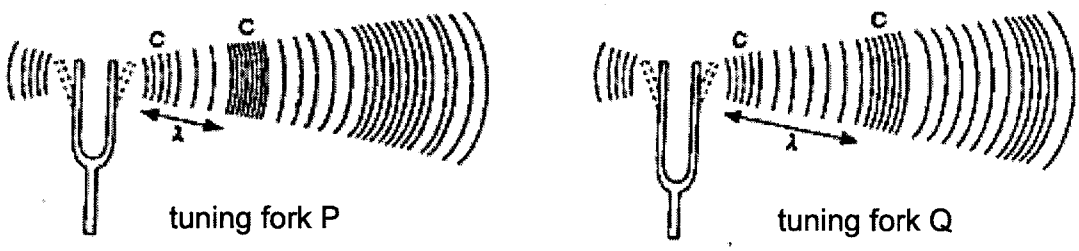



Which of the following statement(s) is/are correct?

I Molecule Q is always at rest.
II The distance between molecules P and Q is the wavelength of the sound wave.
III *d* is the amplitude of the wave.

**A** II only
**B** I and II only
**C** I and III only
**D** I, II and III

**28** Tuning forks with prongs of different lengths produce sounds of different pitch.




Which of the following describes the characteristics of the sound produced?

**A** The sound produced by Q has a longer wavelength and so has a higher pitch.
**B** The sound produced by P has a shorter wavelength and so has a higher pitch.
**C** Q has longer prongs and so the sound it produces has a higher pitch.
**D** The sound produced by P has closer regions of compressions and so has a lower pitch.

**29** An electroscope is used to determine the presence of charges. Plate A is fixed in position but plate B can swing freely about pivot P. Diagram 1 shows that initially, the electroscope is charged positively. Both plates A and B are not touching each other.

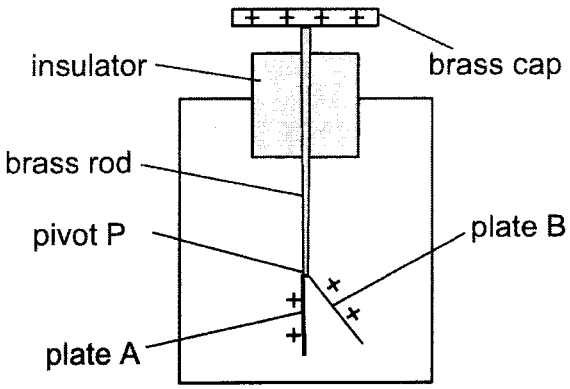



Diagram 1

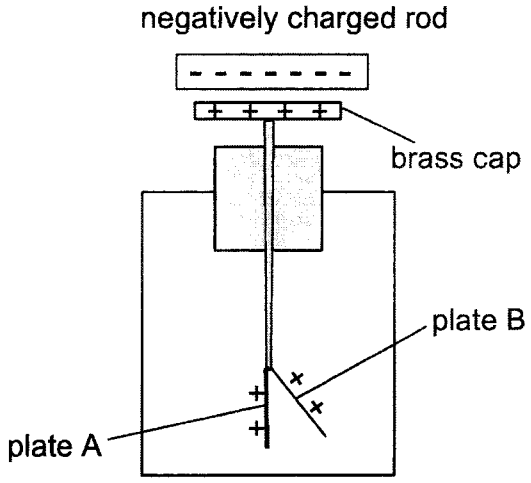



Diagram 2

A negatively charged rod is then placed near the brass cap of the electroscope, as shown in Diagram 2.

Which of the following explains what happens to plate B?

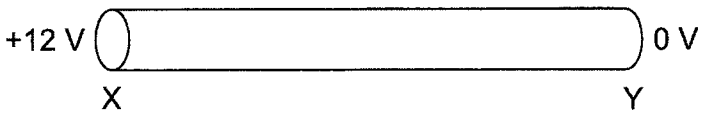
**A** Plate B swings further away from plate A because more positive charges are repelled downwards from the cap, causing both plates to be more positively charged.

**B** Plate B swings further away from plate A because negative charges are repelled downwards from the cap, causing both plates to become negatively charged.

**C** Plate B swings less from plate A because negative charges are repelled downwards from the cap, causing both plates to be less positively charged.

**D** Plate B swings less from plate A because positive charges are attracted upwards to the cap, causing both plates to be less positively charged.

**30** A conductor XY has a potential difference of 12 V between its ends. There is a current of 3 A in XY.




Which statement is correct?

**A** The charge flowing each second in the conductor is 12 C.
**B** Electrons flow from X to Y.
**C** The power dissipated in the conductor is 36 W.
**D** The resistance of the conductor is 3 Ω.

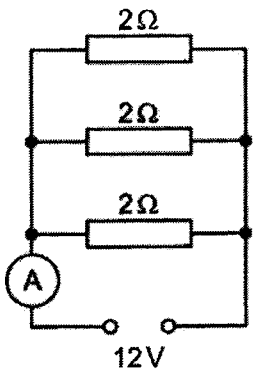
**31** The resistance of a piece of wire, of length 1 m and diameter 0.3 mm, is *R*.

Another piece of wire, made of the same metal, is 2 m longer than the first wire. Its diameter is 50% that of the first wire.

What is the resistance of the second piece of wire?

**A** 4*R*
**B** 6*R*
**C** 8*R*
**D** 12*R*

**32** The diagram shows a circuit containing a 12 V source and three resistors each of resistance 2 Ω. An ammeter measures the current leaving the source.



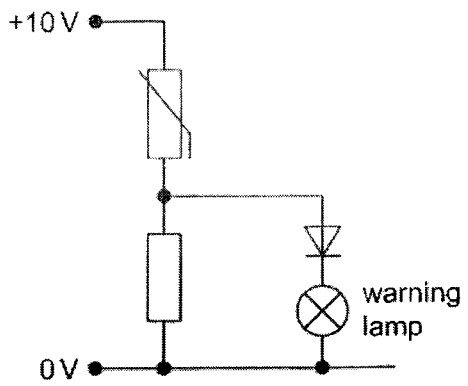

How will the ammeter reading change, if the connection to one of the resistors is broken?

**A** decreases by 6 A
**B** decreases by 1 A
**C** increases by 1 A
**D** increases by 6 A

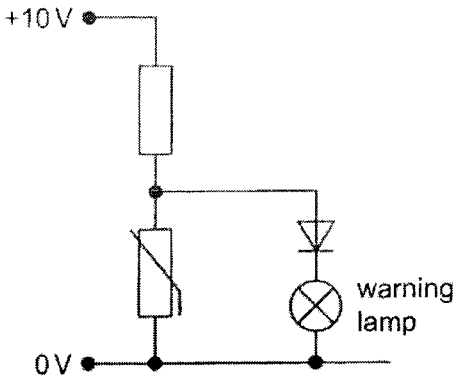
33 A circuit is needed to switch on a warning lamp when the temperature of a thermistor is too high.

Which circuit is suitable?

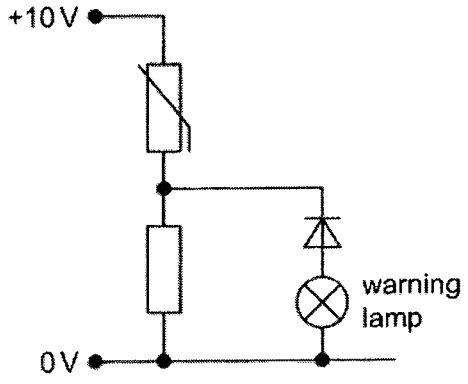
**A**



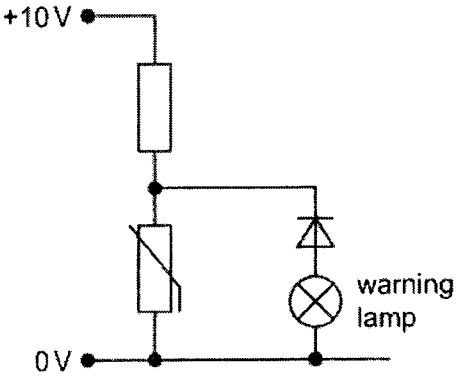

**B**



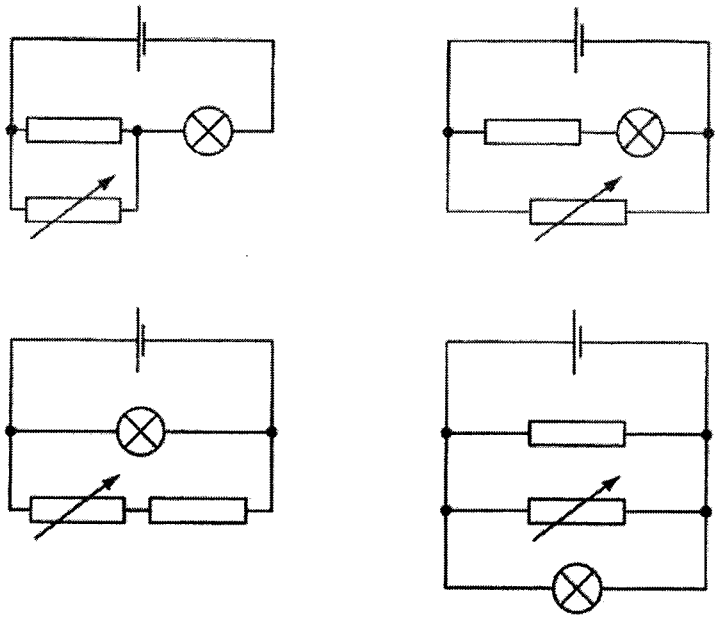

**C**




**D**



**34** A fixed resistor, a variable resistor, a filament lamp and a cell are arranged in four different circuits.



In how many of these circuits will the brightness of the lamp be changed by adjusting the resistance of the variable resistor?

**A** 1
**B** 2
**C** 3
**D** 4

**35** A plug for a lamp contains a fuse with a 3.0 A rating.

Which statement is **incorrect**?

**A** The fuse breaks the circuit if the current exceeds 3.0 A.
**B** The fuse contains a thin wire.
**C** The fuse is connected to the live pin of the plug.
**D** The fuse can be reset like a circuit breaker after it blows.

**36** Diagram 1 shows a compass needle pointing north when there is no other magnet around. It is then placed at a point P near to a magnet surrounded by a soft iron ring as shown in Diagram 2.

Diagram 1

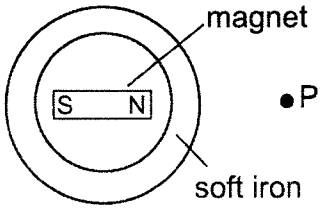
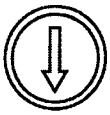



Diagram 2

Which of the following diagrams shows the possible orientation of the compass needle?

**A**

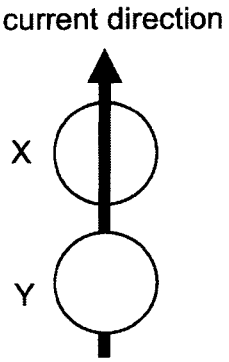


**B**

**C**

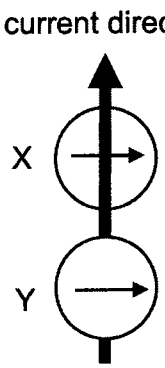
**D**

**37** Plotting compasses X and Y are placed below and on top of a current-carrying wire respectively, as shown in the diagram.

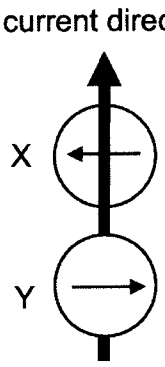



Which of the following shows the possible directions of the compass needles?

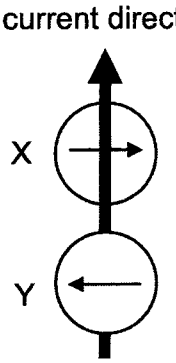
**A**



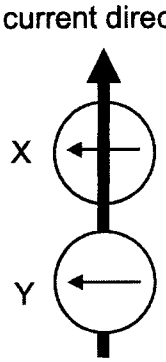

**B**



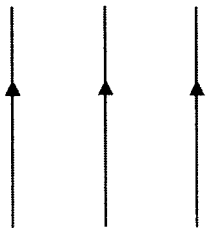

**C**




**D**



**38** Three vertical conducting wires have the same amount of current flowing through them in the direction shown.



Given that the distances between the wires are the same, what is the direction of the resultant electromagnetic force acting on the middle wire?

**A** to the left
**B** to the right
**C** perpendicular to the plane of the paper
**D** resultant electromagnetic force is zero

**39** Diagram 1 shows the oscilloscope trace produced by an input of maximum voltage 2 V and frequency 50 Hz.

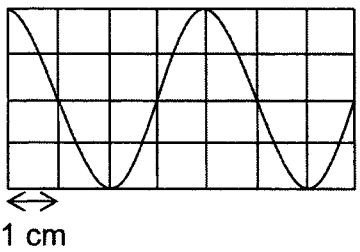



Diagram 1

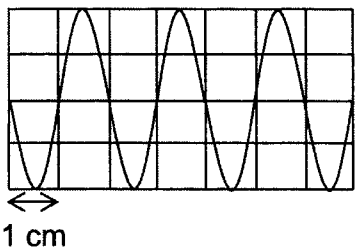


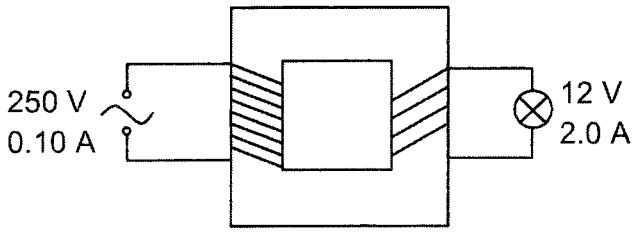

Diagram 2

With no changes in the oscilloscope setup, what are the new values of maximum voltage and frequency as shown in Diagram 2?

**A** 1 V and 50 Hz
**B** 2 V and 25 Hz
**C** 2 V and 100 Hz
**D** 4 V and 100 Hz

**40** A transformer is used to operate a 12 V lamp from a 250 V mains supply. The mains current is 0.10 A and the current flowing through the lamp is 2.0 A.

What is the efficiency of the transformer?




**A** 4.8 %
**B** 5.0 %
**C** 96 %
**D** 104 %

**END OF PAPER**

| NAME: | CLASS: | INDEX NO: |
|---|---|---|

# QUEENSWAY SECONDARY SCHOOL

## PRELIMINARY EXAMINATION 2022

## SECONDARY 4 EXPRESS

Parent's Signature:

**PHYSICS** **6091/02**

Paper 2 Theory **14 September 2022**

**1 hour 45 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

**READ THESE INSTRUCTIONS FIRST**

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

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

**Section B:**
Answer **all** questions. Question 13 has a choice of parts to answer.

Candidates are reminded that **all** quantitative answers should include appropriate units.
The use of an approved scientific calculator is expected, where appropriate.
Candidates are advised to show all their working in a clear and orderly manner, as more marks are awarded for sound use of Physics than for correct answers.

The number of marks is given in brackets [ ] at the end of each question or part question.

| | For Examiner's Use | |
|---|---|---|
| | Section A | /50 |
| | Q11 | /10 |
| | Q12 | /10 |
| E / O | Q13 | /10 |
| | TOTAL | /80 |

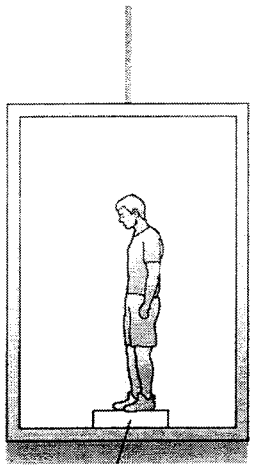
This document consists of **23** printed pages.

Setters: Mrs Pang FH, Ms Tan YN **[Turn over**

## SECTION A

Answer **all** the questions in this section.

**1** Fig. 1.1 shows a man of mass 90 kg standing on a weighing scale in a lift.



weighing scale

**Fig. 1.1**

The gravitational field strength is 10 N $kg^{-1}$.

**(a) (i)** On Fig. 1.1, draw and label the two forces acting on the man. [1]

**(ii)** Explain why the forces in **(a)(i)** are **not** an action-reaction pair.

.....

.....

..... [2]

**(b)** The lift is moving upwards at a velocity of 1.8 m $s^{-1}$. It then comes to a stop in a time of 0.50 s.

Determine the scale reading (in Newton) during this deceleration.

scale reading = .....[2]

2 Fig. 2.1 shows a desk lamp with the dimensions shown. The base of the lamp is circular and has a radius of 10 cm. The total weight of the light bulb and shade is 5.0 N and each of the uniform arms has weight 1.5 N.

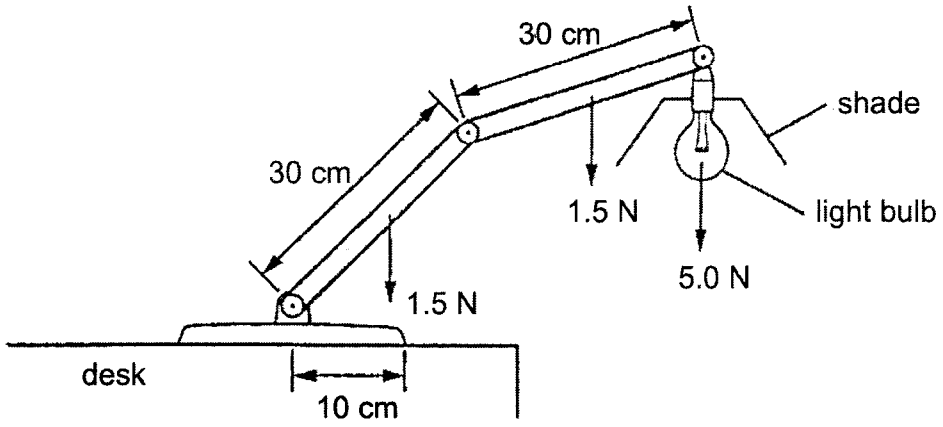



**Fig. 2.1**

The lamp must be constructed so that it does not topple over when fully extended as shown in Fig. 2.2. The base must be heavy enough so that the lamp will not rotate about a point X.

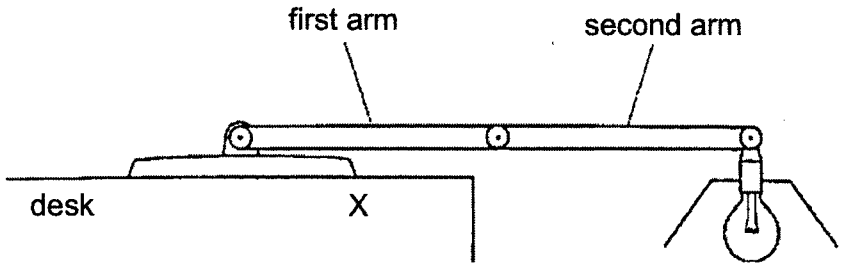



**Fig. 2.2**

**(a)** By taking moments about X, calculate the minimum weight of the base required to prevent toppling.

weight = .....[2]

**(b)** Explain why the lamp tends to topple over when fully extended as shown in Fig. 2.2, rather than when partially extended as shown in Fig. 2.1.

.....

.....

..... [2]

**(c)** State and explain one change that could be made to the base to increase the stability of the lamp. The weight of the base is to remain constant.

.....

..... [1]

3 Fig. 3.1 shows a manometer that is connected to two separate containers containing pressurised gases X and Y. The pressure of both gases is much greater than the atmospheric pressure. There are two immiscible liquids A and B in the manometer, of densities 5.2 g $cm^{-3}$ and 2.8 g $cm^{-3}$ respectively.

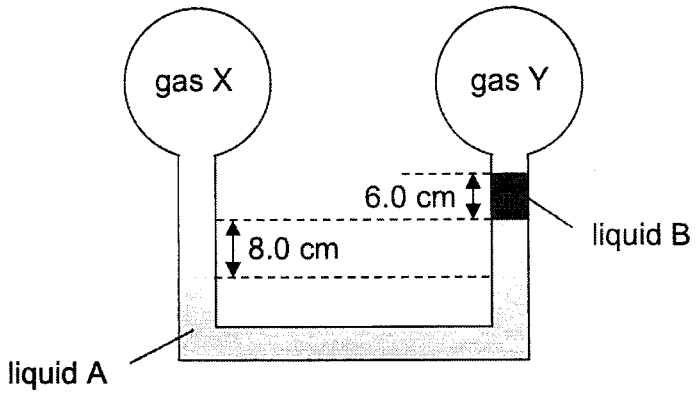



**Fig. 3.1**

The gravitational field strength is 10 N $kg^{-1}$.

**(a)** Explain which gas has a larger pressure.

.....

..... [1]

**(b)** Calculate the pressure difference due to the gases.

pressure difference = .....[3]

**(c)** There is a crack in the container containing gas X.

State and explain what will happen to the liquid levels in the manometer.

.....

.....

.....

..... [2]

4 An archer pulls the string of his bow and it stretches by a horizontal distance of 40 cm, as shown in Fig. 4.1. As he releases the string, an average force of 150 N acts on the arrow before it loses contact with the string.

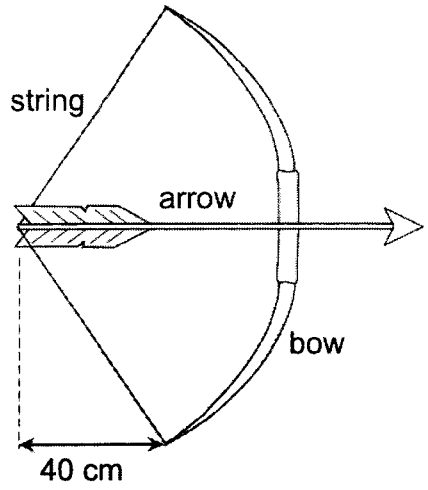



**Fig. 4.1**

**(a)** State the main energy change that occurs as he releases the string.

.....[1]

**(b)** Calculate the average work done on the arrow.

work done = .....[1]

**(c)** **(i)** The arrow has a mass of 100 g.
Calculate the speed of the arrow as it loses contact with the string.

speed = .....[2]

**(ii)** State two ways in which the speed in **(c)(i)** may be increased.

.....

.....[2]

5 A tyre that is originally completely deflated is inflated by using a pump.

**(a)** Describe, using the concept of pressure, how the pump pushes the air into the tyre.

.....

.....

..... [1]

**(b)** Explain, using the kinetic model of matter,

**(i)** how the atmosphere exerts a pressure on the outside of the inflated tyre,

.....

.....

.....

..... [2]

**(ii)** why the air inside the tyre exerts a greater pressure on the tyre than the air outside.

.....

.....

.....

..... [2]

6 Fig. 6.1 shows the positions of a travelling wave at time $t = 0$ s and $t = 4$ s. P is a particle on the wave.

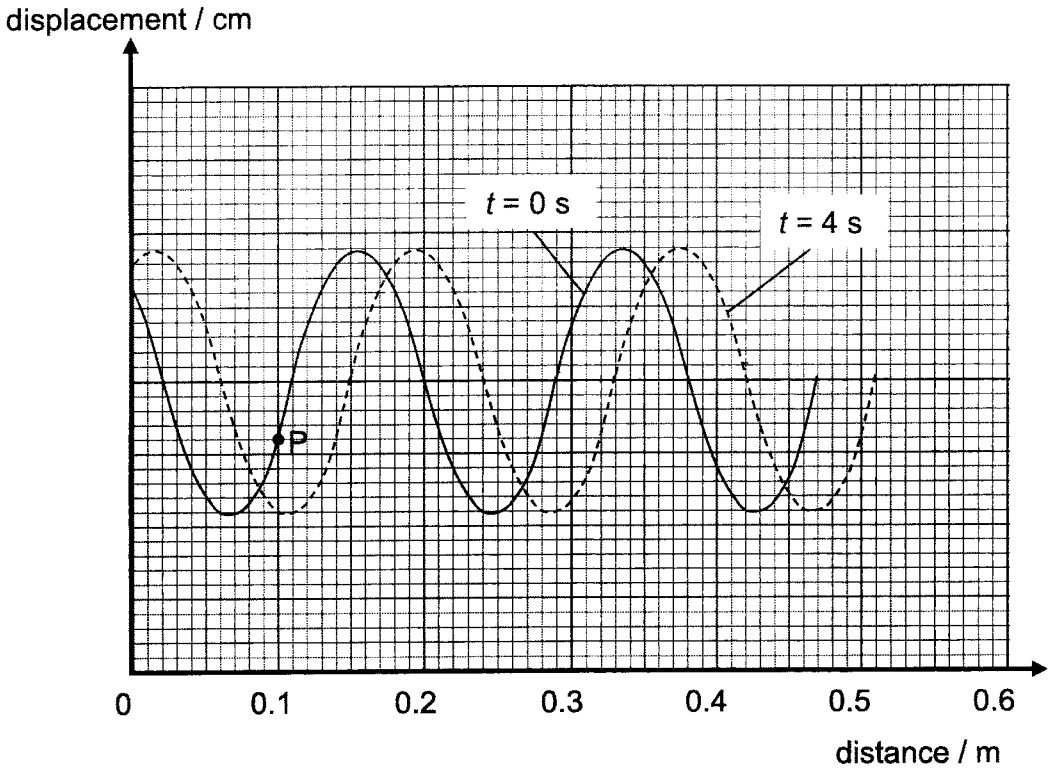



**Fig. 6.1**

**(a)** Describe the movement of P for one complete cycle, starting from $t = 0$ s.

.....

.....

.....

..... [2]

**(b)** Determine the speed of the wave.

speed = .....[2]

7 Fig. 7.1 shows a narrow road with a plane mirror mounted at the corner of a 90° bend. Point C represents a car and point M represents a man. The image of the car seen by the man at M in the mirror is indicated by the point I.

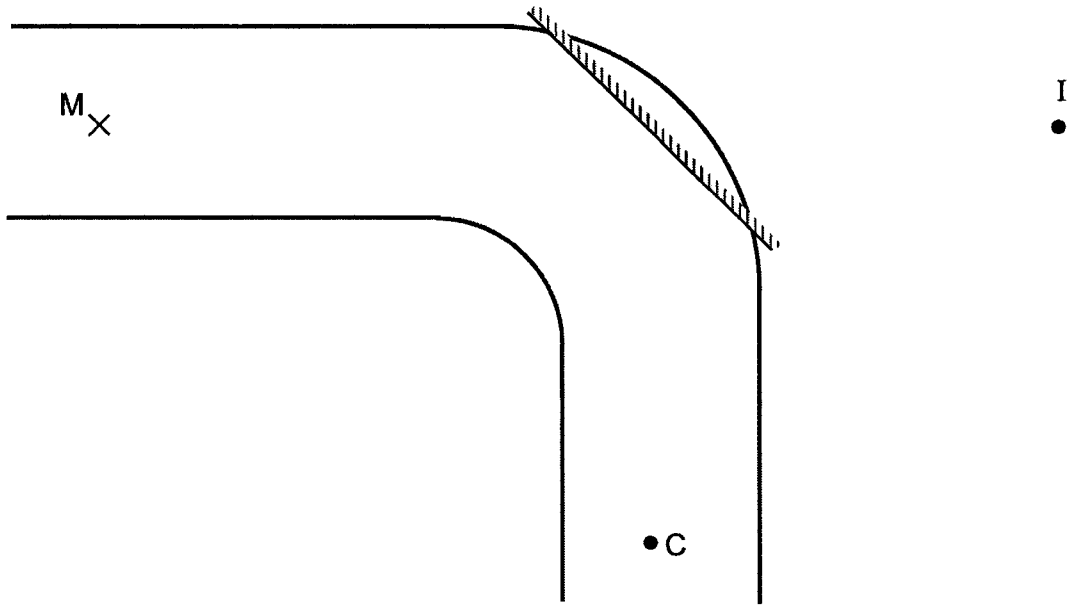



**Fig. 7.1**

**(a)** State one characteristic of the image of the car.

.....[1]

**(b)** Complete the following on Fig. 7.1.

**(i)** Draw a ray of light from C, reflected by the mirror, to the man at M. Mark and label the angle of incidence *i* and the angle of reflection *r*. [2]

**(ii)** Mark the position of the image of the man at M as seen by the driver of the car at C. Label this position M'. [1]

**(iii)** The car is travelling towards the bend. Draw an arrow at I to show the direction in which the image of the car I appears to be travelling to the man at M. [1]

8 Fig. 8.1 shows two horizontal metal plates connected to a high voltage power supply. A charged styrofoam ball is placed between the plates and is observed to be floating above the bottom plate.

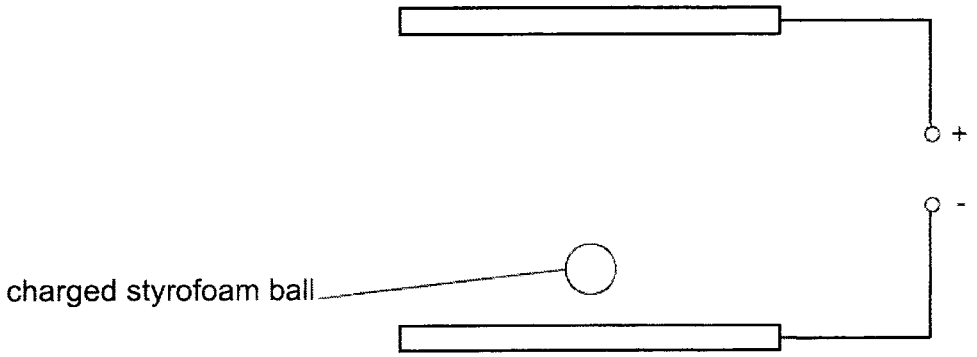



**Fig. 8.1**

**(a)** On Fig. 8.1, draw the electric field lines between the two plates. (Ignore the effect of the field lines of the charged styrofoam ball.) [1]

**(b)** Explain why the styrofoam ball is able to float just above the bottom plate.

.....

.....

..... [2]

9 A lamp is marked 240 V, 60 W.

**(a)** Calculate the charge that flows through the lamp in 2 hours, when it is operating at normal brightness.

charge = .....[2]

**(b)** Calculate the cost of switching on the lamp for 2 hours, given that the cost of electricity is $0.25 per kWh.

cost = .....[2]

**(c)** In practice, the filament in the lamp gets hot and its resistance changes.

Suggest how this affects the current in the lamp and its brightness.

.....

..... [1]

**10** Fig. 10.1 shows a bar magnet hanging from one end of a spring. Its N pole is just inside a vertical coil whose ends are connected to a centre-zero galvanometer.

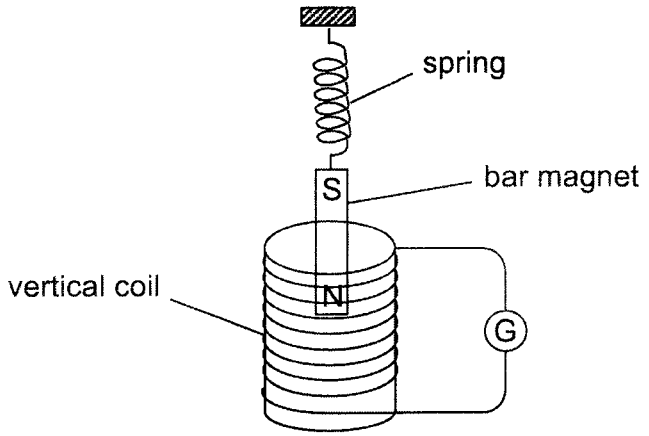



**Fig. 10.1**

The magnet is pulled down and released, such that the S pole stays well above the coil and only the N pole moves in and out of the coil.

**(a)** The galvanometer shows deflection as the magnet moves. Explain why.

.....

.....

.....

..... [2]

**(b)** On the axes in Fig. 10.2, sketch a graph of the readings on the galvanometer for 5 complete oscillations of the magnet.

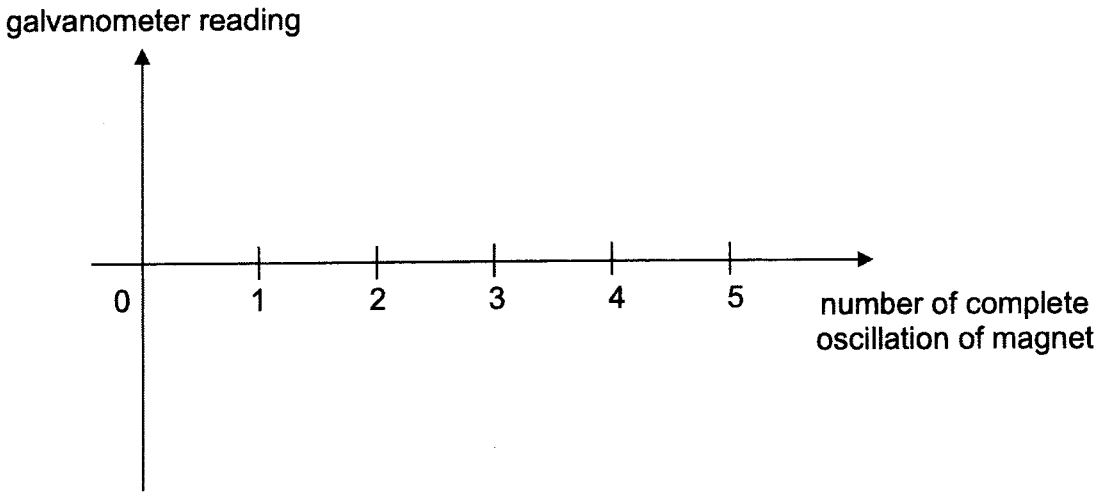



**Fig. 10.2**

[2]

**(c)** Suggest two ways to increase the galvanometer reading.

.....

..... [2]

## SECTION B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 13**.

**11** Fig. 11.1 shows a section of the solar heating system which helps to provide water for a house. It consists of a solar collector placed outside on a roof. Water pipes are connected to the solar collector.

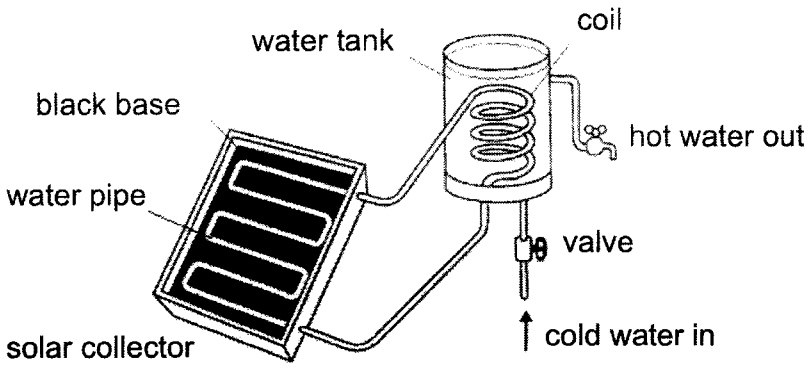



**Fig. 11.1**

It is found that tilting the solar collector at different angles affects the amount of energy received during different months of the year.

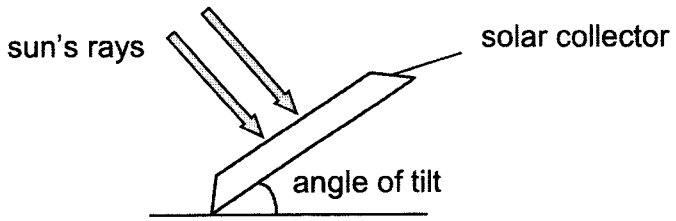



**Fig. 11.2**

Table 11.1 shows the results of the amount of energy in megajoules received by a 1 $m^2$ solar collector at different angles of tilt between the months of April and September.

**Table 11.1 (Energy received in megajoules by a 1 $m^2$ solar collector)**

| | angle of tilt | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| month | 0° | 10° | 20° | 30° | 40° | 50° | 60° | 70° | 80° | 90° |
| April | 20.5 | 22.3 | 23.8 | 24.9 | 24.8 | 24.1 | 22.7 | 20.5 | 18.4 | 15.1 |
| May | 26.3 | 27.7 | 28.4 | 28.8 | 27.4 | 25.2 | 23.0 | 19.8 | 16.6 | 13.0 |
| June | 28.4 | 28.8 | 29.2 | 29.2 | 27.4 | 25.2 | 22.3 | 19.1 | 15.1 | 11.2 |
| July | 28.1 | 28.4 | 28.8 | 29.2 | 27.4 | 25.6 | 23.0 | 20.2 | 16.2 | 12.2 |
| August | 23.0 | 24.8 | 25.6 | 25.9 | 26.3 | 24.8 | 22.7 | 20.5 | 17.3 | 13.7 |
| September | 16.2 | 18.7 | 20.5 | 21.6 | 22.3 | 22.7 | 21.6 | 19.0 | 15.0 | 10.9 |

**(a)** State and explain two features of the solar collector that allow the heating of water in the water pipes to be more efficient.

.....

.....

.....

..... [2]

**(b)** For the range of angles of tilt in Table 11.1, state, for the months from April to July,

**(i)** a similarity in the amount of energy received,

.....

..... [1]

**(ii)** a difference in the amount of energy received.

.....

..... [1]

**(c)** Determine, by calculation, whether it would be better to tilt the solar collector at an angle of 30°. or 40°., between the months of June and September, in order to obtain the greatest amount of total energy.

..... [2]

**(d)** The amount of energy received in September seems very different from the other months. Suggest a reason for this.

.....

..... [1]

**(e)** Fig. 11.3 shows a graph of the power generated by the solar collector on a particular day.

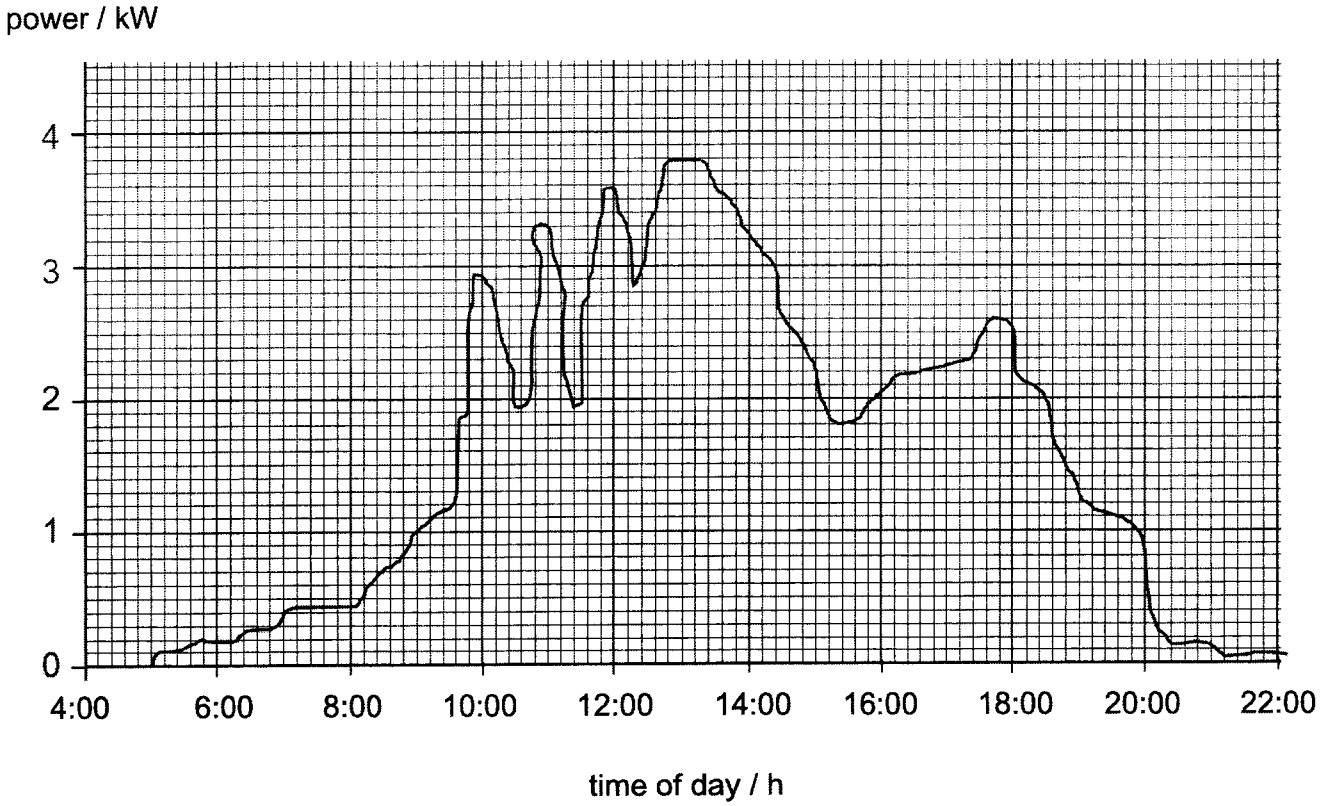



**Fig. 11.3**

**(i)** Suggest a reason for the irregular shape of the graph.

.....

..... [1]

**(ii)** In the solar heating system, the water tank holds 30 kg of water. Calculate the maximum change in temperature of the water in the water tank between 12.55 pm and 1.05 pm. (Specific heat capacity of water = 4200 J $kg^{-1}$ $°C^{-1}$)

temperature change = .....[2]

**12** Fig. 12.1 shows a simple motor that can be used to turn a fan.

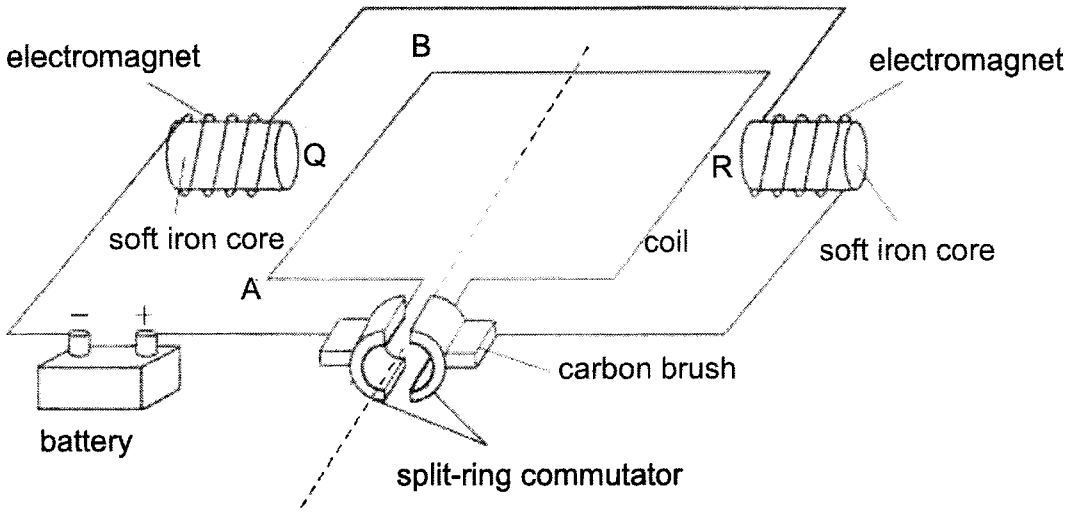



**Fig. 12.1**

**(a)** **(i)** State the polarity of Q and R.

.....[1]

**(ii)** State the purpose of the soft iron core.

.....

.....[1]

**(b)** **(i)** On Fig. 12.1, draw an arrow on wire AB to show the direction of the force acting on the wire. [1]

**(ii)** Explain why the wire experiences a force in the direction shown in **(b)(i)**.

.....

.....

.....

.....[2]

**(iii)** State two ways to increase the magnitude of the force on AB.

.....

.....

.....[2]

**(iv)** Suggest one way to change the direction of rotation of the coil.

.....

..... [1]

**(c)** As the coil rotates by 180°, explain what happens to the

**(i)** current in AB,

.....

..... [1]

**(ii)** force on AB.

.....

..... [1]

**13 EITHER**

A student stands near the edge of a cliff. He throws a ball upwards with a velocity $u$, at a height $h$ from the top of the cliff, as shown in Fig. 13.1. The ball rises vertically a short distance and then falls.

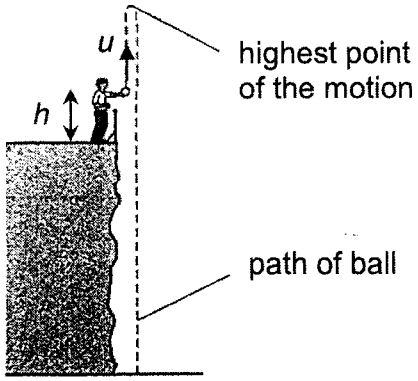



**Fig. 13.1**

**(a)** Fig. 13.2 shows the displacement-time graph and Fig. 13.3 shows part of the velocity-time graph for the first 1.0 s of the motion. Air resistance is very small in the first 1.0 s of the motion.

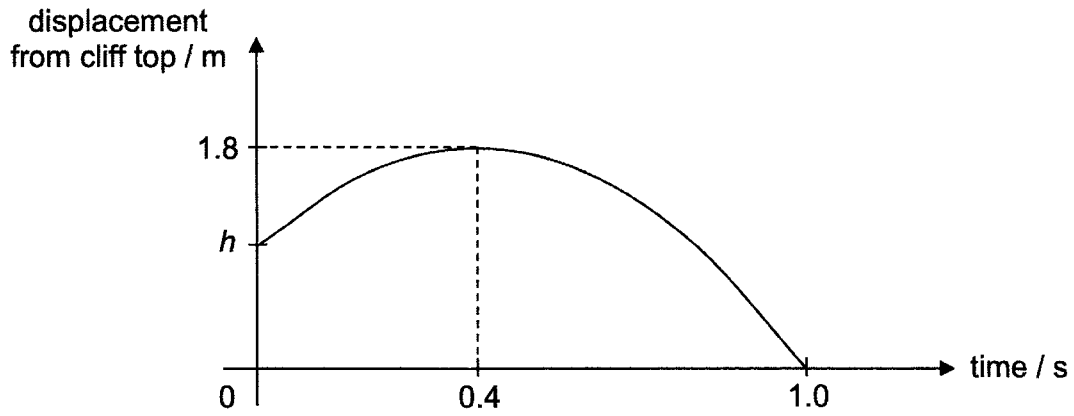



**Fig. 13.2**

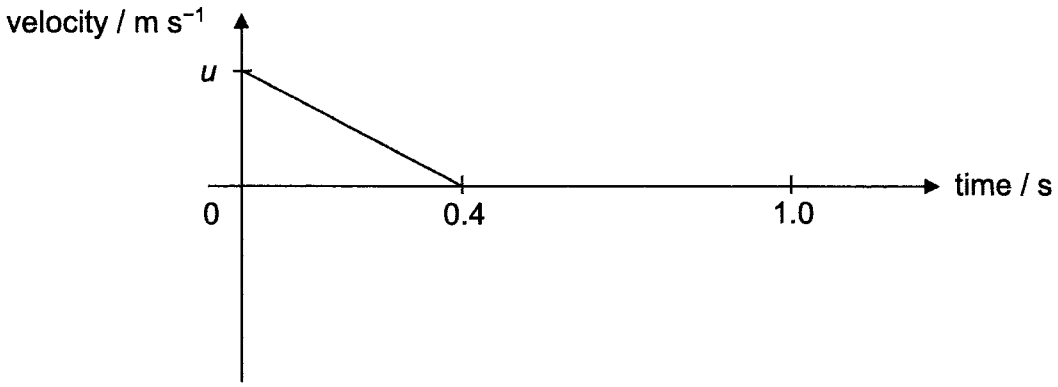



**Fig. 13.3**

Using Fig. 13.2, explain why the velocity is zero at 0.4 s.

.....

..... [1]

**(b)** **(i)** On Fig. 13.3, complete the velocity-time graph for the first 1.0 s of the motion. [1]

**(ii)** Explain your answer to **(b)(i)**.

.....

.....

..... [1]

**(c)** **(i)** Using Fig. 13.3, determine the velocity $u$.

$u$ = .....[2]

**(ii)** Hence, determine the height $h$.

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

**(d)** The ball continues to fall. The effect of air resistance becomes significant and the ball eventually falls at terminal velocity.

Describe the velocity and acceleration of the ball as it falls at terminal velocity.

.....

..... [2]

**OR**

Fig. 13.4 shows the $I$ / $V$ characteristic graph of a diode.

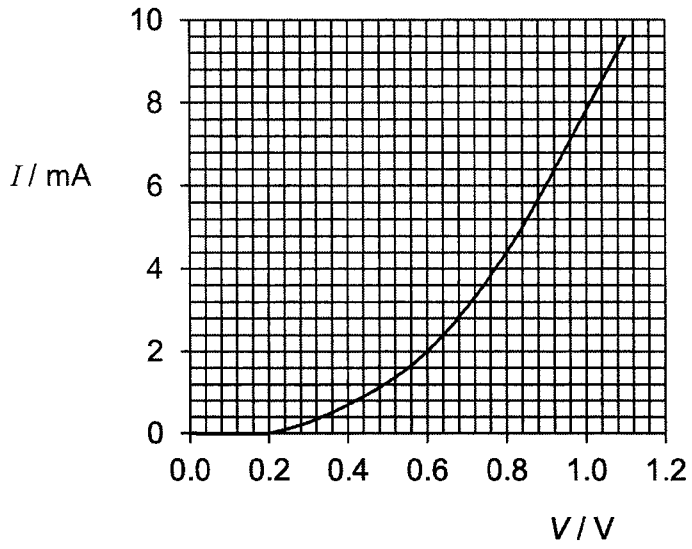



**Fig. 13.4**

**(a) (i)** Describe how the current and the resistance of the diode change as the voltage is increased from 0 to 1.0 V.

.....

.....

.....

.....[2]

**(ii)** Determine the resistance of the diode at 0.8 V.

resistance = .....[2]

**(b) (i)** To obtain the $I$ / $V$ characteristic graph, a student connects the diode to a circuit containing a 1.5 V cell and a variable resistor X, as shown in Fig. 13.5. The maximum resistance of X is 100 Ω.

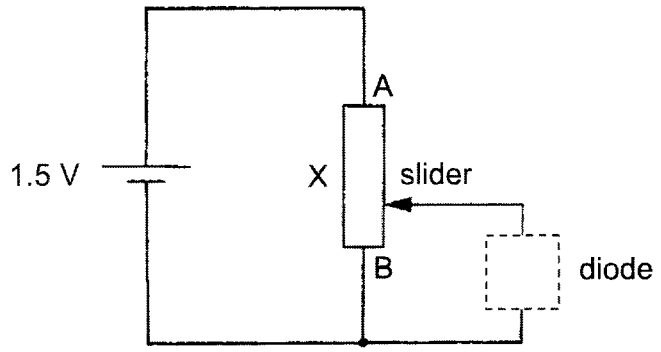



**Fig. 13.5**

On Fig. 13.5, complete the circuit by drawing the following electrical components:

- a diode (inside the dotted box)
- an ammeter
- a voltmeter

[2]

**(ii)** Explain how this circuit can be used to obtain the $I$ / $V$ characteristic graph of the diode.

.....

.....

..... [2]

**(c)** Using the same apparatus in **(b)**, another student sets up a circuit as shown in Fig. 13.6 instead.

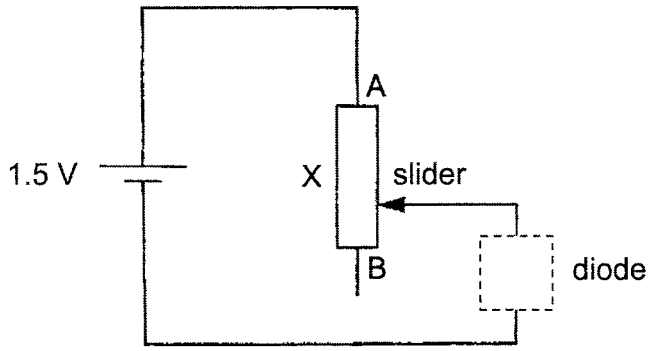



**Fig. 13.6**

State and explain why the circuit shown in Fig. 13.6 is inappropriate for determining the $I$ / $V$ characteristic graph of the diode.

.....

.....

..... [2]

**END OF PAPER**

**Solutions to 2022 4E Physics Prelim Exam**

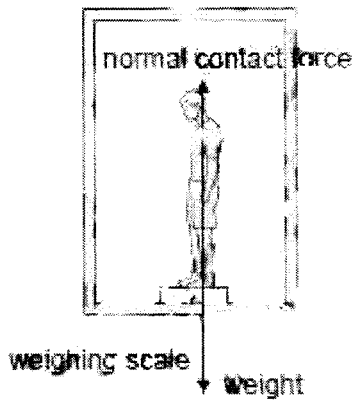
**Paper 1**

**Multiple Choice Questions [40 marks]**

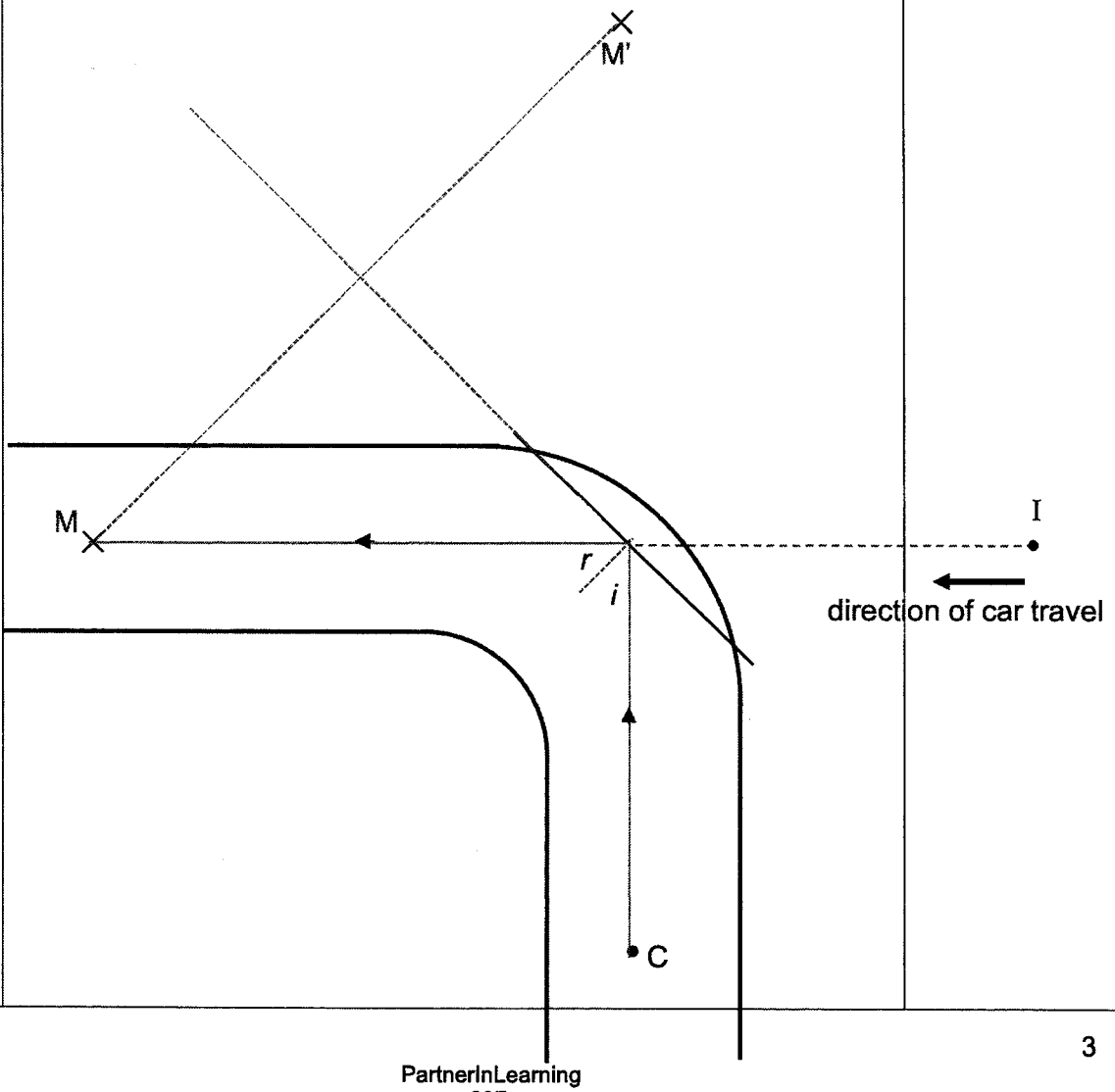
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 1 | B | 11 | D | 21 | D | 31 | D |
| 2 | C | 12 | B | 22 | C | 32 | A |
| 3 | A | 13 | C | 23 | A | 33 | A |
| 4 | C | 14 | D | 24 | C | 34 | A |
| 5 | D | 15 | B | 25 | A | 35 | D |
| 6 | B | 16 | C | 26 | C | 36 | B |
| 7 | C | 17 | A | 27 | A | 37 | B |
| 8 | C | 18 | B | 28 | B | 38 | D |
| 9 | C | 19 | D | 29 | C | 39 | C |
| 10 | A | 20 | A | 30 | C | 40 | C |

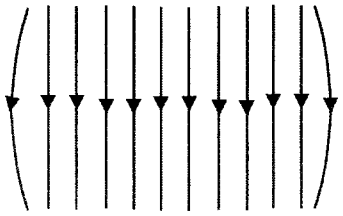
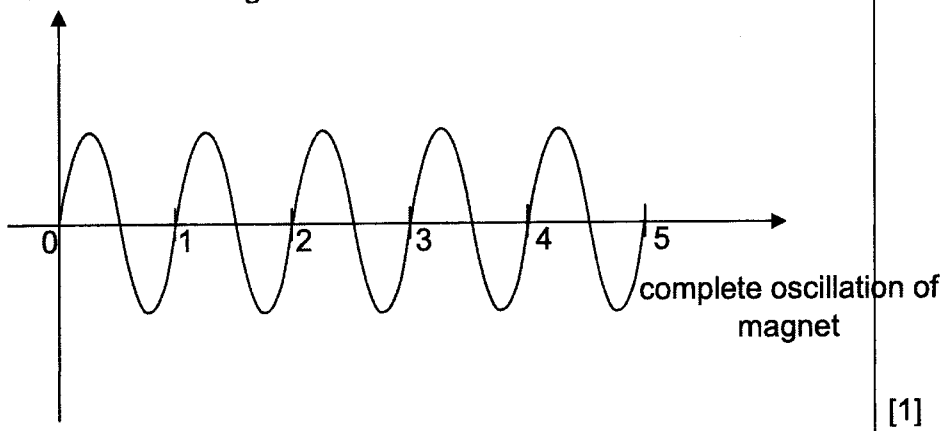
**Paper 2**

**Section A: Structured Questions [50 marks]**

| Qn | Solution | Mark |
|---|---|---|
| 1(a)(i) |  | [1] |
| 1(a)(ii) | They are not of the same nature and they both act on the same body (man). | [2] |
| 1(b) | $a = \frac{0-1.8}{0.50}$<br>$a = -3.6\ \text{m s}^{-2}$<br><br>$W - N = ma$<br>$(90\times10) - N = 90\times3.6$<br>$N = 576\ \text{N}$ | [1]<br><br>[1] |

| | | |
|---|---|---|
| 2(a) | Total anticlockwise moments = total clockwise moments<br>$W \times 10 = (1.5 \times 5) + (1.5 \times 35) + (5.0 \times 50)$<br>$W = 31$ N | [1]<br>[1] |
| 2(b) | The perpendicular distances from the lines of action of the components of the weights to the pivot are maximum,<br>creating the maximum clockwise moments about X. | [1]<br>[1] |
| 2(c) | The area of the base could be increased. This decreases the clockwise moment about the new point X, and increases the anticlockwise moment as well. | [1] any acceptable explanation to increase in stability |
| 3(a) | Gas X has a larger pressure because the liquid level is lower than that exerted by gas Y. | [1] |
| 3(b) | pressure difference<br>= pressure difference due to the liquid levels<br>$= (0.080 \times 5200 \times 10) + (0.060 \times 2800 \times 10)$<br>$= 5840$ Pa | [1] pressure due to liquid A<br>[1] pressure due to liquid B<br>[1] concept and answer |
| 3(c) | Gas X will escape from the container, decreasing its pressure within the container.<br>The liquid level on the left will increase, while the liquid level on the right will decrease. | [1]<br>[1] |
| 4(a) | Elastic potential energy of the string to kinetic energy of the arrow. | [1] |
| 4(b) | Work Done = F x d<br>= 150 x 0.4<br>= 60 J | [1] |
| 4(c)(i) | ½ m $v^2$ = 60<br>½ x 0.100 x $v^2$ = 60 ECF for energy<br>v = 34.6 m / s (accept 3 sf) | [1]<br>[1] |
| 4(c)(ii) | Pull the string a longer horizontal distance back.<br>Use a lighter arrow. | [1]<br>[1] |
| 5(a) | When the pump is pushed down, the volume inside the pump decreases, and the pressure of the air in the pump increases. This air pressure in the pump is higher than the air pressure in the tyre and so the air is pushed into the tyre. | [1] |
| 5(b)(i) | The air molecules outside the tyre are continuously bombarding the walls of the tyre. This bombardment produces a force per unit area and hence an atmospheric pressure on the tyre. | [1]<br>[1] |

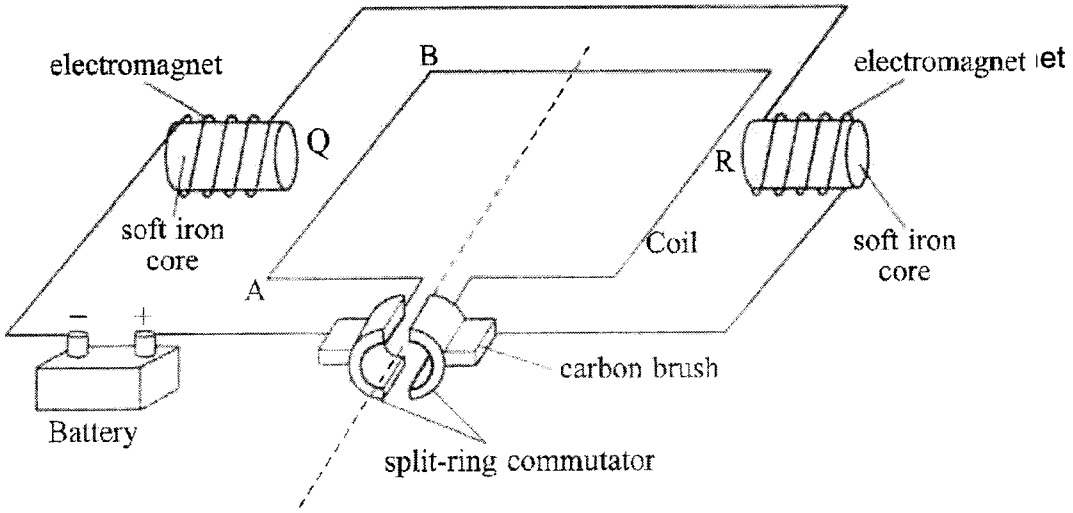
| | | |
|---|---|---|
| **5(b)(ii)** | The <u>tyre contains more air molecules per unit volume than outside.</u> <u>Thus, molecular collisions with the wall are more frequent,</u> resulting in the air inside the tyre exerting a greater pressure in the tyre. | [1]<br>[1] |
| **6(a)** | Particle P will move downwards and reach the maximum negative displacement. It then moves upwards passing the equilibrium position and reach the maximum positive displacement. After which it moves downwards passing the equilibrium position again and back to its starting point. | [1]<br><br>[1] |
| **6(b)** | wavelength, $\lambda$ = **0.18 m** **(0.1/10 × 18)**<br><br>$\frac{4}{18}$ of a wave takes 4 s<br>therefore, $f = \frac{4}{18} \div 4 = \frac{1}{18}$ Hz<br>$v = f\lambda = \frac{1}{18} \times 0.18$ = **0.010 ms$^{-1}$** | [1]<br><br><br><br>[1] |
| **7(a)** | 1. Virtual<br>2. Upright<br>3. Laterally inverted<br>4. As far behind the mirror as the object is in front<br>5. Same size | [1] any one |
| **7(b)** |  | |

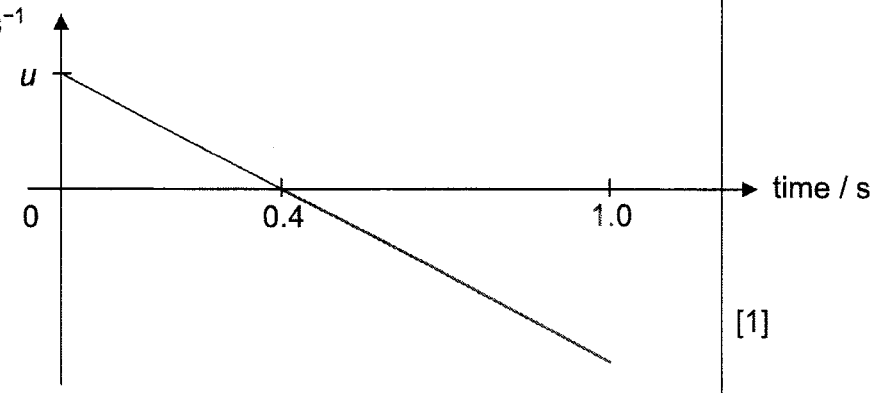
| | | |
|---|---|---|
| | Correct ray drawn with arrows, label *i* and *r*<br>Correct position of M' (equal perpendicular distance from mirror as M)<br>Correct direction of car travel | [2]<br>[1]<br><br>[1] |
| **8(a)** | Correct direction and shape of electric field<br>  <br>charged styrofoam ball | [1] |
| **8(b)** | The ball is negatively charged.<br>Upward electric force balances its downward weight | [1]<br>[1] |
| **9(a)** | $V = \frac{W}{Q}$<br>$240 = \frac{60 \times 2 \times 3600}{Q}$<br>$Q = 1800$ C | <br><br>[1]<br>[1] |
| **9(b)** | $\text{cost} = \frac{60}{1000} \times 2 \times \$0.25$<br>= \$0.03 | [1]<br><br>[1] |
| **9(c)** | The resistance of the lamp increases.<br>Hence, the current decreases and the brightness decreases as well. | [1] |
| **10(a)** | When the magnet moves, its lines of magnetic flux are being cut by the coil, and so a current is induced in the coil which causes the deflection of the pointer of the galvanometer. | [1]<br>[1] |
| **10(b)** | galvanometer reading<br>  <br><br>[1] correct shape, starting at zero<br>[1] 1 complete cycle for one oscillation of the magnet | <br><br><br><br><br><br>[1]<br>[1] |

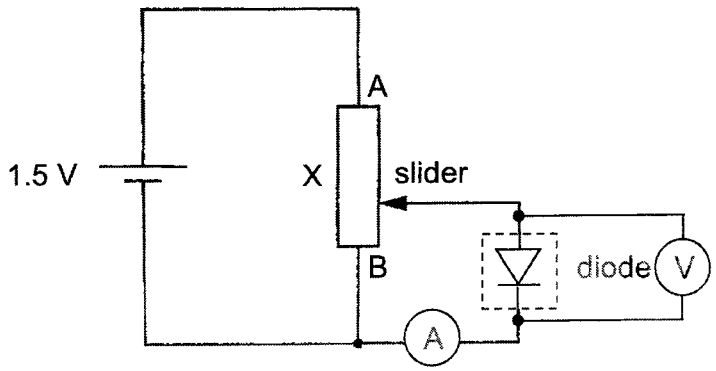
| | | |
|---|---|---|
| **10(c)** | 1. Use a stronger magnet<br>2. Use a coil with more turns per unit length<br>3. Insert the magnet in and out of the coil at a faster rate | [1]<br>[1]<br>Any two ways |

**Section B: Structured Questions [30 marks]**

| Qn | Solution | Mark |
|---|---|---|
| **11(a)** | The base of the solar collector is painted black.<br>Black is a good absorber of infra-red radiation and is able to absorb radiation from the Sun to heat up the water pipes.<br>The water pipes have a loop design.<br>The loops increase the surface area of absorption of radiation to heat up the water pipes. | [1]<br><br><br>[1] |
| **11(b)(i)** | 1. The amount of energy received increases with the angle of tilt from 0°. to 30°. and decreases from 30°. to 90°..<br>2. At angle of tilt of 90°, the energy received is less than 16 MJ (the lowest in all the 4 months)<br>3. At angle of tilt of 30°, the energy received is the highest in all the months April to July | [1] any one reasonable similarity |
| **11(b)(ii)** | 1. At angle of tilt of 0°, the energy received is much higher of more than 25 MJ for May to July but not April<br>2. For every 10° increase in the angle of tilt, the amount of increase or decrease in energy received is not the same for each month. | [1] any one reasonable difference |
| **11(c)** | At 30°, the sum of energy received from June to Sept is 29.2 + 29.2 + 25.9 + 21.6 = 105.9 MJ<br>At 40°, the sum of energy received from June to Sept is 27.4 + 27.4 + 26.3 + 22.3 = 103.4 MJ<br>Hence 30° is a better tilt angle as the collector will receive the most energy | <br><br>[1]<br>[1] |
| **11(d)** | It could be a cloudy / rainy month with not much solar energy received. | [1] accept any reasonable answer |
| **11(e)(i)** | The amount of solar energy received depends on the weather (amount of daylight), any clouds cover above the collector | [1] |
| **11(e)(ii)** | Energy output of the solar collector = 3.8 kW × 10 min × 60<br>= 2.28 MJ<br>Energy output = $mc\Delta\theta$<br>$2.28 \times 10^6 = 30 \times 4200 \times \Delta\theta$<br>$\Delta\theta$ = 18.1°C | [1]<br><br><br>[1] |
| **12(a)(i)** | Q is north pole and R is south pole | [1] for both correct |
| **12(a)(ii)** | The soft iron core will concentrate the magnetic field lines and increase the magnetic field strength of the solenoid. | [1] |

| | | |
|---|---|---|
| **12(b)(i)** |  <br>Correct downwards direction | [1] |
| **12(b)(ii)** | There is a combined magnetic field between that due to the two electromagnets and that due to the current carrying conductor AB.<br>The resultant magnetic field above AB is stronger and the resultant magnetic field below AB is weaker.<br>The difference between the magnetic field strength around the wire AB causes a net force to act on the wire downwards. | [1]<br>[1] |
| **12(b)(iii)** | Increase the strength of the magnetic field by the electromagnets (increase the number of turns per unit length),<br>and increase the current flowing through the wire AB (increase the voltage of the battery). | [1]<br>[1] |
| **12(b)(iv)** | Switch the polarity of the magnets by reversing windings on the solenoid (Not acceptable - switching the polarity of the battery) | [1] |
| **12(c)(i)** | The split-ring commutator changes its contact position with the carbon brushes and so reverses the direction of the current flowing in AB. | [1] |
| **12(c)(ii)** | With the direction of the current flowing in AB reversed, the force acting on AB is reversed. | [1] |
| **EITHER** | | |
| **13(a)** | The gradient of the displacement-time graph at 0.4 s is zero, which shows that the velocity is zero. | [1] |

| | | |
|---|---|---|
| **13(b)(i)** | velocity / m $s^{-1}$<br>  <br> | [1] |
| **13(b)(ii)** | The <u>acceleration remains constant</u> as the ball continues to fall with negative velocity. | [1] any reasonable answer |
| **13(c)(i)** | gradient $= -10$<br>$\frac{u-0}{0-0.4} = -10$<br>$u = 4.0$ m $s^{-1}$ | [1]<br>[1] |
| **13(c)(ii)** | distance moved upwards<br>= area under graph from 0 s to 0.4 s<br>$= \frac{1}{2} \times 0.4 \times 4.0$<br>$= 0.80$ m<br><br>$h = 1.8 - 0.80$<br>$h = 1.0$ m | [1]<br>[1]<br><br>[1] |
| **13(d)** | The <u>velocity remains constant</u> and the <u>acceleration is zero</u>. | [2] |
| **OR** | | |
| **13(a)(i)** | From 0 to 0.2 V, the <u>current is zero</u> and so the <u>resistance of the diode is infinite</u>.<br><br>From 0.2 V to 1.0 V, the <u>current increases at an increasing rate</u> (with respect to p.d.) and the <u>resistance of the diode decreases</u>. | [1]<br><br>[1] |
| **13(a)(ii)** | $R = \frac{0.8}{4.4 \times 10^{-3}}$<br>$R \approx 182\ \Omega$ | [1]<br><br>[1] |

| | | |
|---|---|---|
| **13(b)(i)** |  | [1] diode<br>[1] ammeter and voltmeter |
| **13(b)(ii)** | When the slider is placed at B, the p.d. across the diode is zero and the current flowing through it can be measured.<br><br>As the slider is moved towards A, the p.d. across the diode increases to 1.5 V and the corresponding current values can be measured. | [1]<br><br>[1] |
| **13(c)** | The resistance of the variable resistor X is too small.<br>As the slider moves towards B, there could be no common value of current flowing through both X and the diode. | [1]<br>[1]<br><br>Accept any other reasonable answer. |