Class/ Index Number	Centre Number/ 'O' Level Index Number	Name
/	/	

新加坡海星中学

MARIS STELLA HIGH SCHOOL
PRELIMINARY EXAMINATION
SECONDARY FOUR

PHYSICS **6091/01**

Paper 1 Multiple Choice **3 September 2025**

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 class, index number, Centre number, O level index number and name in the spaces at the top of this page.

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

The total marks for this paper is 40.

At the end of the examination, hand in the following separately:
(1) Multiple Choice Answer Sheet
(2) Question Paper

1 Max Planck's equation of radiation states that the energy, E, of electromagnetic waves is equal to the product of Planck's constant, h and the frequency, f of the electromagnetic wave. The equation is $E=hf$.

What is the unit of Planck's constant, h, expressed as SI **base** units?

A J / Hz

B m s^2 / kg^3

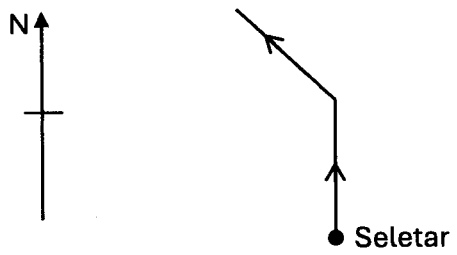
C kg m^2 / s

D kg m^3 / s^2

2 An air-traffic control centre at Seletar looks after aircraft within a 400 km radius of Singapore.

A small aircraft, flying due north at 300 km/h, passes over Seletar at 12:00pm. It carries enough fuel for another 550 km of flying.

At 12:30pm, air traffic control instructs the pilot to turn through 45° onto a north-westerly bearing. The aircraft continues at 300 km/h until 1:30pm.



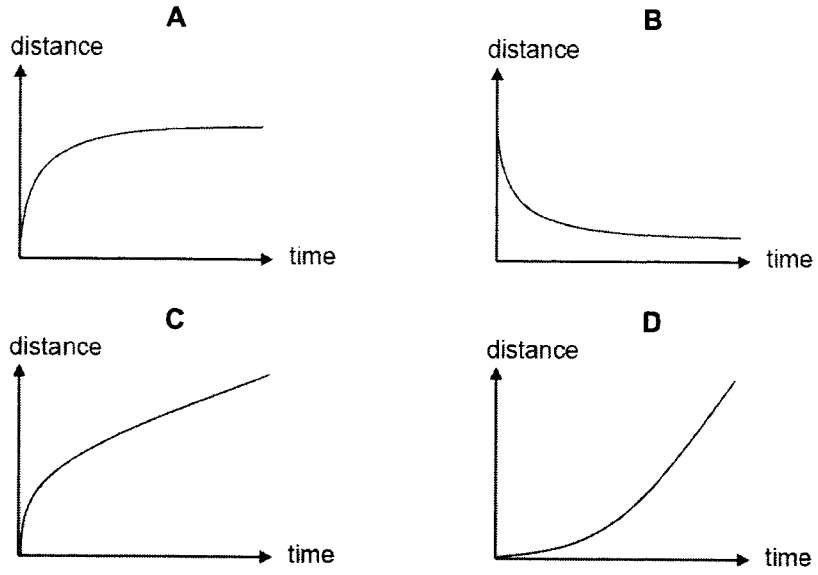
not to scale

At 1:30pm the aircraft is still 150 km from its destination.

What is the location of the aircraft and which action is required?

	location of aircraft	action required
A	outside Seletar's air-traffic control space	carry on to destination
B	outside Seletar's air-traffic control space	make an emergency landing before getting to destination due to insufficient fuel
C	within Seletar's air-traffic control space	carry on to destination
D	within Seletar's air-traffic control space	make an emergency landing before getting to destination due to insufficient fuel

3 Which of the following distance-time graphs best describes a skydiver jumping off a plane till reaching terminal velocity?



4 At the top of a cliff of height 100 m, a girl throws a rock upwards with a velocity of 15 m/s.

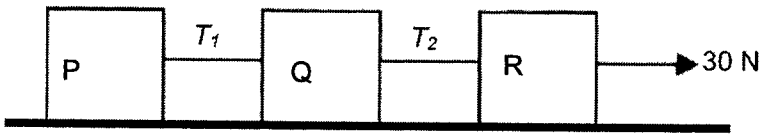
How much time later will the rock hit the bottom of the cliff? Ignore the effects of air resistance and take acceleration due to gravity as $g = 10\ m/s^2$.

A 6.2 s **B** 6.8 s

C 7.5 s **D** 8.2 s

5 P, Q and R are three identical blocks resting on a smooth surface as shown below.

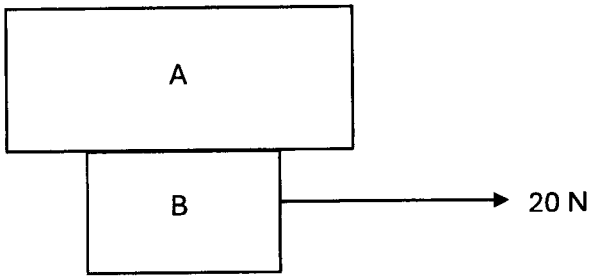
The blocks are joined by strings with tensions T_1 and T_2 when a force of 30 N is applied at one end as shown in the diagram below.



What are the tensions T_1, and T_2 in the strings?

	T_1	T_2
A	15 N	15 N
B	30 N	30 N
C	10 N	20 N
D	10 N	15 N

6 Two objects, A (mass 6.0 kg) and B (mass 4.0 kg), are stacked one on top of the other as shown.



B is pulled by a horizontal force of 20 N and all surfaces are frictionless.

What is the acceleration of A?

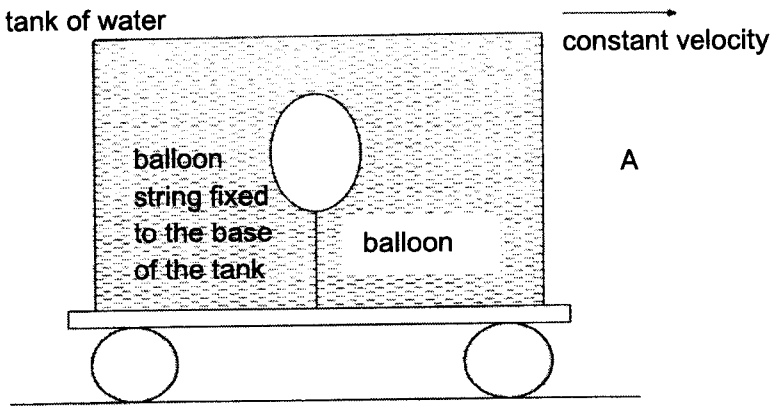
A 0 m/s^2

B 2.0 m/s^2

C 3.3 m/s^2

D 5.0 m/s^2

7 A sealed tank filled to the brim with water is mounted on wheels. A balloon is fixed at the base of the tank. The tank is initially moving at a constant velocity.



Which statement correctly describes the motion of the balloon when the tank starts to slow down?

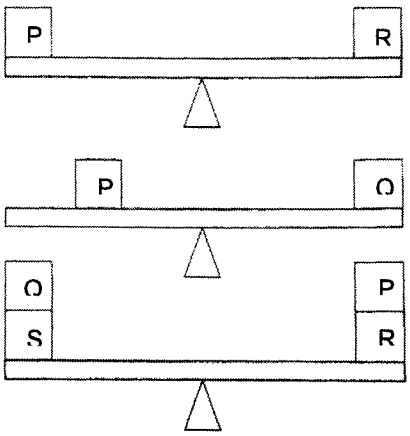
A The balloon will move backward.

B The balloon will move forward.

C The balloon will remain in its original position.

D The balloon will start to oscillate back and forth.

8 Four cubes P, Q, R and S are used to balance a uniform beam pivoted about its mid-point. They have the same volume but different masses.



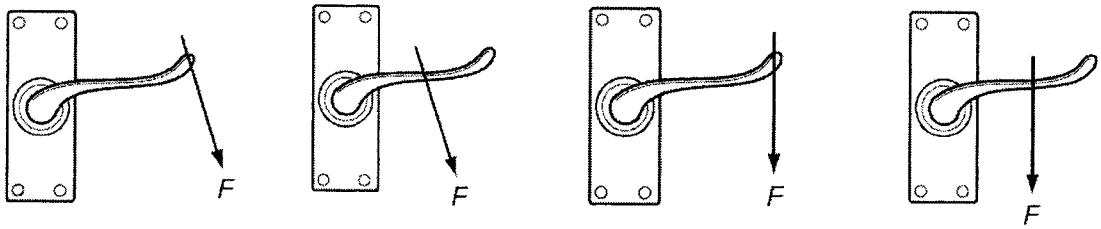
Which cube is the heaviest?

A P **B** Q **C** R **D** S

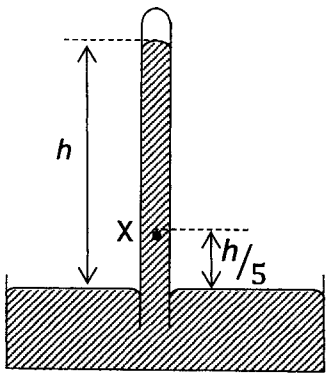
9 The diagrams show a force of magnitude F being applied to the same door handle.

Which diagram shows the greatest moment?

A **B** **C** **D**



10 The diagram shows a mercury barometer.

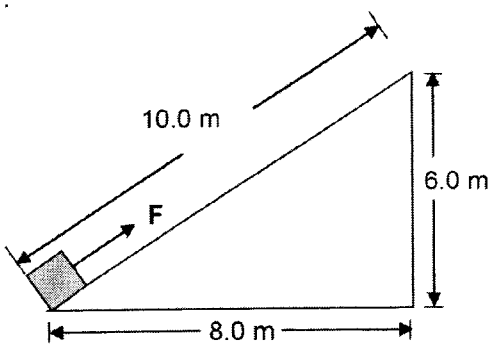


Given that the height of the mercury barometer is h when the atmospheric pressure is 100 000 Pa, what is the pressure at point X?

A 20 000 Pa **B** 80 000 Pa

C 120 000 Pa **D** 180 000 Pa

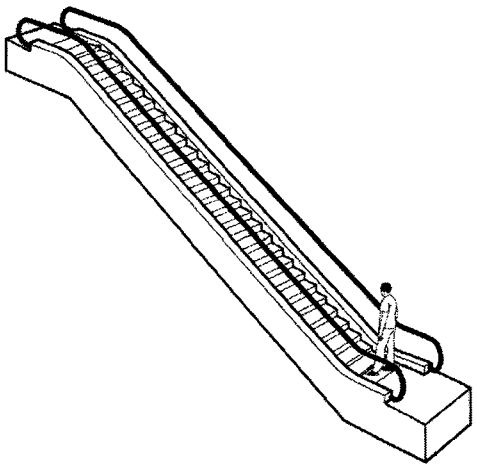
11 The figure below shows a box of mass 6.0 kg being dragged to the top of a slope at a constant speed by a constant force *F*.



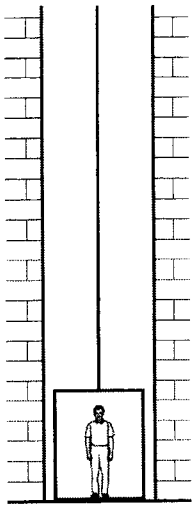
Given that the total work done against friction is 160 J and the gravitational field strength is 10 N/kg, what is the value of force *F*?

A 16 N **B** 20 N **C** 52 N **D** 60 N

12 A man can either take an escalator or a lift to travel up between two floors in a hotel.



escalator



lift

The escalator takes 20 seconds to carry the man between the two floors. The useful work done against gravity is *W*. The useful power developed is *P*. The lift takes 30 seconds to carry the same man between the same two floors.

How much useful work against gravity is done by the lift, and how much useful power is developed by the lift?

	useful work done against gravity by lift	useful power developed by lift
A	more than *W*	less than *P*
B	more than *W*	*P*
C	*W*	less than *P*
D	*W*	*P*

13 When a hot gas is left to cool, its internal energy decreases.

What causes this?

A a decrease in the kinetic energy of the gas particles

B a decrease in the gravitational potential energy of the gas particles

C an increase in the average speed of the gas particles

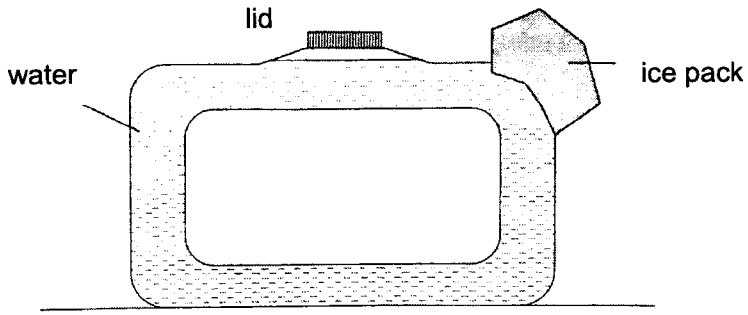
D an increase in the average distance of separation of the gas particles

14 An experiment is carried out to investigate the rate of transfer of internal energy by conduction and radiation through different mediums – mercury, vacuum and wood.

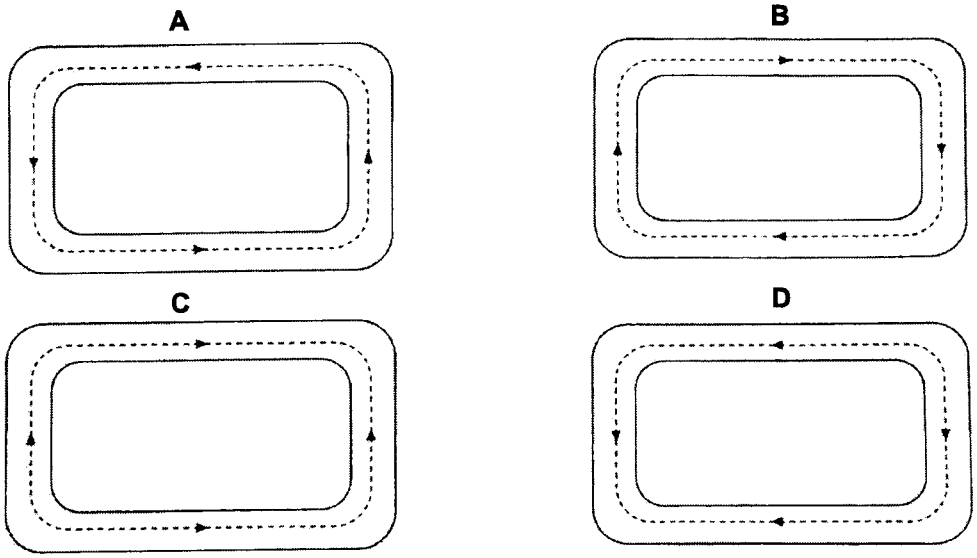
Which mediums show the greatest rate of transfer of internal energy by conduction and radiation?

	conduction	**radiation**
A	mercury	vacuum
B	vacuum	mercury
C	vacuum	wood
D	wood	vacuum

15 A student filled an upright ring-shaped container completely with warm water. He then placed a pack of ice at a corner of the container.



Which is a correct illustration of the convection current that was set up?



16 Two different liquids, P and Q with the same mass and initial temperature, are heated by the same heat source. Liquid P reaches a temperature of 80°C faster than liquid Q.

This shows that

A liquid P has a higher specific heat capacity than liquid Q.

B liquid P has a lower specific heat capacity than liquid Q.

C liquid P has a higher specific heat of vapourisation than liquid Q.

D liquid P has a lower specific heat of vapourisation than liquid Q.

17 A wave in the sea collides with a cliff.

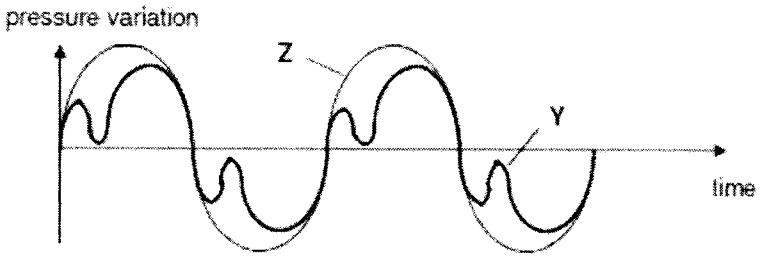
A crest of the wave hits the cliff once every 6.0 s.

The horizontal distance between a crest and the adjacent trough of the wave is 4.5 m.

What is the speed of the wave?

A 0.67 m / s **B** 0.75 m / s **C** 1.3 m / s **D** 1.5 m / s

18 The figure below shows two waveforms produced by a flute (Y) and tuning fork (Z) played by two students.



How do the loudness and pitch of the sound from the tuning fork Z compare to that of the flute Y?

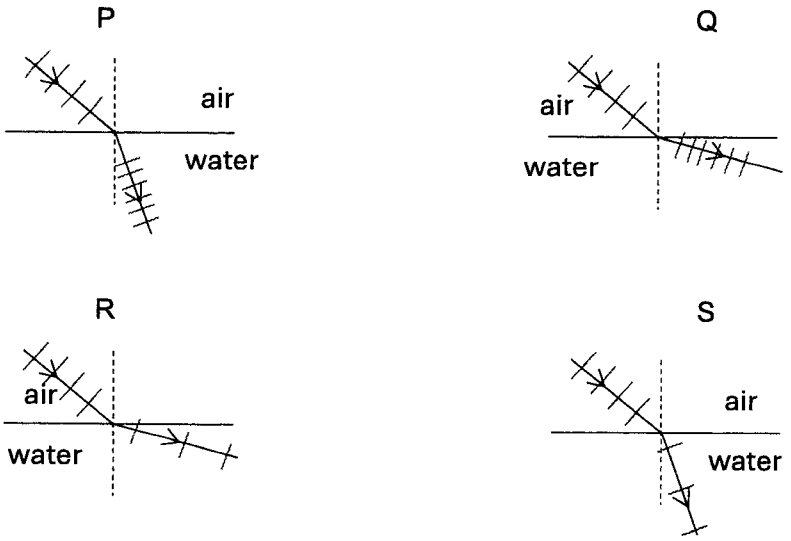
A The loudness of Y is lower but its pitch is the same as Z.

B Both Y and Z have the same loudness and pitch.

C The loudness of Y is higher but its pitch is lower than Z.

D The loudness of Y is the lower but its pitch is higher than Z.

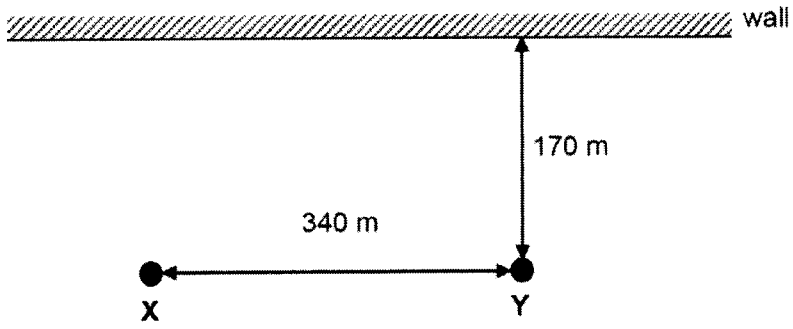
19 The diagrams below show the waves travelling from air to water. The wave direction and wavefronts along the wave are also shown in each diagram.



Which of the diagrams above correctly represent light and sound waves as it travels from air to water?

	light wave	sound wave
A	P	Q
B	S	Q
C	P	R
D	S	R

20 The diagram shows two persons (X and Y) standing 340 m apart and 170 m away from the wall.



When person X fires a gun, person Y hears the gunshot twice.

Given that the speed of sound in air is 340 m/s, what is the time interval between the two gunshot sounds heard by person Y?

A 0.41 s **B** 0.50 s **C** 0.62 s **D** 1.24 s

21 What is one of the uses of ultrasound?

A cleaning jewellery

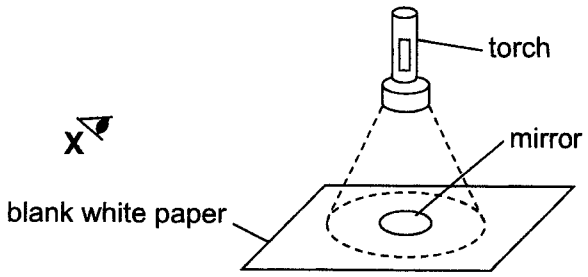
B fluorescent tubes

C optical fibres

D sunbeds

22 One night, Chester switched off all the lights in his room and placed a large piece of blank white paper onto his table.

He placed a small mirror, with its reflecting surface facing upwards, at the centre of the paper. Chester then shined a torch directly above the mirror as shown in the diagram below.



What would Chester see if he looks at the setup at position **X**?

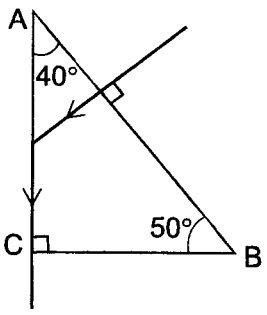
A The mirror appears brighter than the paper as most of the light rays undergo regular reflection into his eyes.

B The mirror appears brighter than the paper as most of the light rays undergo diffused reflection into his eyes.

C The paper appears brighter than the mirror as most of the light rays undergo regular reflection into his eyes.

D The paper appears brighter than the mirror as most of the light rays undergo diffused reflection into his eyes.

23 The diagram shows a ray of light entering a glass prism at the surface AB and travelling along the surface AC.



What is the refractive index of the glass prism?

A 1.31 **B** 1.42 **C** 1.50 **D** 1.56

24 Applications use different components of the electromagnetic spectrum.

Which shows correct applications for X-rays, ultraviolet light and microwaves?

	X-rays	ultraviolet light	microwaves
A	mobile phone	fluorescent tube	intruder alarm
B	killing cancerous cells	sterilising surgical instruments	satellite television
C	medical imaging	television controller	sunbed
D	sterilising surgical instruments	television controller	detecting cracks in metal

25 An electrically charged plastic ball is dropped from rest.

Which types of fields are caused by the ball?

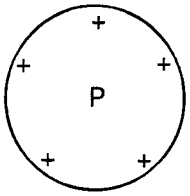
A gravitational and magnetic only

B electric and gravitational only

C electric and magnetic only

D electric, gravitational and magnetic

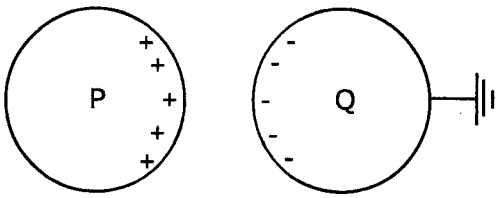
26 A metal sphere P has a positive charge distribution as shown.



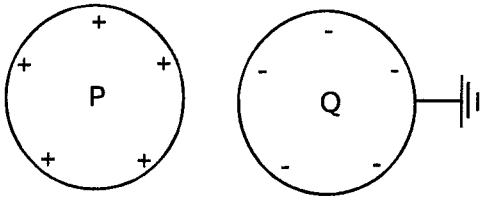
A similar sphere Q, connected to an earthing wire, is brought close to P.

Which diagram best shows the final distribution of charge between the two spheres?

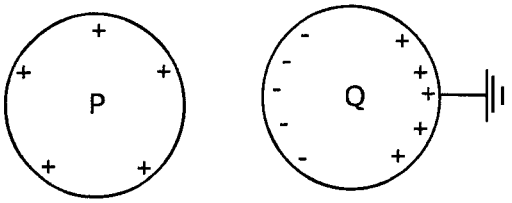
A



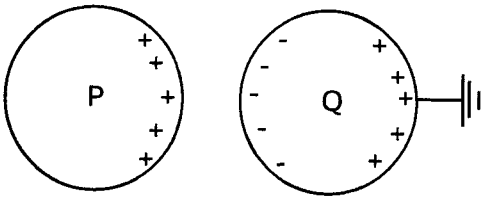
B



C



D



27 A student touches the body of a car that has become charged during its journey.

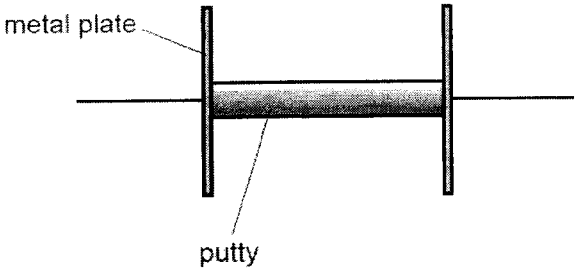
A current of 10 mA passes through him for 20 ms.

How much charge flows through him?

A 2.0×10^{-4} C **B** 0.50 C **C** 2.0 C **D** 200 C

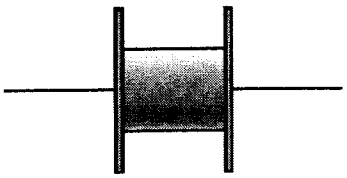
28 Conducting putty is a soft material which can easily be made into different shapes. It conducts electricity.

50 g of conducting putty is placed between two metal plates as shown.



With the putty arranged like this, it has a resistance of 8 Ω.

The plates are now squeezed together so that the distance between them is halved.

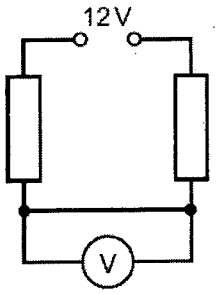


What is the resistance of the putty now?

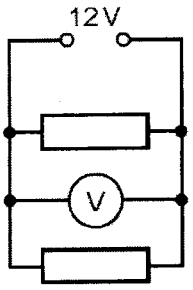
A 2 Ω **B** 4 Ω **C** 8 Ω **D** 16 Ω

29 In which circuit does the voltmeter not read 12 V?

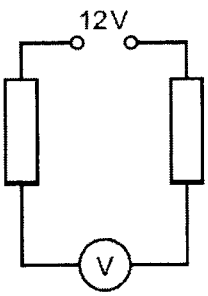
A



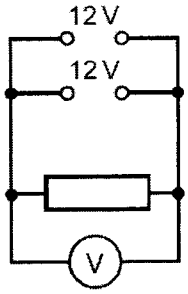
B



C



D



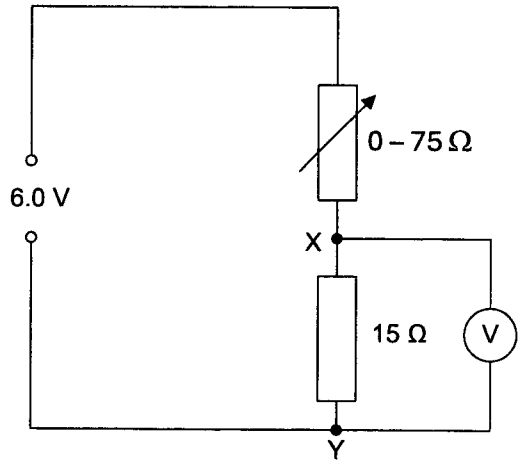
30 When the flash on a camera is used, a charge of 1.5 C flows for 0.0030 s through the flash lamp.

The average voltage across the flash lamp is 3600 V.

What is the energy supplied electrically to the flash lamp and what is the average power supplied?

	energy / J	power / W
A	2400	7.2
B	2400	800 000
C	5400	16.2
D	5400	1.8×10^6

31 The diagram shows two resistors in a circuit with a power supply and a voltmeter.



What is the range of voltages that can be obtained between points X and Y?

A 0.0 V to 1.0 V

B 0.0 V to 6.0 V

C 1.0 V to 3.0 V

D 1.0 V to 6.0 V

32 At a construction site, a metal scaffolding is firmly embedded in the damp ground. A builder holds a mains-operated electric drill in one hand, and the metal scaffolding with the other hand.

The power cable of the drill is damaged such that parts of the exposed cable enters the metal casing of the drill, where an earth wire is connected.

Which of the following could happen?

A A current could pass through the builder and electrocute him.

B A current in the scaffolding could heat him up and burn him.

C The large current could blow the fuse.

D The large current could make the motor spin too quickly.

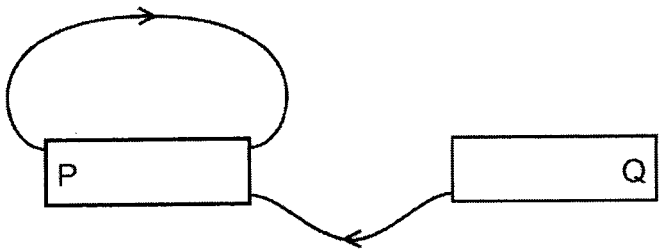
33 A 240 V mains circuit contains eight 60 W lamps in parallel.

At the time when the lamps are switched on, the filaments are cold and the current is four times as large as the final steady current in the circuit.

What is the initial current supplied by the mains?

A 0.25 A **B** 1.0 A **C** 2.0 A **D** 8.0 A

34 The diagram shows two magnetic field lines of the magnetic field around two bar magnets.

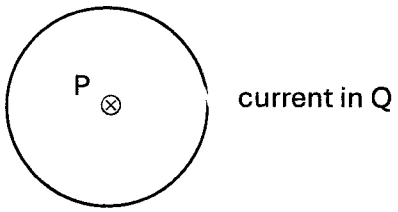


Which row shows the magnetic poles at end P and end Q of the two magnets?

	P	Q
A	N	N
B	N	S
C	S	N
D	S	S

35 A long straight wire P is placed along the axis of a flat circular coil Q.

The wire and the coil each carry a current as shown.



What can be deduced about the force acting on each part of Q due to the current in P?

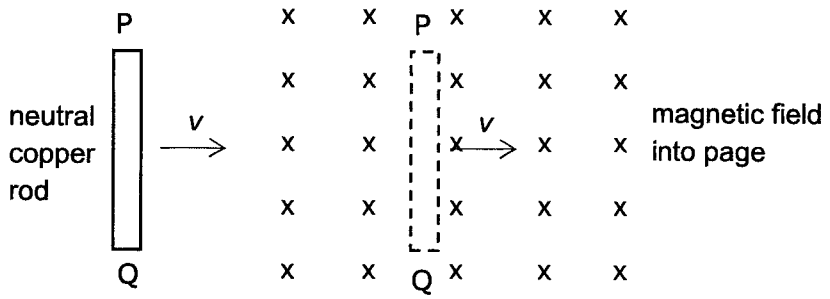
A The force is away from P.

B The force is towards P.

C The force is perpendicular to the plane in the diagram.

D There is no force in any direction.

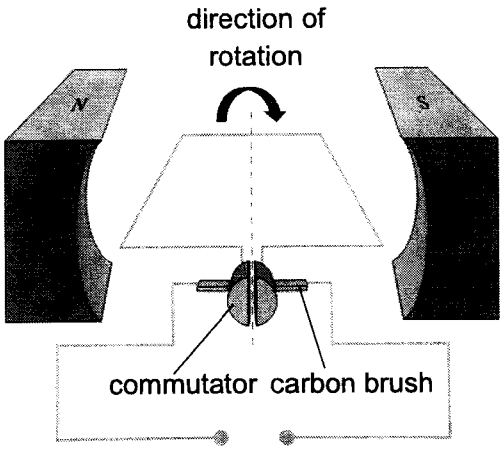
36 The diagram below shows an electrically neutral copper rod moving at speed *v* into a magnetic field. The direction of the field is into the page. P and Q are the ends of the copper rod.



Which of the following options best describes the net charge found at P and Q when the rod is moving and is completely inside the magnetic field?

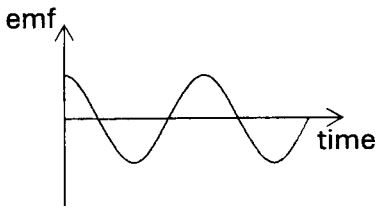
	P	Q
A	positive	postive
B	negative	positive
C	neutral	neutral
D	positive	negative

37 The figure shows an electrical generator, which consist of a rotating coil between a pair of permanent magnets.

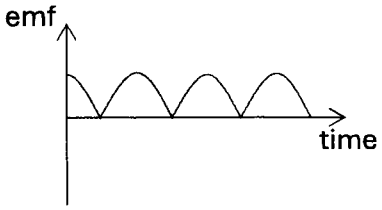


Which of the following graphs shows the variation of e.m.f. produced by the generator?

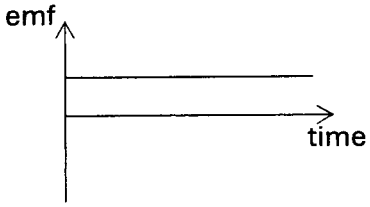
A



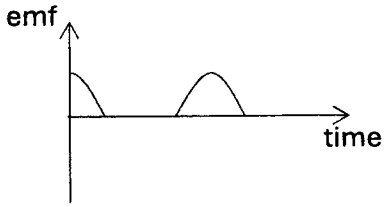
B



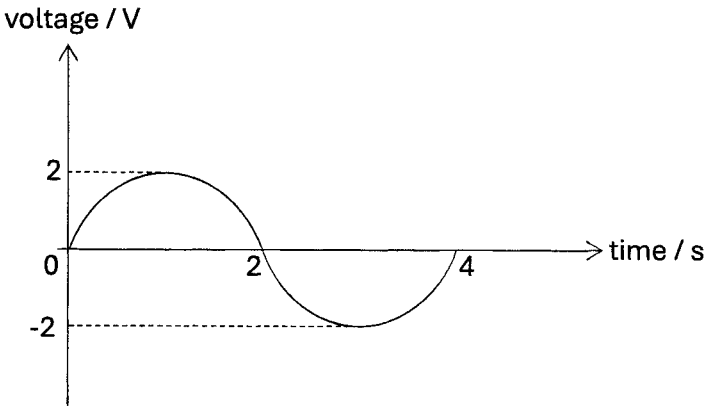
C



D



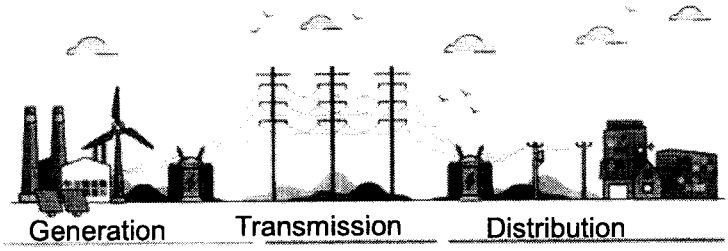
38 A simple a.c. generator produces a voltage which varies with time as shown in the graph below.



Which of the following reflects how the correct voltage varies with time when the generator rotates at half the original speed?

	maximum voltage / V	frequency / Hz
A	1	0.13
B	1	0.50
C	4	0.13
D	4	0.50

39 Long-distance power transmission occurs at high alternating voltages.



The following are reasons suggested to explain why high alternating voltages are used.

reason	
1	Alternating voltages can be stepped up or down efficiently by transformers.
2	For a given transmission power, the current will be reduced if a high voltage is adopted.
3	The power loss in the transmission cables will be reduced if a high voltage is adopted.

Which of the above reasons are correct?

A both reasons 1 & 2

B both reasons 1 & 3

C both reasons 2 & 3

D all the given reasons

40 A radioisotope has a half-life of 18 hours.

At 9:00 am on 1 May, a sample was prepared which contained 4.00 mg of the radioisotope.

At what time will the mass of the radioisotope remaining be 0.50 mg?

A 3:00 am on 2 May

B 3:00 pm on 3 May

C 9:00 am on 4 May

D 9:00 pm on 7 May

- End of paper -

Class / Index Number /	Centre Number / 'O' Level Index Number /	Name

新加坡海星中学

MARIS STELLA HIGH SCHOOL

PRELIMINARY EXAMINATION

SECONDARY FOUR

PHYSICS **6091/02**

Paper 2 Structured and Free Response **28 August 2025**

1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

Write your class, index number and name 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.
Write your answers in the spaces provided.

Section B
Answer one question.
Write your answers in the spaces provided. **Circle your choice** of question on the **cover page**.

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.
The total marks for this paper (Sections A and B) is 80.

For Examiner's Use	
Section A	70
Section B (11 / 12)	10
Total	80

This document consists of **22** printed pages.

Section A

Answer **all** questions in this section.

1 (a) A ball is thrown vertically down towards the ground and rebounds as illustrated in Fig. 1.1.

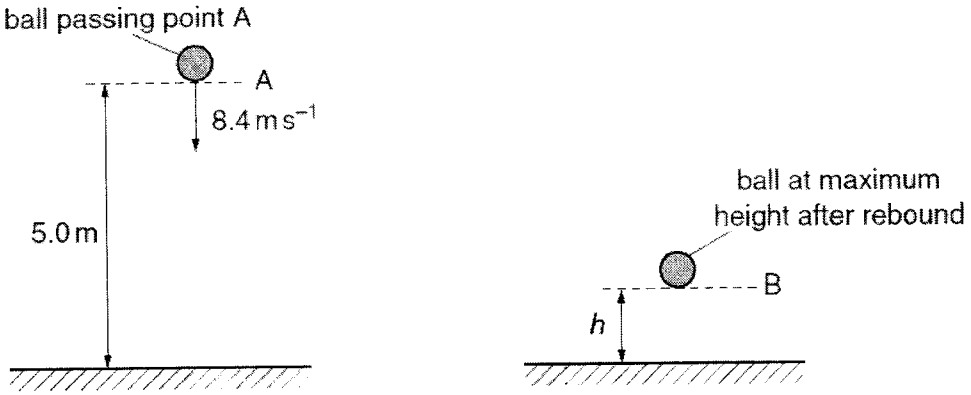


Fig. 1.1

As the ball passes A, it has a speed of 8.4 m s^{-1}. The height of A is 5.0 m above the ground. The ball hits the ground and rebounds to B. Assume that air resistance is negligible.

(i) Calculate the speed of the ball just before hitting the ground.

speed = ... [2]

(ii) Show that the time taken for the ball to reach the ground is 0.46 s.

[1]

(b) The ball rebounds vertically with a speed of 4.2 m s^{-1} as it leaves the ground. The time the ball is in contact with the ground is 20 ms. The ball rebounds to a maximum height *h*.

The ball passes A at time t = 0. On Fig. 1.2, plot a graph to show how the velocity *v* of the ball varies with time *t*. Continue the graph until the ball has rebounded from the ground and reaches B.

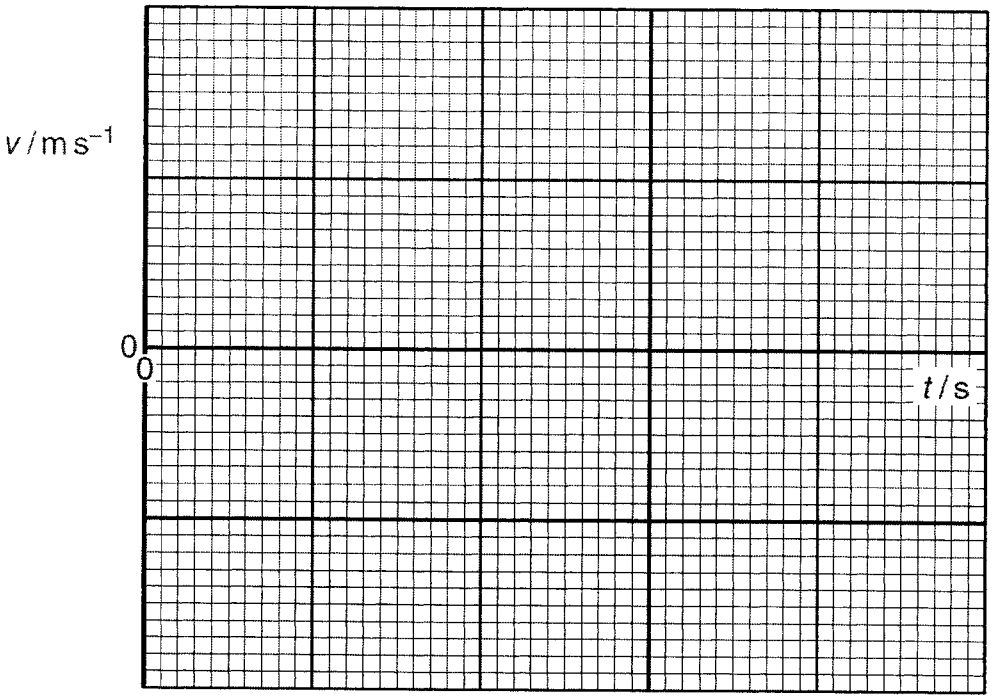


Fig. 1.2

[3]

[Total: 6]

2 Fig. 2.1 shows a 60.0 kg painter on a uniform scaffold of mass 25.0 kg and length 6.0 m, supported from above by ropes at points A and B. A 4.0 kg pail of paint is placed 1.0 m away from one of the supports.

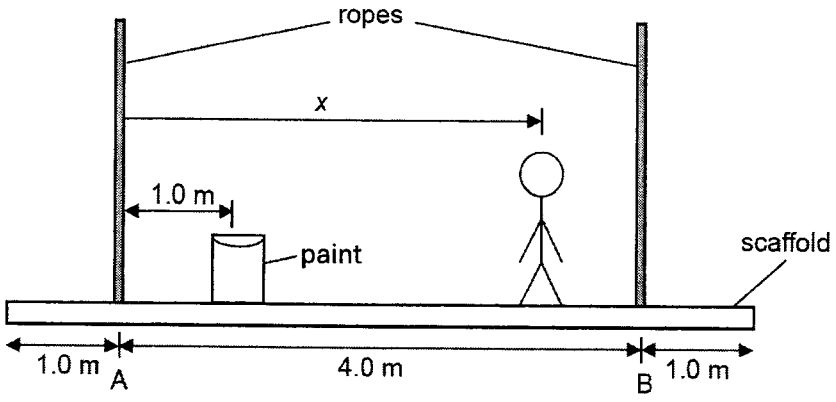


Fig. 2.1

(a) On Fig. 2.2, draw and label the forces acting on the scaffold. [2]

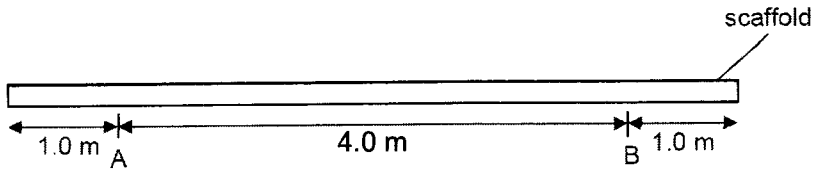


Fig. 2.2

(b) Given that the painter is standing at x = 3.6 m, determine

(i) the tension in the rope attached to point B,

tension = ... [2]

(ii) the tension in the rope attached to point A.

tension = ... [2]

(c) Describe and explain what would happen to the tension in both ropes as the painter walks slowly towards point A on the scaffold.

.....

.....

.....

.....

.....

..... [3]

[Total: 9]

3 Fig. 3.1 shows a gas sealed in container using a rubber bung. The container is connected to a mercury manometer.

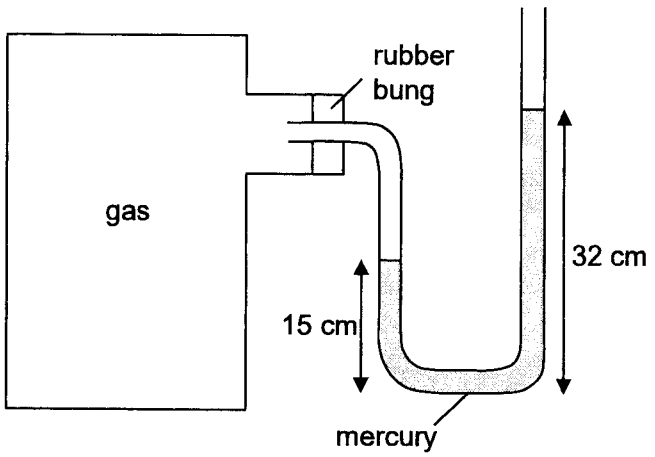


Fig. 3.1

(a) The atmospheric pressure is 76 cm Hg and density of mercury is 13 600 kg/m^3.

Calculate the pressure of the gas in pascal. Take *g* as 10 N/kg.

pressure = ...[2]

(b) The gas pressure exerted at the rubber bung is equal to the gas pressure exerted at the walls of the container. Explain why this is true, in terms of the particles of the gas.

.....

.....

.....

.....

.....

..... [3]

(c) A Physics student notices that small increases in gas pressure are not noticeable enough because the mercury level in the right column of the manometer rises very little.

Suggest and explain a change that the student can implement to the manometer so that the rise in level is more noticeable.

.....

.....

.....

.....

..... [2]

[Total: 7]

4 *Yunnan Guoqiao-mixian* (云南过桥米线) is a famous Chinese noodles dish.

The first step in preparing this dish is to cook a pot of chicken broth. A pot of water containing chicken is heated over a high flame until it boils. A low flame is then used to keep the soup boiling for 3.0 hours.

(a) Explain, in terms of molecules, why the temperature of the boiling soup remains unchanged, even though it is being heated.

.....

..... [1]

(b) **(i)** The power output of the low flame is 300 W. If 70% of the energy supplied is transferred to the surroundings, calculate the mass of soup that would be vaporized after being heated for 3.0 hours. Assume the specific latent heat of vaporization of the soup is 2.26×10^6 J kg^{-1}.

mass of soup vaporized = ... [2]

(ii) Explain, in terms of the amount of water molecules remaining in the soup, why it is preferable to use a low flame than a high flame to keep the soup boiling.

.....

..... [1]

(c) As shown in Fig. 4.1, customers ordering the *mixian* are served with the following:

a bowl of hot soup with a layer of oil on the surface,
a dish of thin slices of raw meat, and
a bowl of pre-cooked *mixian* (noodles)

Fig. 4.1

The meat is first put into the soup. After a while, the *mixian* is also added.

(i) Explain, in terms of thermal processes, why the meat must be sliced into thin pieces.

.....

..... [1]

(ii) Explain, in terms of thermal processes, the purpose of adding a layer of oil to the bowl.

.....

..... [1]

(iii) The following data are given:

Mass of the soup	= 1.0 kg
Initial temperature of the soup	= 97°C
Specific heat capacity of the soup	= 4200 J kg^{-1} K^{-1}
Mass of each slice of meat	= 0.020 kg
Initial temperature of the meat	= 27°C
Specific heat capacity of the meat	= 3500 J kg^{-1} K^{-1}

For health reasons, the meat has to be heated to a minimum temperature of 82°C.

Determine the maximum number of slices of meat that can be added to the soup. You may assume that there is no transfer of energy to the surroundings.

maximum number of meat slices = ... [2]

(iv) A customer first places the *mixian* into the soup before adding the meat.

Explain why this is undesirable.

.....

..... [1]

[Total: 9]

5 Fig. 5.1 shows an object placed 20 mm from a converging lens of focal length 40 mm.

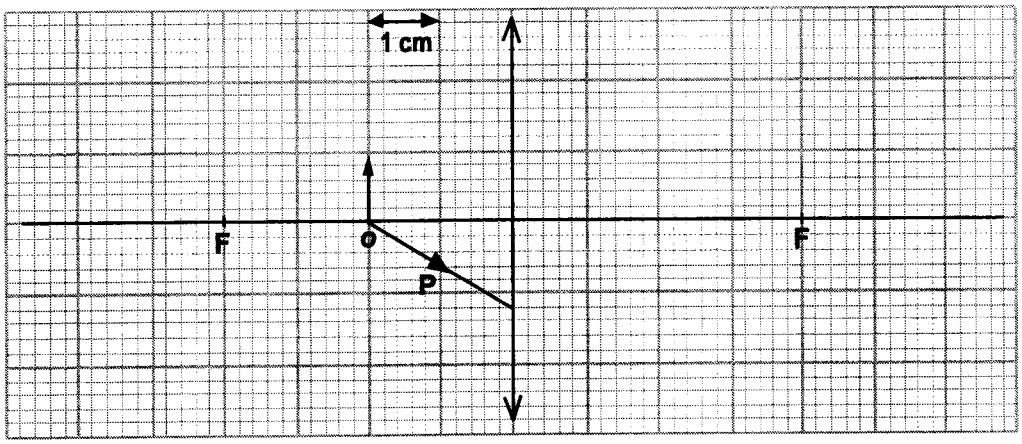


Fig. 5.1

(a) On Fig. 5.1, complete the diagram to locate the position of the image. [2]

(b) Ratio of image to object size is known as the magnification.

Using Fig. 5.1, determine the magnification.

magnification = ... [1]

(c) On Fig. 5.1, complete the path of the given ray P to show its passage through the lens and to the image. [1]

[Total: 4]

6 Fig. 6.1 shows a conducting sphere that has been given excess positive charges. The sphere is mounted on an insulating stand.

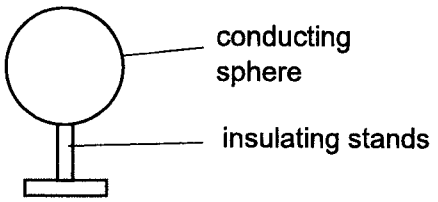


Fig. 6.1

(a) Draw in Fig. 6.1 the distribution of excess charges on the conducting sphere. [1]

(b) Draw in Fig. 6.1 the electric lines of force produced by these excess charges. [1]

(c) An electrically neutral aluminum ball suspended from a nylon string is brought near to the conducting sphere. It is attracted towards the conducting sphere but not touching the sphere as shown in Fig. 6.2.

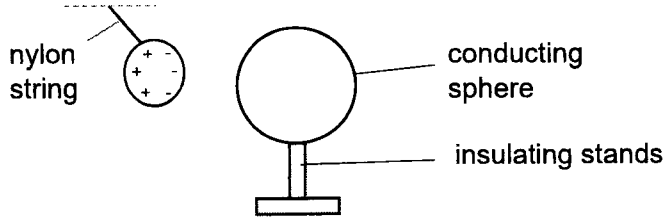


Fig. 6.2

Charges are induced on the aluminum ball as shown in Fig. 6.2.

Explain, in terms of electric forces, why the aluminum ball is attracted towards the positively charged conducting sphere.

.....

.....

.....

..... [2]

(d) The aluminum ball is moved to the right such that it is allowed to touch the conducting sphere as shown in Fig. 6.3.

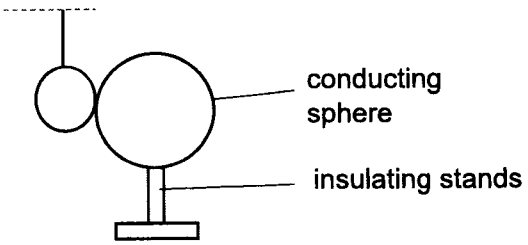


Fig. 6.3

On Fig. 6.3, draw the final position of the aluminum ball and label it as **(d)**.

Explain, in terms of charges, your answer for the final position of the aluminum ball.

.....

..... [2]

[Total: 6]

7 A battery of electromotive force 12 V and negligible internal resistance is connected to two resistors and a light-dependent resistor (LDR), as shown in Fig. 7.1.

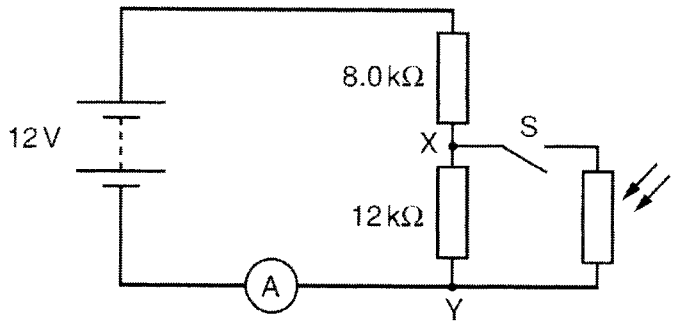


Fig. 7.1

An ammeter is connected in series with the battery. The LDR and switch S are connected across the points XY.

(a) The switch S is open. Calculate the potential difference (p.d.) across XY.

p. d. = ... [2]

(b) The switch S is closed. The resistance of the LDR is 4.0 kΩ. Calculate the current in the ammeter.

current = ... [2]

(c) The switch S remains closed. The intensity of the light on the LDR is increased. State and explain the change to

(i) the ammeter reading,

.....

.....

..... [2]

(ii) the p.d. across XY.

.....

.....

..... [2]

[Total: 8]

8 **(a)** Current is passing through an air-cored solenoid that is connected to a direct current (d.c.) emf voltage source as shown in Fig. 8.1.

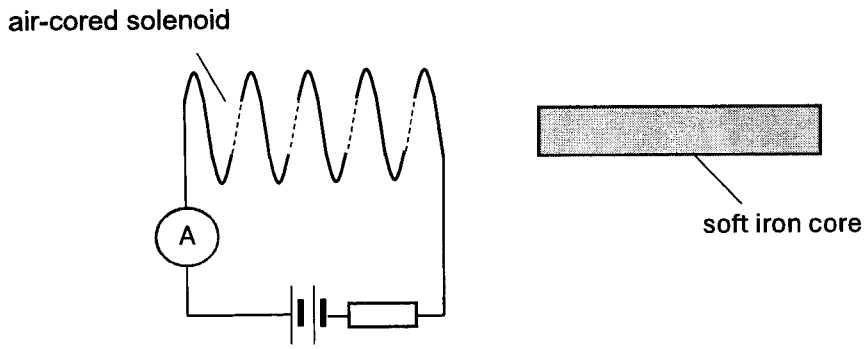


Fig. 8.1

Explain why reading on the ammeter decreases when an soft iron core is inserted into the solenoid.

.....

.....

.....

..... [2]

(b) The primary coil of a transformer is connected to the mains supply. The voltage of the a.c. mains supply is 240 V.

Fig. 8.2 is a diagram of the arrangement.

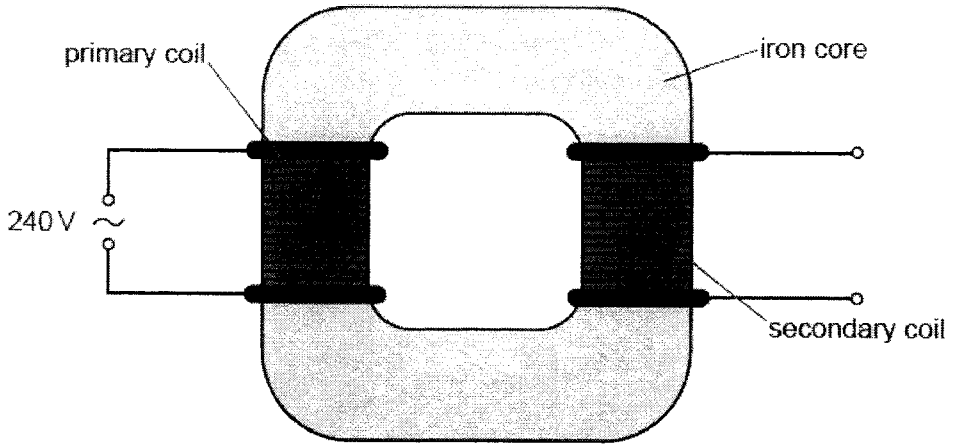


Fig. 8.2

There are 5600 turns on the primary coil of the transformer and 350 turns on the secondary coil.

The output of the transformer is connected to a 90 W filament lamp which operates at normal brightness.

Calculate the current in the lamp.

current = ... [3]

[Total: 5]

9 Sodium-24 is used in the treatment of various conditions. It is used to trace blood flow and locate obstructions in blood vessels.

The half-life of $^{24}_{11}Na$ is 15 hours. A sample of $^{24}_{11}Na$ having an activity of 32×10^3 disintegrations per second is injected into the blood stream of a patient.

After 45 hours, 6.0 cm^3 of blood is taken out from the patient's body and its activity is found to be 5.0 disintegrations per second.

(a) Deduce the number of half-lives elapsed after 45 hours.

..... [1]

(b) Estimate the volume of blood in the patient's body.

volume = ... [2]

(c) Suggest a reason for using $^{24}_{11}Na$ as a medical tracer.

.....

..... [1]

[Total: 4]

10 A light bulb manufacturer makes 240 V, 60 W bulbs, like the one shown in Fig. 10.1.

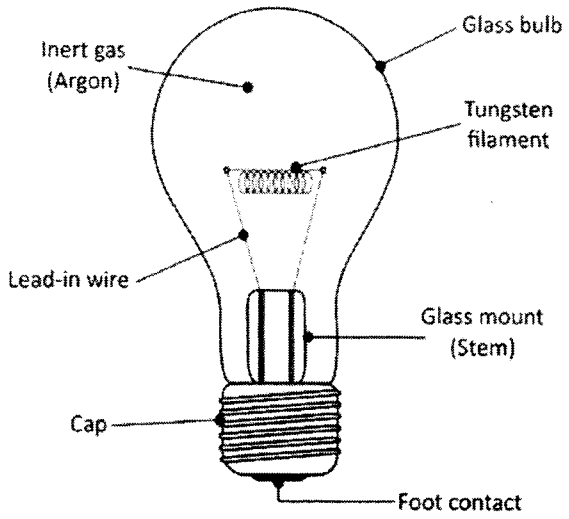


Fig. 10.1

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

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

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

The manufacturer is going to make the 3 bulbs using different length and diameters of tungsten filament as shown in Fig. 10.2. The filament B is used to manufacture the standard bulb operating at 2600 °C.

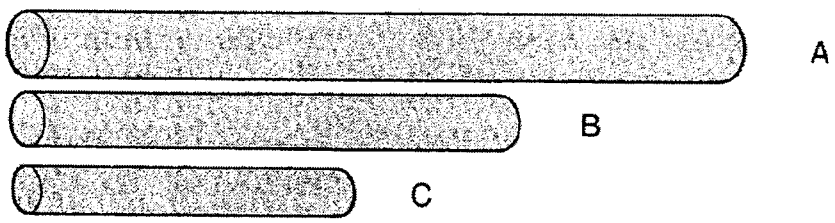


Fig. 10.2

The manufactured bulbs will have the same resistance.

(a) (i) State what is meant by the resistance of the bulb.

.....

.....[1]

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

resistance = ... [2]

(b) Calculate the diameter of tungsten wire needed to manufacture this bulb if the length of the filament wire in bulb B is 0.14 m. Leave your answer in mm.

diameter = ...mm [2]

(c) Explain how it is possible for the filaments in Fig. 10.2, to have the same resistance.

.....

.....[1]

(d) State and explain which filament should be used to manufacture the bulb that can last 2000 hours.

.....

.....

.....[2]

(e) Fig 10.3 compares the characteristics of the different filaments.

	A	B	C
resistance/ Ω			
diameter/ mm	0.0129		0.0113
length/ m		0.14	

Fig. 10.3

Complete the missing values in Fig. 10.3. [2]

(f) The bulb at the highest temperature lasts 500 hours. The cost of manufacturing each bulb is \$0.50 and each kilowatt-hour electricity costs \$0.172.

Determine the running cost when used for a duration of 2000 hours.

running cost = ... [2]

[Total: 12]

Section B

Answer **one** question in this section.

11 Fig. 11.1 shows a bar magnet dropped from rest through the centre of a coil of wire which is connected to a resistor and datalogger.

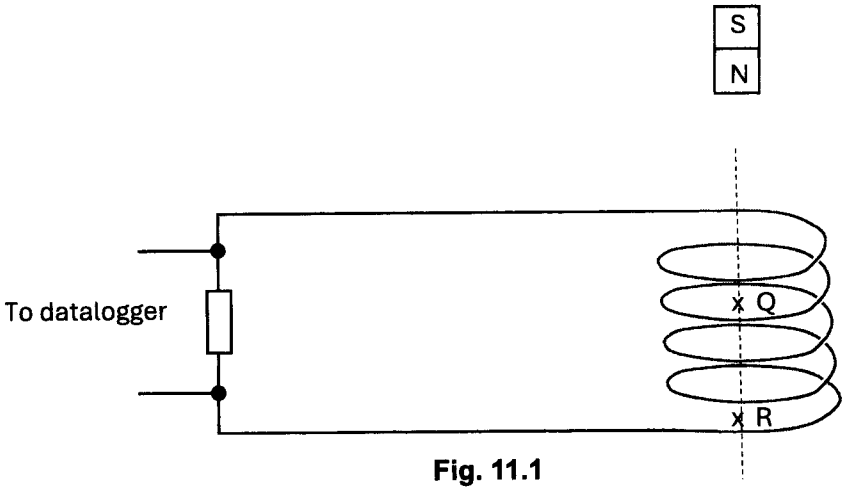


Fig. 11.1

(a) In Fig. 11.1, points Q and R represent positions lying along the central axis of the coil.

Identify and explain the position (Q or R) where the acceleration of the falling magnet is greater.

.....

.....

.....

..... [2]

(b) Fig. 11.2 shows the variation of the induced current in the resistor with time as the magnet falls.

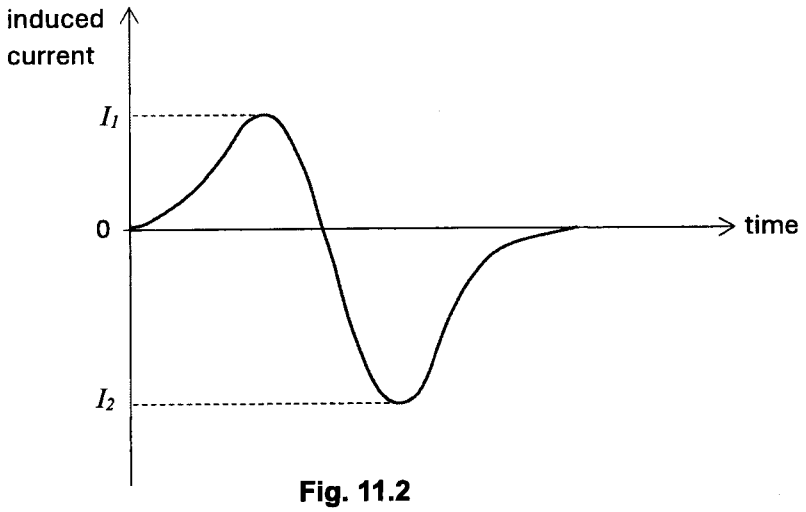


Fig. 11.2

(i) Explain why the magnitude of I_2 is greater than I_1.

.....

.....

.....

..... [2]

(ii) With reference to Fig. 11.2, explain why direction of the current changes in the coil as the magnet falls.

.....

.....

.....

..... [2]

(iii) The experiment is repeated with a length of coil of wire that is much longer than before, for instance 10 times or more than the magnet's length.

On the same axes in Fig. 11.2, sketch the expected current – time graph. [2]

(c) The original setup in **(a)** is now modified with a diode connected in series to the coil as shown in Fig. 11.3 below.

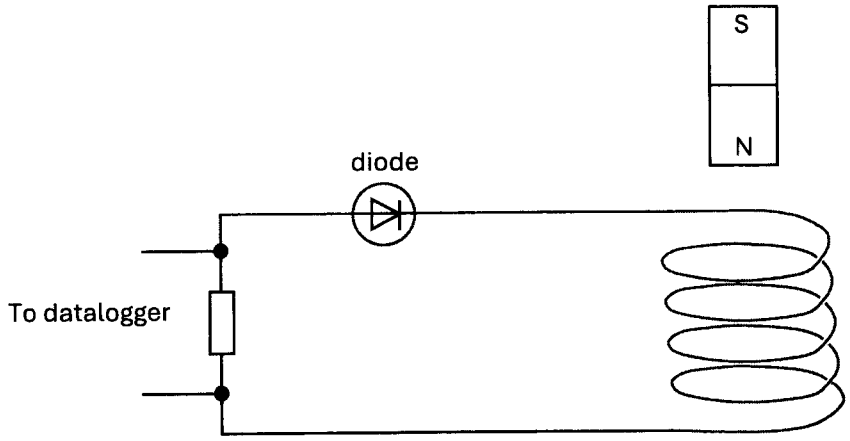


Fig. 11.3

Describe how the motion of the magnet and the current in the coil are being affected by the diode.

.....

.....

.....

..... [2]

[Total: 10]

12 Fig. 12.1a shows a smoke detector. The circuit within the detector is shown in Fig. 12.1b.

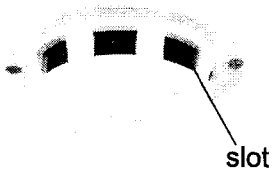


Fig. 12.1a

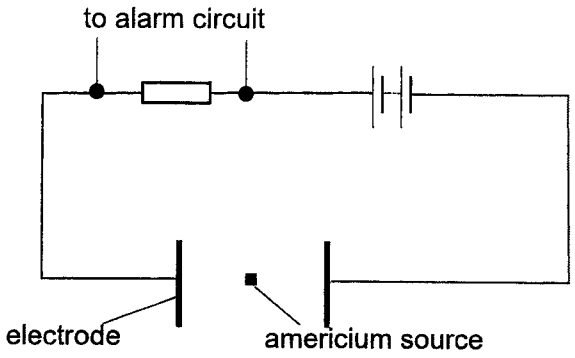


Fig. 12.1b

A small amount of the radioisotope americium-241 ($^{241}_{95}Am$) is placed between two electrodes. The two electrodes are connected to a battery and an alarm circuit. The detector has slots in it to allow air flow.

(a) An americium-241 nucleus decays by emitting an α-particle to form a daughter nucleus neptunium (Np), with a half-life of 432 years.

(i) Write down an equation for the decay of an americium-241 nucleus.

..... [1]

(ii) Deduce the number of neutrons in the daughter nucleus.

number of neutrons = ... [1]

(b) Under normal conditions, a small current flows in the circuit inside the detector. However, when smoke particles enter the detector, the current drops significantly. This triggers the alarm to sound.

(i) Explain why a current flows between the electrodes under normal conditions.

.....

..... [1]

(ii) Suggest one possible reason why the current drops when smoke particles enter the detector.

.....

..... [1]

(c) Explain why it is preferable for the radioactive source used in smoke detectors to have a long half-life.

.....

.....

.....

..... [2]

(d) Carbon-14 ($^{14}_{6}C$) is a radioisotope which decays by emitting β-particles and has a half-life of 5700 years.

Explain whether this source is suitable for use in smoke detectors.

.....

.....

.....

..... [2]

(e) Members of public are concerned about the biological hazards of radiation.

If you were the manufacturer of the smoke detector, describe how you would convince the public that using the detector will not pose a health hazard.

.....

.....

.....

..... [2]

[Total: 10]

- End of paper –

2025 MSHS 6091Physics
Prelim Exam Solutions

PAPER 1

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

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

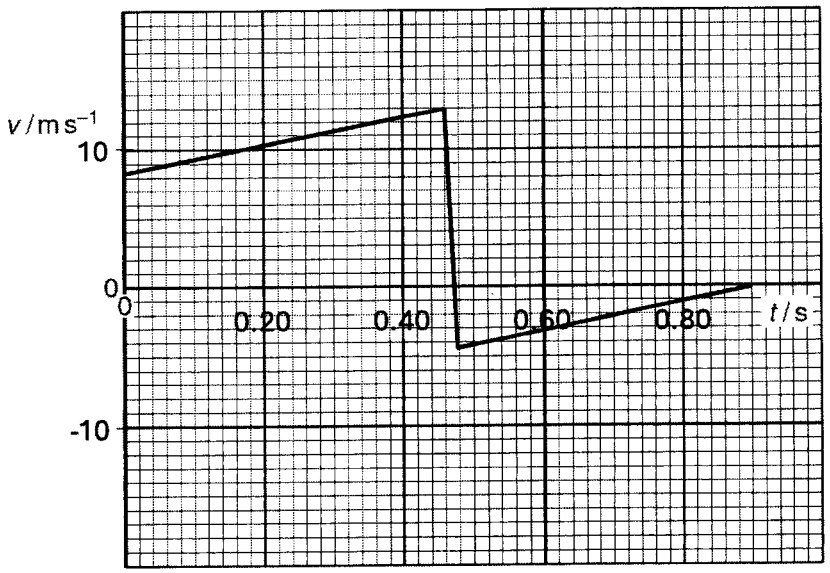
21	22	23	24	25	26	27	28	29	30
A	**A**	**D**	**B**	**D**	**A**	**A**	**A**	**A**	**D**

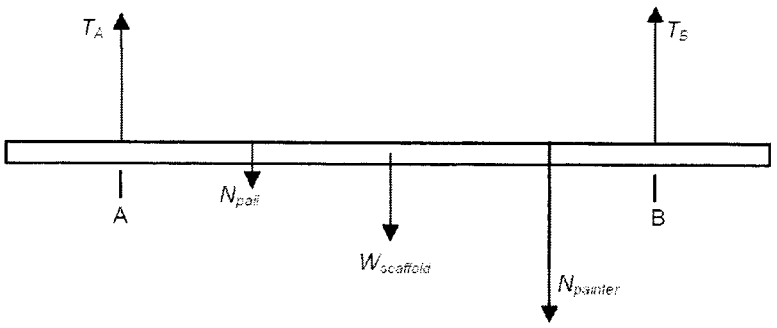
31	32	33	34	35	36	37	38	39	40
D	**C**	**D**	**B**	**D**	**D**	**B**	**A**	**D**	**B**

Deductions
U (units) – 1M for each occurrence capped at 1 M **per question**
SF (significant figures) & P (presentation) – 1M for each occurrence capped **at 1M per paper**

PAPER 2

SECTION A

1(ai)	Distance = Area under v-t graph $5 = \frac{1}{2}\left(\frac{\Delta v}{10}\right)(8.4 + 8.4 + \Delta v)$ $\Delta v^2 + 16.8\Delta v - 100 = 0$ Δv = 4.66 m/s v = 8.4 + 4.66 = 13 m/s	C1 A1
1(aii)	Acceleration = gradient of v-t graph $10 = \frac{13 - 8.4}{t}$ t = 0.46 s	C1 A1
1(b)	 reasonable shape suitable scale correctly plotted 1st and last points at (0,8.4) and (0.90,0) with non-vertical line at 0.46 s	 M1 A1 A1

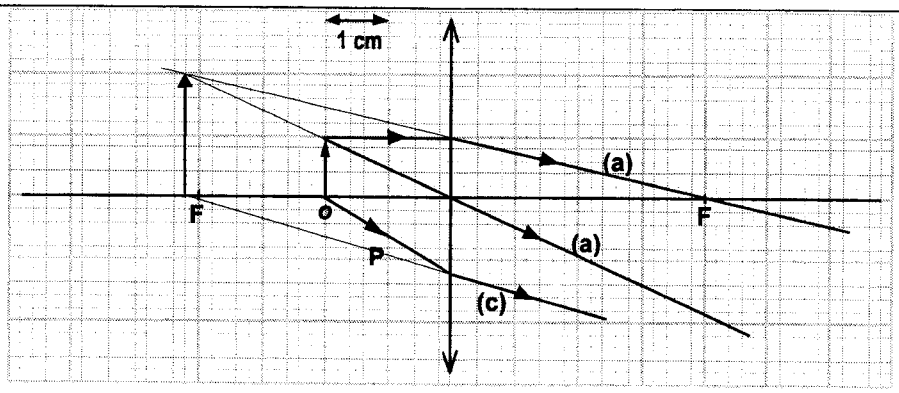
2(a)	 all correct any 3 correct	 A2 A1
2(bi)	Taking moments about point A, sum of anti-clockwise moments = sum of clockwise moments T_B x 4.0 = 4.0 x 10 x 1.0 +25.0 x 10 x 2.0 + 60.0 x 10 x 3.6 T_B = 675N	 C1 A1
2(bii)	Sum of forces acting on scaffold = 0 N Upward forces = downward forces $T_A + T_B$ = 4.0g + 25.0g + 60.0g T_A = 89 x 10 - 675 = 215 N	 C1 A1
2(c)	As the painter walks towards point A, the tension in rope A will increase and the tension in rope B will decrease. By considering the moment of the forces about point A, as x decreases, the sum of clockwise moment decreases. (Since the beam is in equilibrium), tension in rope B must also decrease. Hence the tension in rope A increases, as total downward force remains the constant.	 B1 B1 B1

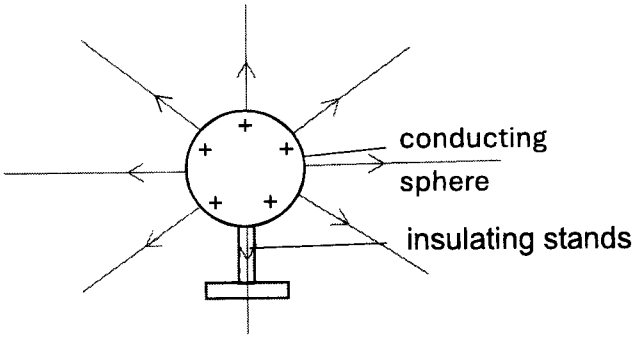
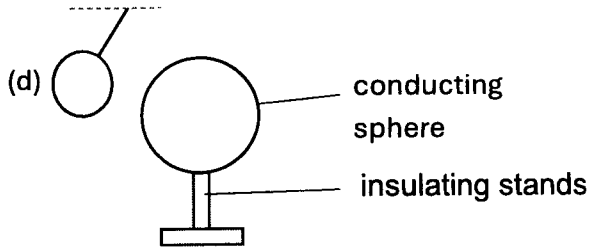
3(a)	height difference = 32 - 15 = 17 cm P_{gas} = 76 + 17 = 93 cmHg $P_{gas} = \rho gh$ = 13600 x 0.93 x 10 = 126000 Pa	 M1 A1

3(b)	The number of gas molecules per unit volume is equal both at the bung and at the walls. Hence, the frequency of collision of the gas molecules per unit area against the walls and the bung are equal, exerting equal force per unit area, which is the same gas pressure.	B1 B1 B1
3(c)	Use a liquid of smaller density. For any gas pressure increase, the height increase will be more because the density is lesser, according to the formula $P = \rho gh$.	B1 B1

4(a)	During the change in state, energy is being transferred to the internal potential store of the molecules. Since there is no increase in energy in the internal kinetic store, temperature remains constant.	B1
4(bi)	Energy transferred from flame = Energy transferred to soup $(Pt) \times 30\% = ml_v$ $(300)\ (3.0)\ (3600)\ (0.30) = m\ (2.26 \times 10^6)$ $m = 0.430$ kg	C1 A1
4(bii)	When high flame is used, large amount of soup will be vaporized in 3 hours. Hence a large amount of energy will be wasted in preparing the soup.	B1
4(ci)	• Meat is a poor conductor of heat. If it is too thick, its interior might not be fully cooked. • To increase the size of contact area between the meat and the soup. Either one of the above.	B1
4(cii)	The layer of oil helps to reduce the rate of evaporation from the soup. This reduces the energy transferred from the soup to the surroundings.	B1
4(ciii)	Let n be no. of slices of meat Energy transferred from soup = Energy transferred to meat slices	C1

	(1.0) (4200) (97 – 82) = (0.020) (3500) (82 – 27) n n = 16.4 Maximum no. of slices is 16.	A1
4(d)	Energy will be transferred from the soup to mixian which will reduce temperature of the soup significantly. This might result in the meat not able to reach 82 °C subsequently.	B1

5(a)	 Ray through optical centre drawn correctly and ray through focal point drawn correctly. Arrows included for light rays. Dotted lines used for construction.	B1 B1
5(b)	Magnification = 2 / 1 = 2	A1
5(c)	Ray P extends backwards from lens to base of image. Light ray from lens forms a straight line to the base of image.	B1

6(a) **6(b)**	At least 4 charges At least 4 lines (originate from centre)  	B1 B1
6(c)	Negative charges nearer to sphere Attractive force stronger than repulsive force	B1 B1
6(d)	 Aluminum drawn displaced to the left Negative charges move from aluminum to sphere, resulting in net positive charge of both objects.	 B1 B1
6(d)	Copper is a non-magnetic material whereas steel is a magnetic material. Steel will magnetise and interfere with the function of the solenoid.is this excess? Can delete?	B1

7(a)	total resistance = 20 kΩ current = 12 / 20 mA or potential divider formula p.d. = [12 / 20] × 12 = 7.2 V	C1 A1
7(b)	parallel resistance = 3 kΩ total resistance 8 + 3 = 11 kΩ current = 12 / 11 × 10^3 = 1.09 × 10^{-3} or 1.1 × 10^{-3} A	C1 A1
7(ci)	LDR resistance decreases total resistance (of circuit) is less hence current increases	M1 A1
7(cii)	resistance across XY is less less proportion of 12 V across XY hence p.d. is less	M1 A1

8(a)	Inserting the iron core gives rise to rate of change of flux within the solenoid and e.m.f is induced in solenoid induced e.m.f. opposes applied d.c. emf so current smaller/acts to reduce current	M1 A1
8(b)	$\frac{V_S}{V_P} = \frac{N_S}{N_P}$ $\frac{V_S}{240} = \frac{350}{5600}$ $V_S = 15$ V $I_S = P / V_S$ $= 90 / 15$ $= 6.0$ A	C1 C1 A1

9(a)	Number of half-lives elapsed = 45/15 = 3	A1
9(b)	Initial activity of 6.0 cm^3 blood = ((5 x 2) x 2) x 2 = 40 Let V be volume of blood $\frac{V}{6} = \frac{32 \times 10^3}{40}$ $V = 4800$ cm^3	C1 A1
9(c)	The half-life of 15 hours is short and hence the source will not remain inside the body for a long time.	B1

10(ai)	Resistance of the bulb is the ratio of the potential across the bulb to the current flowing through it.	B1
10(aii)	$R = \frac{V^2}{P}$ $R = \frac{240^2}{60}$ $R = 960\ \Omega$	 C1 A1
10(b)	$R = \frac{\rho l}{A}$	

	$R = \frac{\rho l}{(\pi/4)d^2}$ $d = \sqrt{\frac{\rho l}{(\pi/4)(R)}}$ $d = \sqrt{\frac{(7.9 \times 10^{-7})(0.14)}{(\pi/4)(960)}}$ d = 0.0121 mm	C1 A1
10(c)	By varying the length and cross-sectional area of the wires so that the ratio l/A remains constant.	B1
10(d)	Filament A. It has the lowest resistance per unit length. Hence power dissipated per unit length is the lowest and it will take a longer time to break.	B1 B1

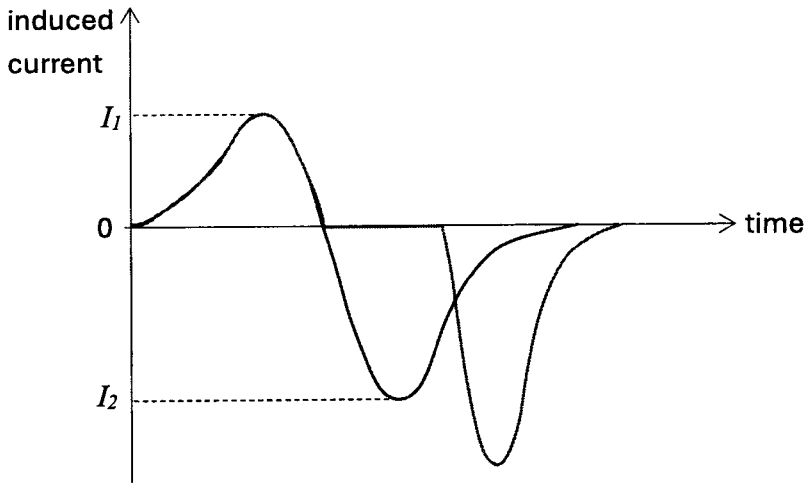
<table>
<tr><td>10(e)</td><td>
<table>
<tr><td></td><td>A</td><td>B</td><td>C</td></tr>
<tr><td>resistance/ Ω</td><td>960</td><td>960</td><td>960</td></tr>
<tr><td>diameter/ mm</td><td>0.0129</td><td>0.0121</td><td>0.0113</td></tr>
<tr><td>length/ m</td><td>0.158</td><td>0.14</td><td>0.122</td></tr>
</table>
All values correct

Three to five values correct
</td><td>A2

A1</td></tr>
<tr><td></td><td></td><td></td></tr>
<tr><td>10(f)</td><td>Running cost = cost of electrical consumption + cost to make bulbs
= ((60/1000) x 2000) x 0.172 + (2000/500) x 0.50
= $22.6</td><td>C1

A1</td></tr>
</table>

SECTION B

11(a)	The position with greatest acceleration is Q. At point Q, there is no net change in magnetic flux of the coil, hence there will not be e.m.f. or opposing magnetic field produced by the induced current to slow down the magnet.	B1
	When the magnet is just falling into (P) or out of the coil (R), it produces a change of magnetic flux within the coil. This induces a current in the coil which produces an opposing magnetic field to slow down the magnet according to Lenz's Law.	B1
11(bi)	As the magnet falls through the coil, it speeds up due to gravitational force, this results in a greater rate of change of magnetic flux.	B1
	Based on Faraday's Law, greater rate of change of magnetic flux results in greater induced e.m.f. and hence current.	B1
11(bii)	As the N-pole of the magnet approaches the coil, current flows within the coil to produce a N-pole at the top of the coil to repel the falling magnet.	B1
	When the S-pole of the magnet is leaving the coil, current flows in the opposite direction in the coil to produce a N-pole at the bottom of the coil to attract the falling magnet.	B1
11(biii)		
	No current between the two parts of the graph	B1
	No change to the part representing magnet just falling into the coil. Larger peak and shorter duration for the part representing magnet falling out of the coil.	B1
11(c)	Presence of the diode allows current to flow only in one direction.	

	Hence current is unable to flow within the coil when the magnet just falls through it. Therefore, the magnet does not encounter an opposing force when it is entering the coil. However, induced current in the coil is able to flow when the magnet is leaving it. Hence, it will produce a N-pole at the bottom to slow down the magnet when it is leaving the coil.	B1 B1

12(ai)	$^{241}_{95}\text{Am} \rightarrow {}^{237}_{93}\text{Np} + {}^{4}_{2}\propto$	B1
12(aii)	Number of neutrons = 237 – 93 = 144	A1
12(bi)	The α-particles emitted by the source will ionize the air molecules to produce ions. The ions are attracted to the electrode with an opposite charge. As a result, a current flows between the electrodes.	B1
12(bii)	The smoke particles block the movement of the ions. As a result, fewer ions reach the electrodes, so the current drops.	B1
12(c)	The activity of the radioactive source remain stable for a long period of time. So, the detector needs not be replaced frequently.	B1 B1
12(d)	As β-particles have a weak ionizing power, the current flowing between the electrodes will be extremely small. So, Carbon-14 is not suitable.	B1 B1
12(e)	Due to the small amount of radioactive material used, the radiation dose from the smoke detector is very small, moreover, the emitted α-particles have low penetrating ability, so the radioactive emissions are sealed and shielded preventing harmful radiation from escaping. Hence, using the detector will not pose any health hazard.	B1 B1