Paper 2A	☐ s.f. ☐ formula	50

Name:		Index Number:		Class:	

CATHOLIC HIGH SCHOOL
Preliminary Examination
Secondary 4 (O-Level Programme)

PHYSICS
6091/02

Paper 2 Theory

25 Aug 2023
1 hour 45 minutes

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

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.

Section B
Answer **all** questions. Question 12 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 only:

Section A	/ 50
Section B	/ 30
Total	**/ 80**

Overall	Marks	%
Paper 1	40	30%
Paper 2A	50	50%
Paper 2B	30	
Paper 3	40	20%

Section A

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

1 A rock of mass 7.5 kg is projected vertically upwards from the surface of planet X. The rock leaves the surface of planet X with a velocity of 4.0 m / s at time t = 0 s. The variation of velocity v with time t of the rock is shown in Fig. 1.1.

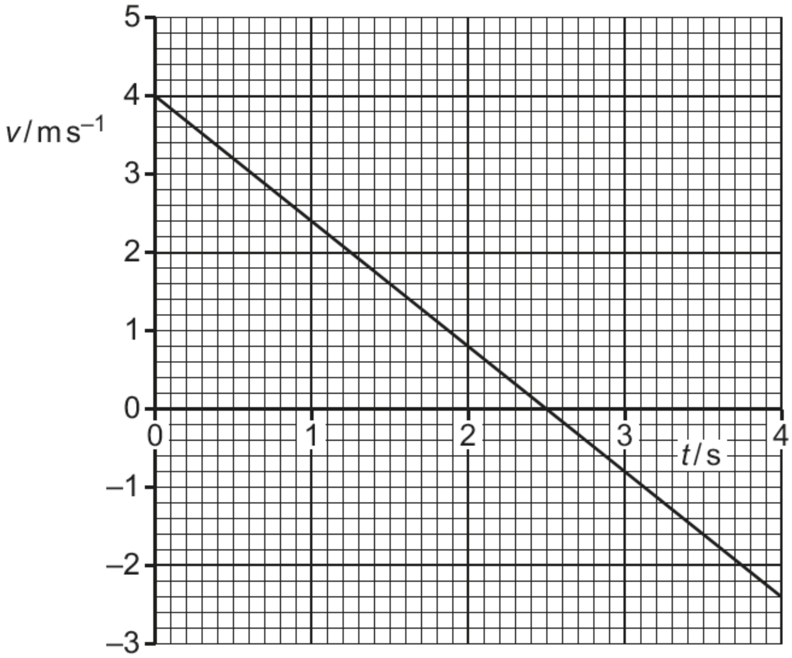

Fig. 1.1

Assume that the air resistance acting on the rock is zero.

(a) **(i)** Determine the height of the rock above the surface of planet X at time t = 2.5 s.

height = ... [2]

(ii) Determine the deceleration of the rock.

deceleration = ... [2]

(b) The rock is now thrown vertically upwards on another planet Y with an initial velocity of 4.0 m / s. Planet Y has the same gravitational field strength as planet X. Air resistance acting on the rock is **not** negligible.

(i) The resultant force acting on the rock is downwards and decreasing as it travels upwards.

On Fig. 1.1, draw the velocity-time graph of the rock on planet Y until it reaches the highest point.

[1]

(ii) Determine the magnitude of air resistance when the rock is travelling at terminal velocity at planet Y.

air resistance = ... [1]

2 Fig. 2.1 shows a rocket about to be launched.

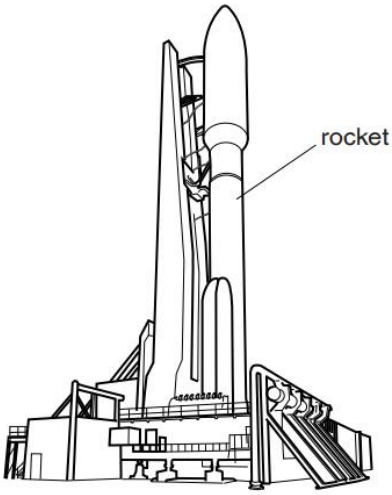

Fig. 2.1

The total mass of the rocket and its full load of fuel is 2.8×10^6 kg. The motor of the rocket provides a constant force.
The vertical acceleration of the rocket immediately after lift-off is 1.4 m / s^2.
The gravitational field strength of Earth is 10 N / kg.

(a) Calculate the constant force provided by the motor of the rocket.

constant force = ... [3]

(b) Suggest two reasons why the acceleration of the rocket increases as it rises above the Earth's surface.

....

....

.... [2]

3 A rod XY is pivoted at point P, as shown in Fig. 3.1.

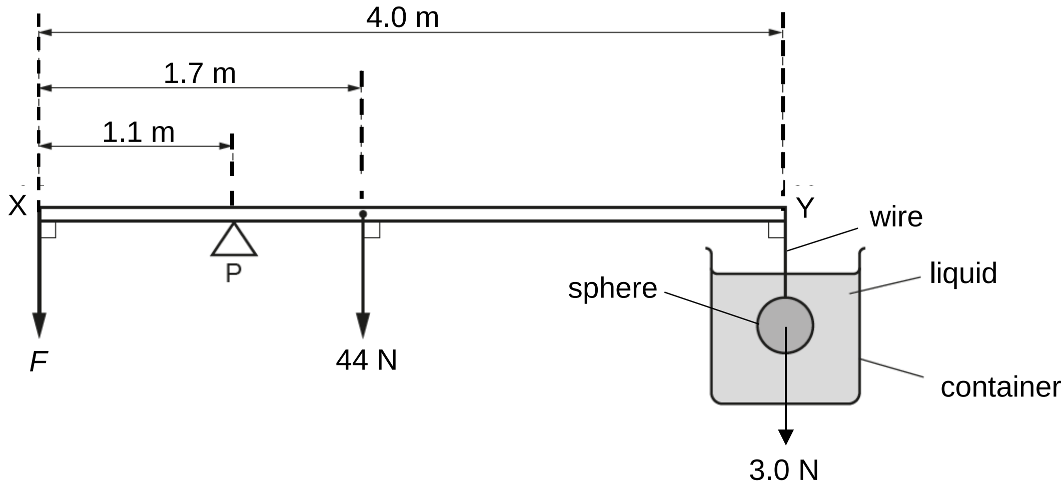

Fig. 3.1

The rod has a length of 4.0 m and its weight is 44 N. The centre of gravity of the rod is 1.7 m from end X of the rod. Point P is 1.1 m from end X.

A sphere hangs by a wire from end Y of the rod and is immersed in a liquid in a container. The weight of the sphere is 3.0 N. The weight of the wire is negligible.

A force *F* is applied vertically downwards at end X so that the horizontal rod is in equilibrium.

(a) **(i)** State what is meant by the *centre of gravity* of an object.

....

.... [1]

(ii) Explain whether the rod XY is a uniform rod.

....

.... [1]

(b) The liquid exerts an upward force of magnitude 2.5 N on the sphere which reduces the force exerted by the sphere on the rod.

Determine force F.

force F = ... [2]

(c) The sphere is removed from the container with liquid as shown in Fig. 3.2. The magnitude of force F remains unchanged.

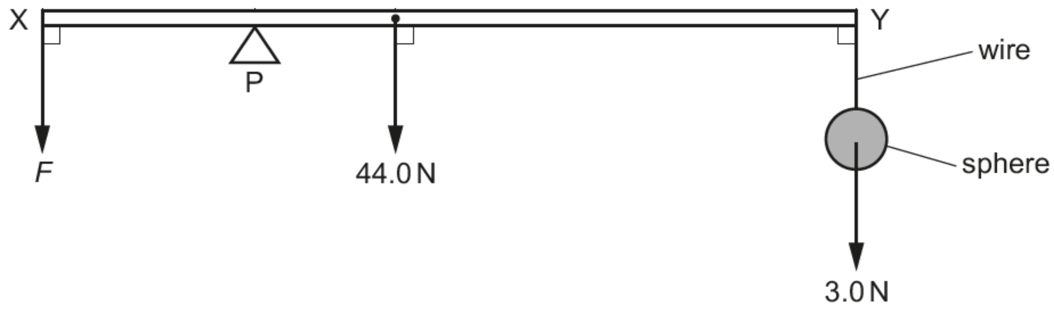

Fig. 3.2

Explain how pivot P should be shifted for rod XY to remain in equilibrium.

....

....

.... [2]

4 Two physical properties are being considered for use to construct a temperature scale of a thermometer. They are the volume of water and the pressure of a fixed mass of gas at constant volume.

Table 4.1 shows the values of the physical quantities at different temperatures.

Table 4.1

temperature / °C	volume of water / cm^3	pressure of gas / Pa
0.0	3.47	2270
8.0	3.47	2340
30.0	3.49	2520
50.0	3.52	2690
80.0	3.58	2940
100.0	3.63	3100

(a) Using Table 4.1, suggest why the volume of water is **not** an appropriate choice to construct the Celsius scale of a thermometer.

....

....

.... [2]

(b) Fig. 4.2 shows a constant volume gas thermometer that measures temperature by using the variation in the pressure of a gas.

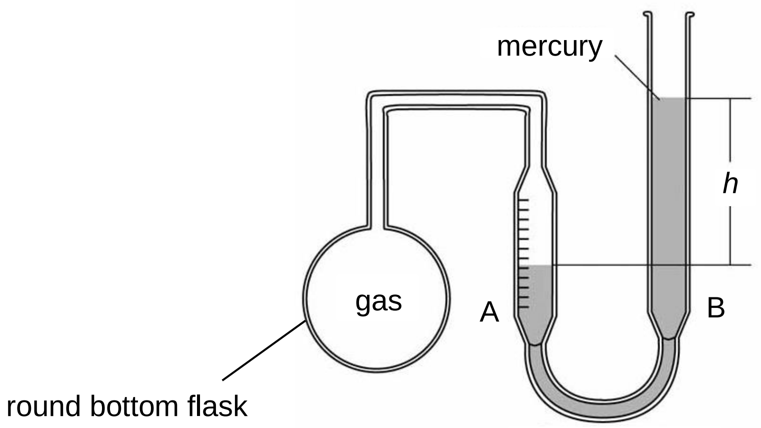

Fig. 4.2

As the temperature of the gas increases, the mercury level at A will decrease initially. The volume of the gas in the flask is then kept constant by raising or lowering the reservoir of mercury in B to keep the mercury level at A constant.

(i) Using ideas about molecules, explain why the mercury level at A decreases initially as the temperature of the gas increases.

....

....

....

.... [3]

(ii) The round bottom flask is immersed into a container of hot water.

State and describe the main process of heat transfer between the flask and the gas.

....

....

....

....

.... [2]

5 In an experiment to find the specific latent heat of vaporisation of water, the readings in Table 5.1 were taken.

Table 5.1

θ	initial temperature of water	35 °C
m_1	mass of water at 100 °C, before boiling starts	120 g
m_2	mass of water at 100 °C, after boiling finishes	80 g
V	potential difference across the heater	12 V
I	current through the heater	2.0 A
t_1	time that the heater was supplying energy to raise the temperature of water from 35 °C to 100 °C	2700 s
t_2	time that the heater was supplying energy during boiling	3750 s

(a) The total mass of water does not change as the temperature of water is raised from 35 °C to 100 °C.

Calculate the specific latent heat of vaporisation of water from the readings in Table 5.1.

specific latent heat of vaporisation = ... [3]

(b) Explain, in terms of the energy of molecules, why the specific latent heat of vaporisation of water has a high value.

....

....

.... [1]

6 A water wave travels through a ripple tank from left to right. Fig. 6.1 shows the variation of the displacement d_A of a point A on the water wave with time.

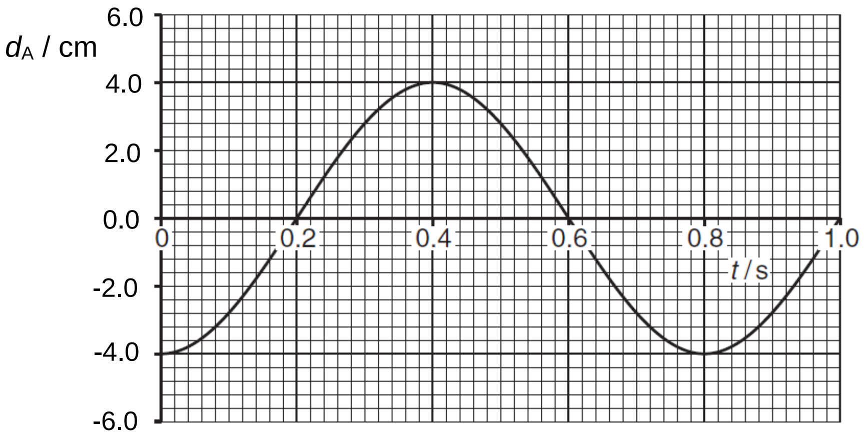

Fig. 6.1

Fig. 6.2 shows a section of the water wave travelling through the ripple tank at time t = 0 s. A point on the water wave B is as indicated.

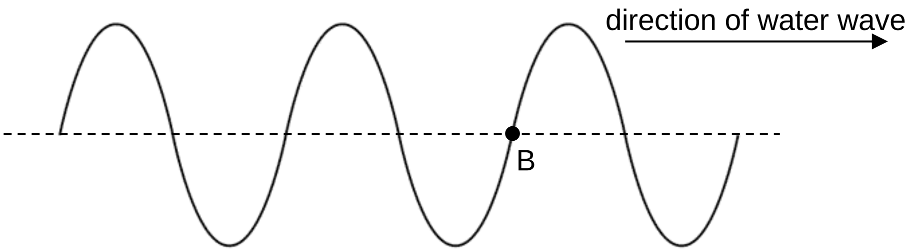

Fig. 6.2

(a) Determine the frequency of the wave shown in Fig. 6.1.

frequency = ... [2]

(b) On Fig. 6.1, draw the displacement-time graph for the water particle at point B for one period. [1]

(c) Point A is at least one wavelength behind point B on the water wave.

On Fig. 6.2, mark the position of point A with an ‘X’. [1]

(d) The water wave then travels through another section of the ripple tank which is of a shallower depth.

State and explain how the wavelength of the water wave in Fig. 6.2 changes when it travels through the shallower section of the ripple tank.

....

....

.... [2]

7 Fig. 7.1 shows the various regions of the electromagnetic spectrum arranged in order of increasing frequency.

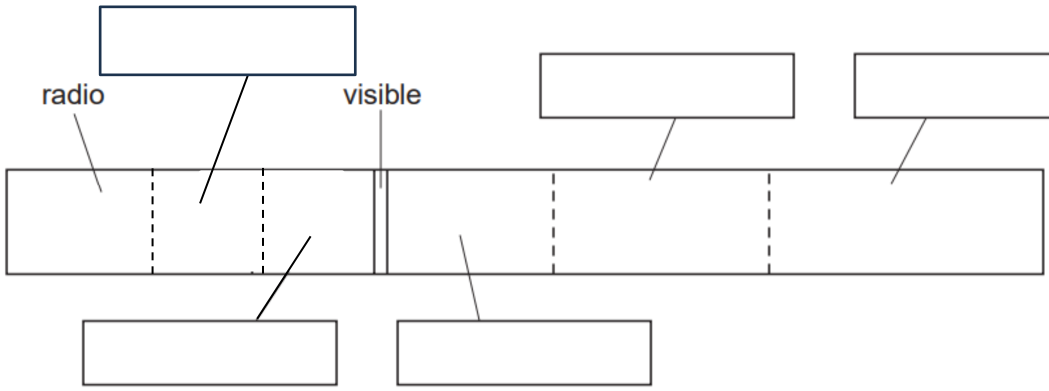

Fig. 7.1

Two of the regions have been labelled.

(a) In the boxes provided, write the names of the other regions. [2]

(b) Some components of the electromagnetic spectrum cause ionisation. They are known as ionising radiation.

(i) State what is meant by *ionisation* and state one region in **(a)** that is **not** an ionising radiation.

....

....

.... [2]

(ii) When absorbed by living cells of a human, ionising radiation can result in damage and death to the cells.

Suggest one other possible effect on the living cells of the human.

....

.... [1]

8 A small, charged metal sphere is placed in a metal box that is earthed. Fig. 8.1 shows the electric field between the sphere and the metal box.

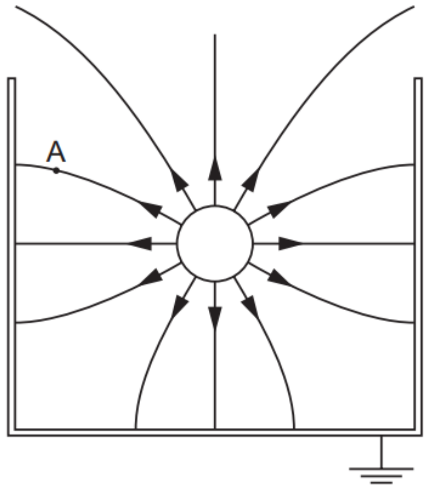

Fig. 8.1

(a) Using Fig. 8.1, state and explain whether the sphere is positively or negatively charged.

....

....

.... [2]

(b) On Fig. 8.1, draw an arrow to show the direction of the force on a stationary electron situated at point A. [1]

(c) Draw the charge induced on the metal box. Explain your answer.

....

....

.... [2]

9 A student turns the handle of an alternating current (a.c.) generator and the coil rotates.

Fig. 9.1 shows the structure of the a.c. generator.

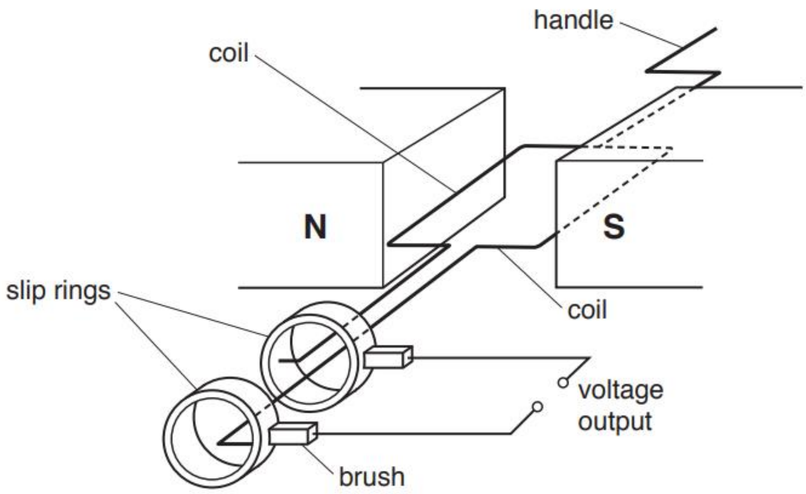

Fig. 9.1

(a) There is an alternating voltage output between the two terminals.

(i) Explain why rotating the coil produces an output voltage.

....

....

.... [2]

(ii) State the position of the rotating coil when the alternating output voltage is at a maximum value and explain why the maximum output voltage occurs at this position.

....

....

.... [2]

(b) A resistor is connected in series to the output terminals of the a.c. generator.

The student now has to apply a greater force on the handle in order to rotate it at the same frequency.

Explain why this is so.

....

....

.... [2]

Paper 2B	☐ s.f. ☐ formula	30

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PHYSICS

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25 Aug 2023

1 hour 45 minutes

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

Section B

Answer **all** the questions in this section.
Answer only one of the two alternative questions in **Question 12**.

10 Fig. 10.1 shows a simplified circuit diagram of an appliance.

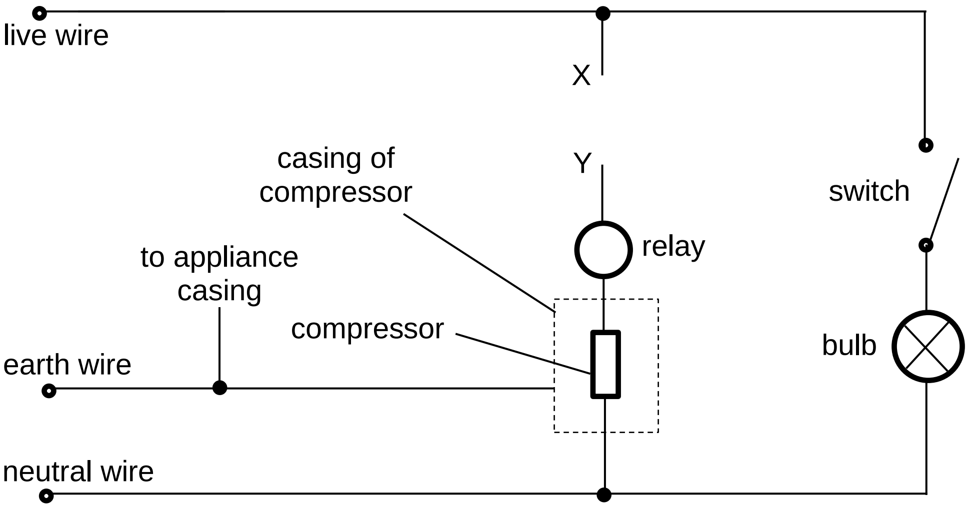

Fig. 10.1

(a) A temperature sensor is connected across XY to measure the temperature within the appliance. Table 10.1 shows how the resistance of the temperature sensor varies with temperature.

Table 10.1

temperature / °C	resistance / kΩ
-30.0	53
-20.0	29
-10.0	17
0.0	10
10.0	6.0
20.0	3.7
30.0	2.4
40.0	1.6
50.0	1.1
60.0	0.75
70.0	0.53

(i) Suggest a possible electrical component for the temperature sensor and draw its circuit symbol across XY. Explain your answer using the data in Table 10.1.

....

....

.... [2]

(ii) The resistance of the bulb changes when the switch is closed for a long period of time.

State and explain how the resistance of the bulb changes.

....

....

.... [1]

(b) The relay is used to start the compressor of the appliance.

Fig. 10.2. shows the circuit within the relay.

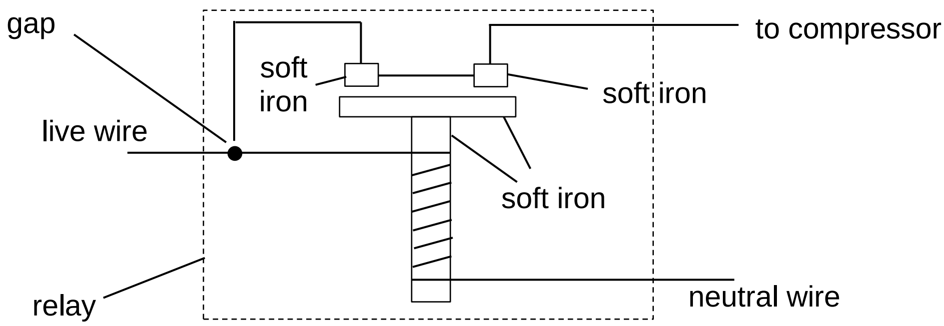

Fig. 10.2

Explain how a current flowing through the solenoid is used to start the compressor.

....

....

.... [2]

(c) Details about the power used by the appliance is shown in Table 10.2.

Starting power is the power consumed when the appliance is just switched on. Operating power is the power consumed while the appliance is in operation after it is switched on.

Table 10.2

starting power	1800 W
operating power	180 W
operating voltage	230 V

(i) Suggest a suitable fuse rating for the appliance.

.... [1]

(ii) The appliance is recommended to have its own power socket during installation.

Using the data in Table 10.2, explain why.

....

....

.... [2]

(iii) The cost of electricity is \$0.32 / kWh.

Determine the cost of electricity to operate the appliance for a day.

cost = ... [2]

11 Fig. 11.1 shows a smooth metal block about to slide down BD, along DE and then up EF. BD and DE are frictionless surfaces, but EF is rough. The block stops at F.

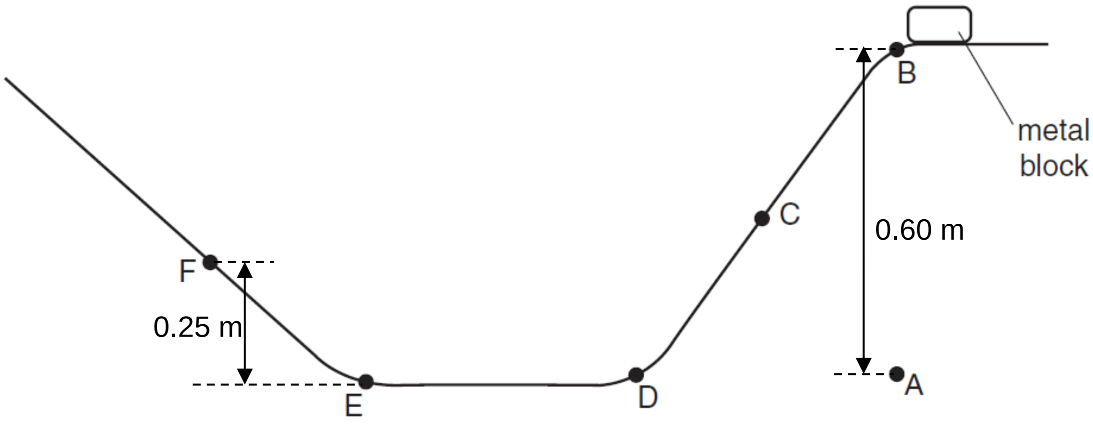

Fig. 11.1

The mass of the block is 0.20 kg. The vertical height of B above A is 0.60 m.
The acceleration due to gravity is 10 m / s^2.
There is no air resistance acting on the block throughout its motion.

(a) **(i)** Calculate the work done in lifting the block from A to B.

work done = ... [2]

(ii) Hence or otherwise, determine the speed of the block at D.

speed = ... [2]

(iii) Explain how your answer in **(a)(ii)** will change if the mass of the block is increased.

....

.... [1]

(b) As the block passes D, the speed of the block remains almost constant but the velocity changes.

Using the terms *vector* and *scalar*, explain this statement.

....

.... [2]

(c) The vertical height of F above E is 0.25 m. The distance along the slope between E and F is 0.35 m.

(i) Describe the main energy changes as the block moves from E to F.

....

.... [1]

(ii) Determine the frictional force acting on the block.

frictional force = ... [2]

EITHER

12 **(a)** The filament of a lamp is placed at the focal point of a lens, as shown in Fig. 12.1.

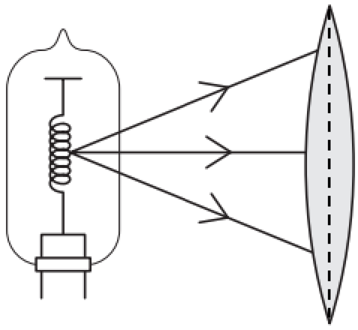

Fig. 12.1

(i) On Fig. 12.1, continue the three rays through the lens and out into the air on the right of the lens. [1]

(ii) On Fig. 12.1, indicate the focal length of the lens. Label the focal length as *f*. [1]

(b) The lens in the scale diagram in Fig. 12.2 has a focal length of 2.0 cm.

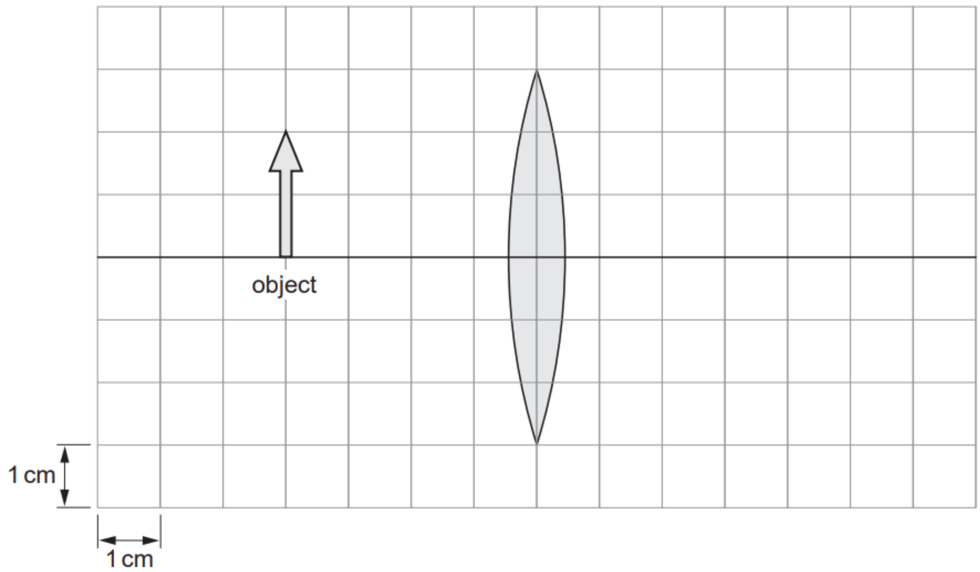

Fig. 12.2

(i) On Fig. 12.2, draw rays from the top of the object to show how the image is formed.

[2]

(ii) State how the image of the object formed on a screen compares with **(b)(i)** if the focal length of the lens in Fig. 12.2 is now larger.

.... [1]

(c) Fig. 12.3 shows radiation from a lamp passing through a glass prism. The radiation from the lamp consists of several different types of radiation including visible light.

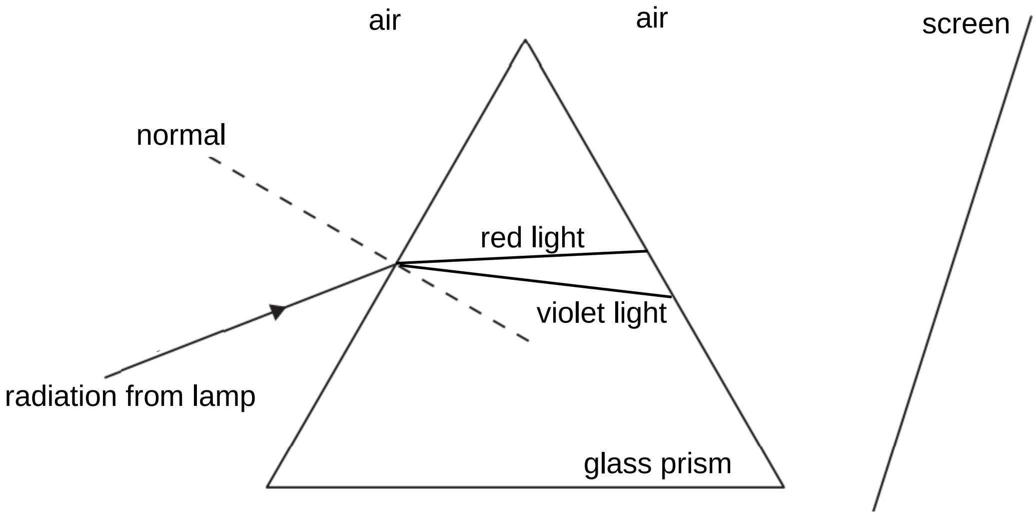

Fig. 12.3

The path of red and violet light after entering the lens is shown above.

(i) On Fig. 12.3, draw a possible path of a ray of red light after passing through the prism until it reaches the screen.

[1]

(ii) Using Fig. 12.3, explain whether the refractive index of violet light in glass is greater than that of red light.

....

....

.... [1]

(d) Fig. 12.4 shows a ray of light in air striking the outer surface of the glass wall at point P at an angle of 25°. The glass wall has a refractive index of 1.54.

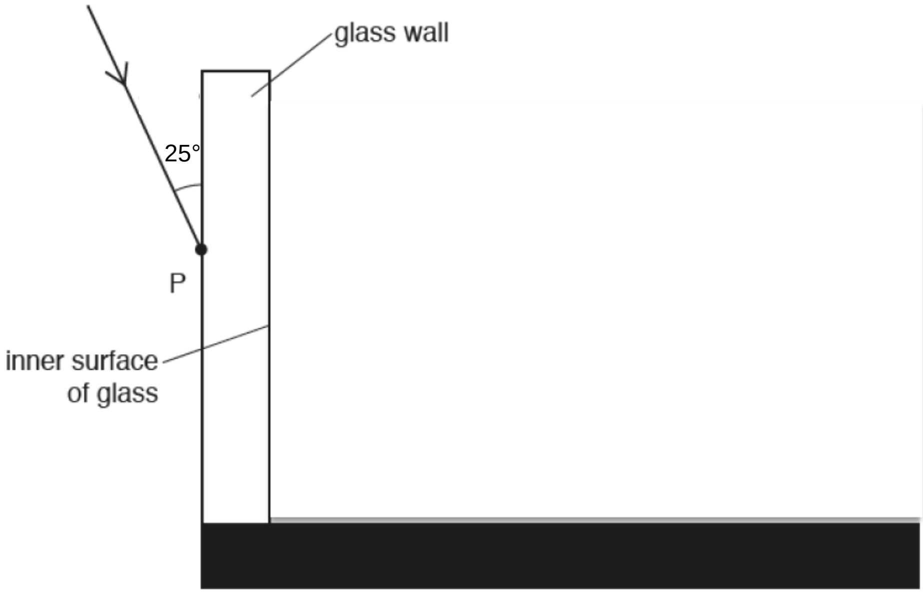

Fig. 12.4

(i) Determine the angle of refraction when the light enters the glass wall.

angle of refraction = ... [2]

(ii) Light can enter the glass wall from the **outer surface** at any angle between 0° to 90° from the normal.

Explain why total internal reflection **cannot** occur at the **inner surface** of the glass wall as light exits the glass wall into air.

....

.... [1]

OR

12 **(a)** Two long straight parallel copper wires A and B are clamped vertically. The wires pass through holes in a horizontal sheet of card PQRS, as shown in Fig. 12.5.

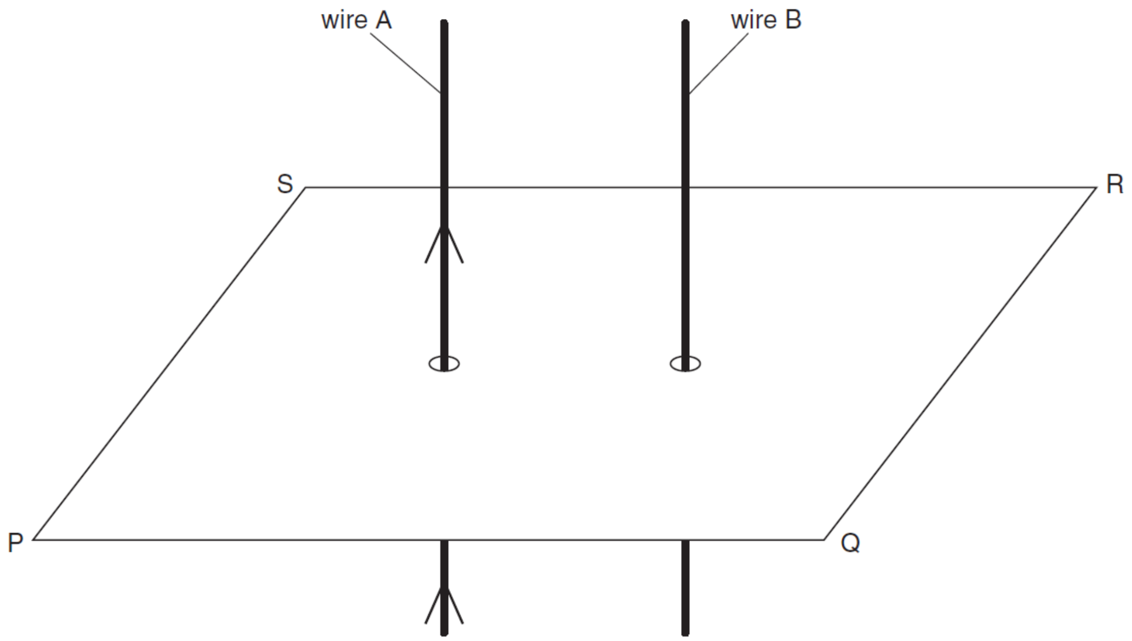

Fig. 12.5

(i) There is a current in wire A in the direction as shown on Fig. 12.5.

On Fig. 12.6, draw three field lines in the plane PQRS to represent the magnetic field due to the current in wire A.

[2]

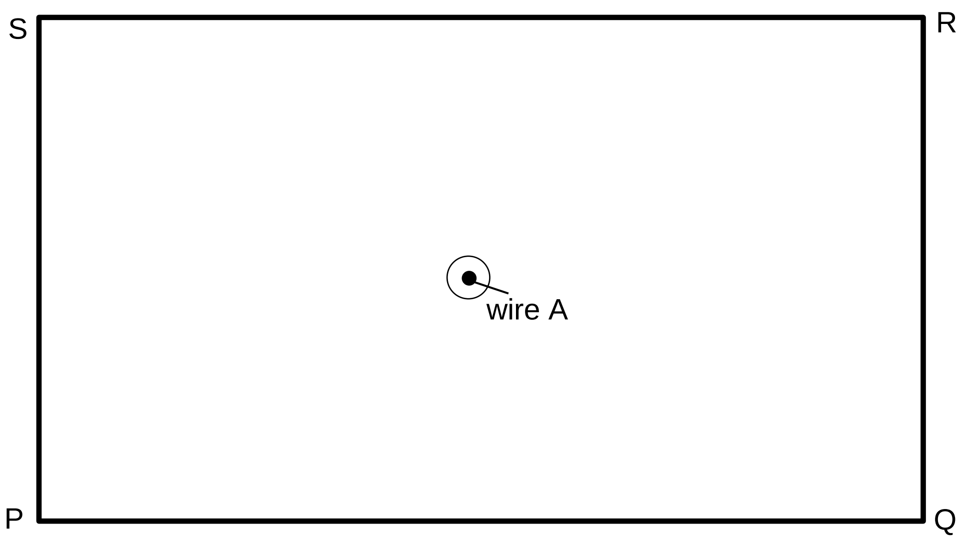

Fig. 12.6

(ii) A direct current is now passed through wire B in the same direction as that in wire A. The current in wire B is larger than the current in wire A.

A force is exerted on wire B when a direct current is passed through it.

1. Explain why there is a force exerted on wire B.

....

....

.... [2]

2. On Fig. 12.5, draw an arrow in the plane PQRS to show the direction of the force on wire B. [1]

3. Wire A also experiences a force.

State and explain which wire, if any, will experience the larger force.

....

....

.... [2]

(b) Fig. 12.7 shows a conductor with rectangular faces placed in a magnetic field.

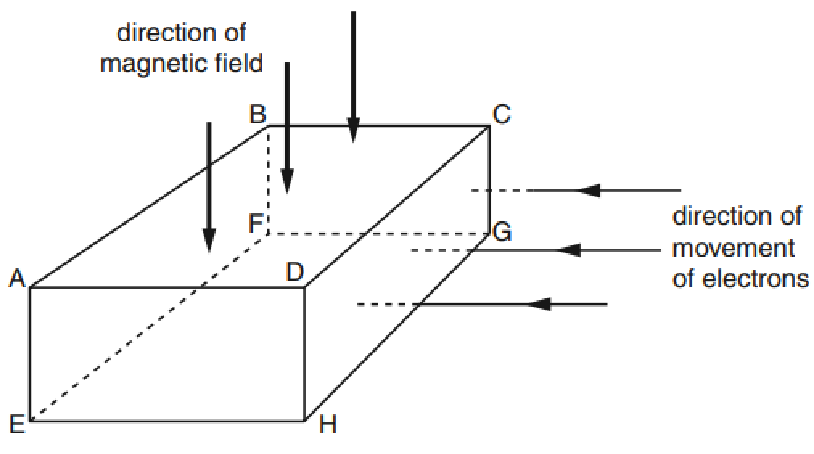

Fig. 12.7

The magnetic field is normal to face ABCD in the downward direction.

Electrons enter face CDHG at right-angles to it. As the electrons pass through the conductor, they experience a force due to the magnetic field.

(i) The movement of the electrons in the magnetic field causes a potential difference between two faces of the conductor.

On Fig. 12.7, shade the two faces between which this potential difference will occur.

[1]

(ii) Explain why the potential difference in **(b)(i)** causes an additional force on subsequent electrons entering face CDHG of the conductor.

....

....

.... [2]

--- END OF PAPER ---