



MINISTRY OF EDUCATION, SINGAPORE  
in collaboration with  
CAMBRIDGE ASSESSMENT INTERNATIONAL EDUCATION  
General Certificate of Education Ordinary Level

CANDIDATE  
NAME

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CENTRE  
NUMBER

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INDEX  
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## PHYSICS

**6091/02**

Paper 2 Structured and Free Response

**For examination from 2024**

SPECIMEN PAPER

**1 hour 45 minutes**

Candidates answer on the Question Paper.

No Additional Materials are required.

### READ THESE INSTRUCTIONS FIRST

Write your Centre number, 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.

**DO NOT WRITE ON ANY BARCODES.**

#### Section A

Answer **all** questions.

Write your answers in the spaces provided.

#### Section B

Answer **one** question.

Write your answers in the spaces provided.

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.

This document consists of **19** printed pages and **1** blank page.



Singapore Examinations and Assessment Board



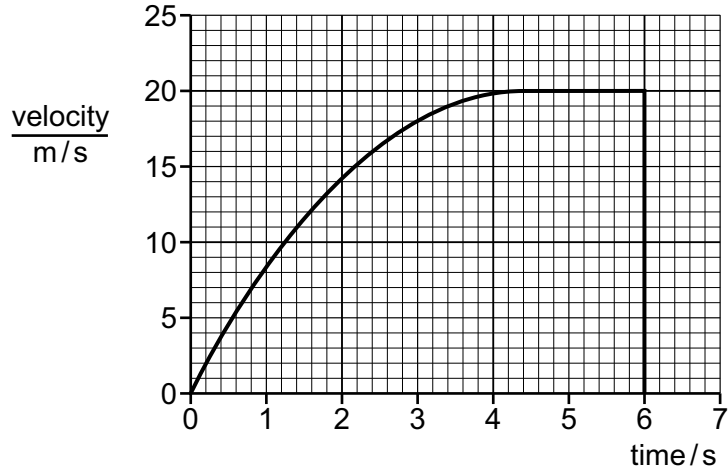
Cambridge Assessment  
International Education

**Section A**

Answer **all** questions.

- 1 A large plastic ball is dropped vertically downwards from the top of a tall building.

Fig. 1.1 shows the velocity–time graph for the falling ball until it hits the ground.



**Fig. 1.1**

- (a) Estimate the change in displacement of the ball while it is falling with terminal velocity.

change in displacement = ..... [2]

- (b) Use Newton’s laws of motion to explain why the ball accelerates at first and then reaches terminal velocity.

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

- (c) The weight of the ball is one of the two forces that form an action-reaction pair of forces.

Describe the other force of this pair.

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

[Total: 7]

- 2 Fig. 2.1 shows a manometer used to measure the pressure difference between the inside of a plastic container and the atmosphere outside.

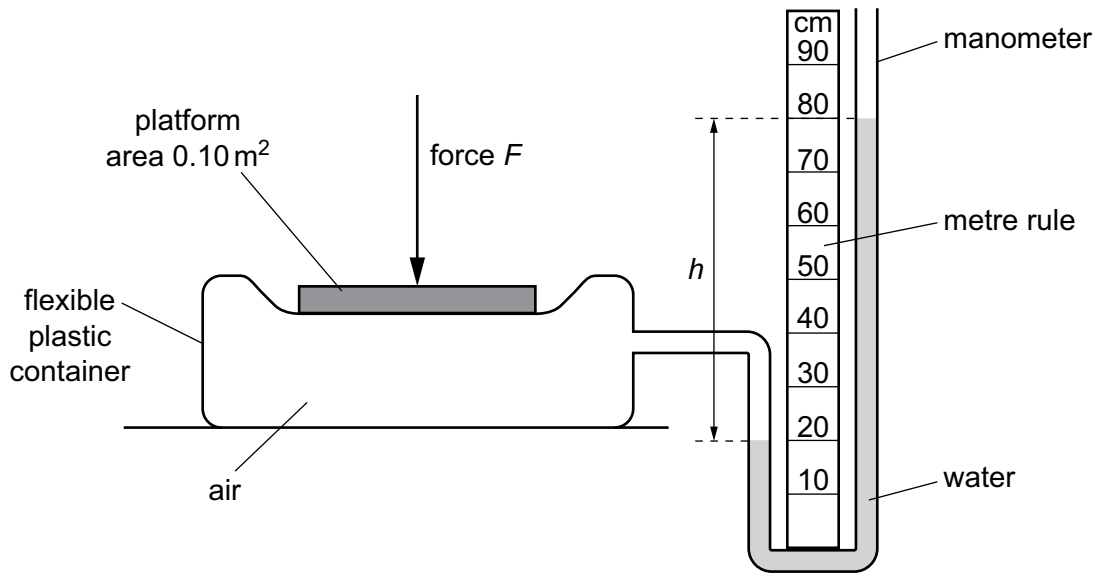


Fig. 2.1

The density of water is  $1000 \text{ kg/m}^3$ . The gravitational field strength  $g$  is  $10 \text{ N/kg}$ .

- (a) Using Fig. 2.1, determine the pressure difference shown by the manometer.

Give your answer in Pa.

pressure = ..... Pa [2]

- (b) State what happens to the distance  $h$  in Fig. 2.1 if:

- (i) the manometer tube is narrower

..... [1]

- (ii) a liquid denser than water is used in the manometer.

..... [1]

- (c) The pressure difference measured by the manometer is all caused by the force  $F$ . This force is equal in magnitude to the weight of a student standing on the platform with a cross-sectional area  $0.10 \text{ m}^2$ .

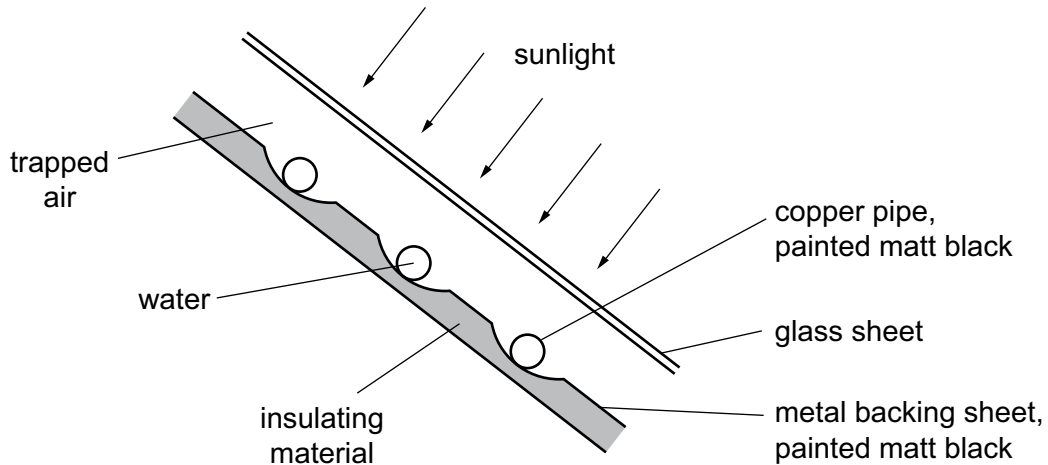
Calculate the weight of the student.

weight = ..... [2]

[Total: 6]

**[Turn over**

- 3 A solar thermal panel is mounted on the roof of a house. Fig. 3.1 shows a section through part of the solar thermal panel.



**Fig. 3.1**

A pump makes water circulate through the copper pipes. The water is heated as it passes through the solar thermal panel.

(a) Suggest why:

- (i) the pipes are made of copper

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

- (ii) the pipes and the backing sheet are painted black

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

- (iii) an insulating material is attached to the metal backing sheet

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

- (iv) the presence of the glass sheet increases the energy collected by the water.

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

- (b) During one day, 250 kg of water is pumped through the solar thermal panel. The temperature of this water rises from 16 °C to 38 °C.

The water absorbs 25% of the energy falling on the solar thermal panel, and the specific heat capacity of water is 4200 J/(kg °C)

Calculate the energy falling on the solar thermal panel during that day.

energy = ..... [4]

[Total: 8]

- 4 Fig. 4.1 shows an incorrect electromagnetic spectrum drawn by a student. The parts of the spectrum and the wavelengths are in the wrong order. The values of the wavelengths do **not** match the correct parts of the spectrum.

short wavelength						long wavelength
microwaves	radio waves	ultraviolet	infrared	gamma rays	X-rays	visible
$10^3$ m	$10^{-14}$ m	$10^{-10}$ m	$10^{-8}$ m	$10^{-2}$ m	$10^{-6}$ m	$10^{-5}$ m

**Fig. 4.1**

- (a) On Fig. 4.2, complete the table of the electromagnetic spectrum. Radio waves and their correct wavelength have been inserted for you.

short wavelength						long wavelength
						radio waves
						$10^3$ m

**Fig. 4.2**

[3]

- (b) Describe how over-exposure to electromagnetic waves can have a hazardous effect on living cells.

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

- (c) State **two** uses of infrared.

1 .....

2 .....

[2]

[Total: 6]

5 Electrostatic charges can be placed on objects by rubbing the objects together.

- (a) State the name of the charged particle that is transferred from one object to the other in this process.

..... [1]

- (b) Fig. 5.1 shows petrol being pumped into a can. Electrostatic charges build up on the petrol and the pipe.

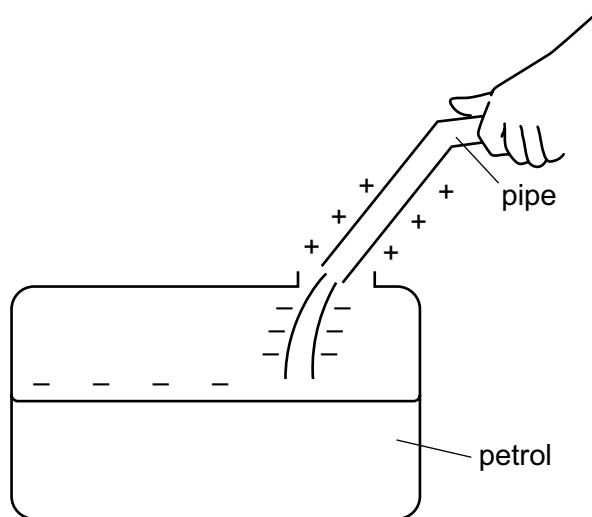


Fig. 5.1

- (i) Explain why this is dangerous.

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

- (ii) State what can be done to stop the electrostatic charges building up in this way.

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

[Total: 4]

- 6 Fig. 6.1 shows a piece of magnetic data storage tape passing under a recording head. An alternating current is passed through the coil. The tape is coated with a magnetic material which becomes magnetised.

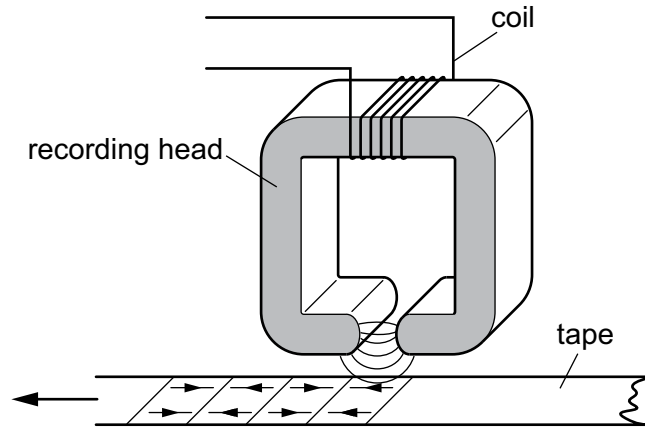


Fig. 6.1

- (a) (i) Explain why the tape becomes magnetised.

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

- (ii) Fig. 6.1 shows that the sections of the tape are magnetised in opposite directions. Explain how this is caused.

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

- (iii) The tape is moved faster past the recording head. State how this changes the pattern on the tape.

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

- (b) (i) Explain what happens if the tape coating is made from a temporary magnetic material.

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

- (ii) State the name of a permanent magnetic material.

..... [1]

[Total: 5]



- 7 Fig. 7.1 shows a long, straight wire between the poles of a permanent magnet. It is connected through a switch to a battery so that, when the switch is closed, there is a steady current in the wire.

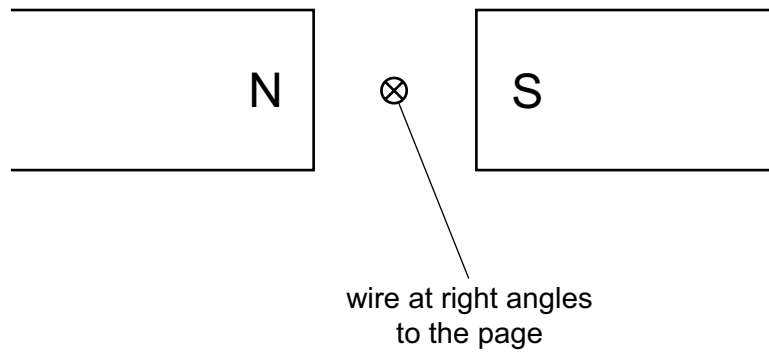


Fig. 7.1

- (a) State the direction of the magnetic field between the poles of the magnet.

..... [1]

- (b) The wire is free to move. The current is switched on so that its direction is into the page.

- (i) State the direction of movement of the wire.

..... [1]

- (ii) Explain how you deduced your answer to (b)(i).

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

- (c) This movement is the basis of an electric motor.

Describe **two** changes to the arrangement shown in Fig. 7.1 that enable continuous rotation to take place.

1 .....

.....

2 .....

..... [2]

[Total: 6]

- 8 Fig. 8.1 shows two coils wound on an iron ring. One coil is connected in series to a switch and a d.c. supply, and the other is connected to a very sensitive centre-zero voltmeter.

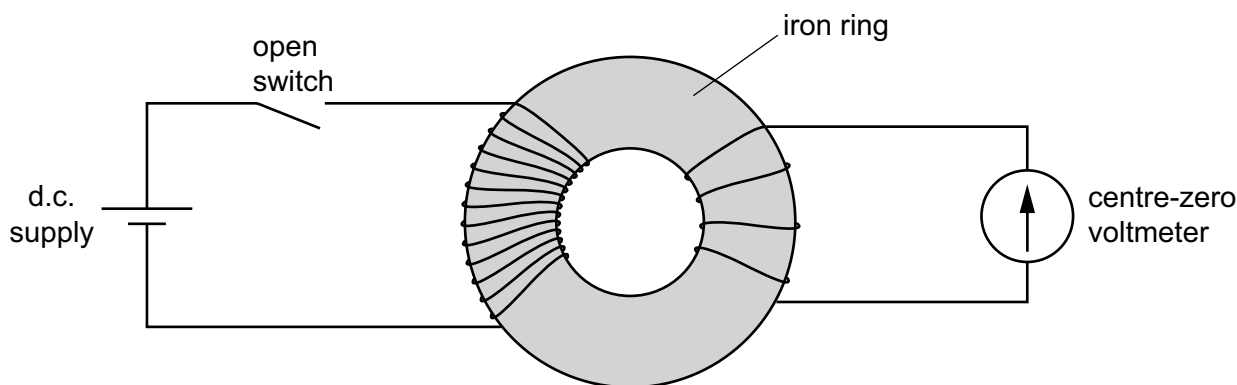


Fig. 8.1

At first the switch is open, as shown in Fig. 8.1.

- (a) The following actions are taken in turn.

Describe and explain what happens to the reading on the voltmeter in each case.

- (i) The switch is closed.

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

- (ii) The switch is left closed for a long time.

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

- (iii) The switch is opened.

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

- (b) State why an a.c. supply, rather than a d.c. supply, must be used for a transformer.

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

[Total: 8]

9 Fig. 9.1 shows a multi-mode optical fibre made from glass of uniform refractive index.

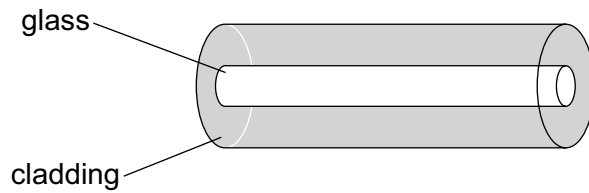


Fig. 9.1

Fig. 9.2 shows three rays of light entering the fibre from the air. Each of these rays follows one of the three possible paths through the fibre.

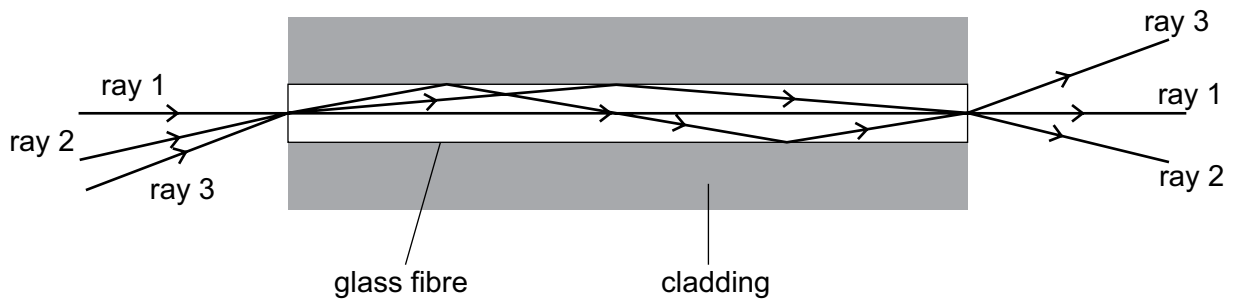


Fig. 9.2 (not to scale)

The three rays travel different distances and take different times to pass through the fibre. Fig. 9.3 gives information about the three rays and their paths in a 1 km and a 2 km cable.

	angle of incidence on entry / °	angle of refraction on entry / °	distance covered in 1 km cable / m	time spent in 1 km cable / μs	distance covered in 2 km cable / m	time spent in 2 km cable / μs
ray 1	0	0	1000	5.0	2000	10.0
ray 2	20	13	1027	5.1	2054	10.3
ray 3	35	X	1082	5.4	2164	10.8

Fig. 9.3

(a) Using data for ray 1 from Fig. 9.3, calculate the refractive index of the glass.

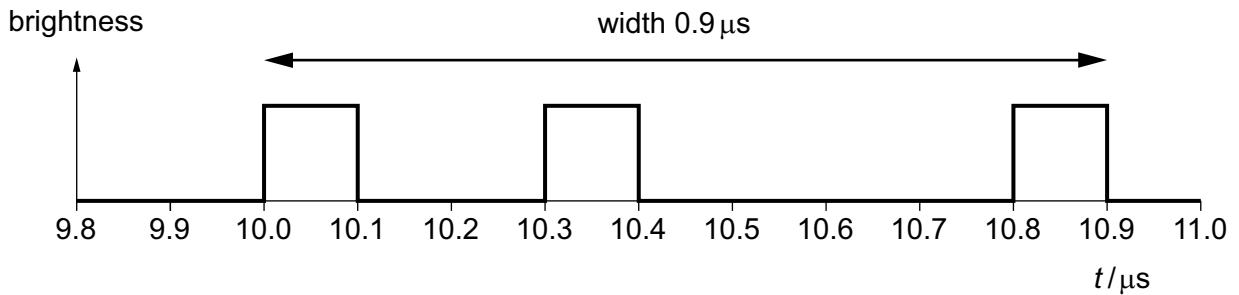
The speed of light in air is  $3.0 \times 10^8$  m/s.

refractive index = ..... [2]

(b) Calculate the angle of refraction  $X$  for ray 3.

angle = ..... [2]

(c) At time  $t = 0$ , a single pulse of light enters an optical fibre of length 2 km. The pulse lasts  $0.1 \mu\text{s}$ . Fig. 9.4 shows the pulses of light that leave the fibre.



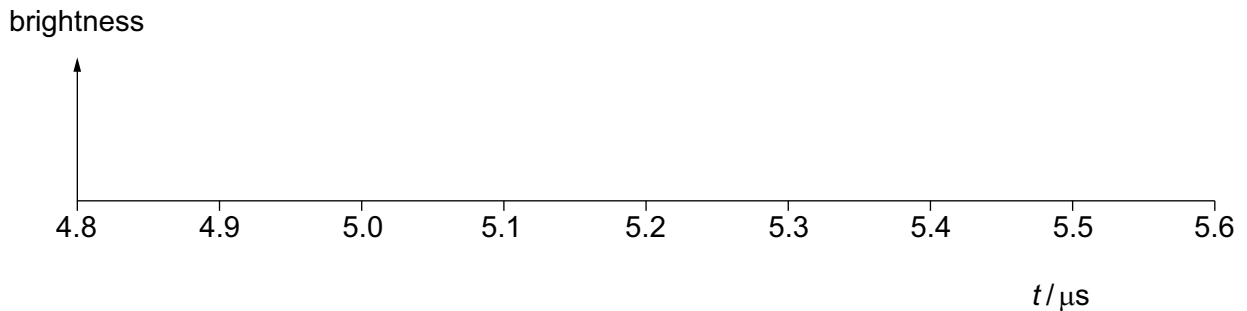
**Fig. 9.4**

(i) Using data from Fig. 9.3, explain Fig. 9.4.

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

(ii) At  $t = 0$ , a single pulse of light enters an optical fibre of length 1 km. This pulse also lasts  $0.1 \mu\text{s}$ .

On Fig. 9.5, draw the pulses of light that leave the fibre.



**Fig. 9.5**

[2]

- (iii) Fig. 9.4 shows that a pulse of light, lasting  $0.1 \mu\text{s}$  when it enters the 2 km optical fibre, becomes three pulses lasting in total  $0.9 \mu\text{s}$  that leave the fibre.

In a telephone conversation, a series of pulses is sent along an optical fibre. It is important that no light from one pulse overlaps light from the next pulse. A second pulse of  $0.1 \mu\text{s}$  must enter the fibre at least  $0.9 \mu\text{s}$  after the first.

Estimate the maximum number of pulses of light that can enter the 2 km optical fibre in one second.

number of pulses in one second = ..... [2]

- (iv) Explain why multi-mode optical fibres are **not** used to transmit data at high rates over very long distances.

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

[Total: 10]

10 Fig. 10.1 shows a radioactive source used to measure and control the thickness of cardboard during manufacture.

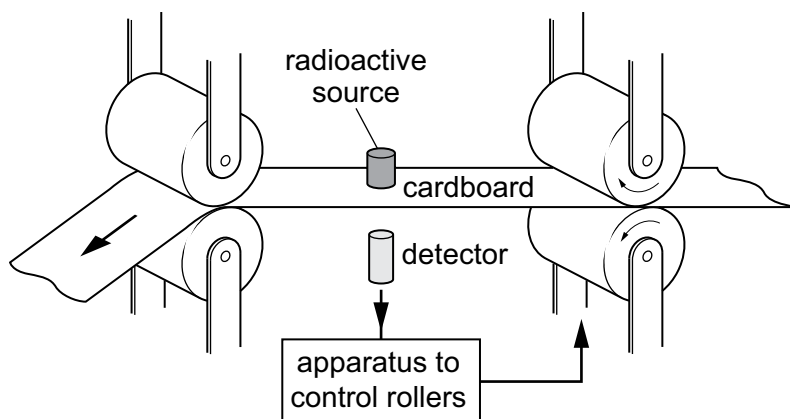


Fig. 10.1

(a) Some radioactive sources emit alpha-particles, some beta-particles and some gamma radiation. These different radiations have different penetrating abilities.

Place **one** tick (✓) in each row of Table 10.1 to compare alpha, beta and gamma radiation.

Table 10.1

	alpha ( $\alpha$ )	beta ( $\beta$ )	gamma ( $\gamma$ )
least penetrating			
most penetrating			

[1]

(b) Strontium-90 is an isotope used in the radioactive source in Fig. 10.1.

A nucleus of strontium-90 emits a beta-particle as it decays.

(i) The radioactive decay of a nucleus is a random and spontaneous process.

1. Explain what is meant by a *random* decay.

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

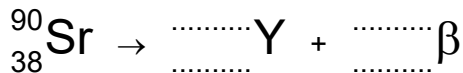
2. Explain what is meant by a *spontaneous* decay.

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

- (ii) In nuclide notation, strontium-90 is written as  ${}^{90}_{38}\text{Sr}$ .

When a nucleus of strontium-90 emits a beta-particle ( $\beta$ ), it decays to an isotope of yttrium (Y).

Complete the decay equation below for this decay.



[2]

- (iii) Beta decay can be considered as the decay of a neutron to a proton and an electron.

Explain how the composition of the nuclei of the strontium and yttrium isotopes illustrates this statement.

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

- (c) The half-life of strontium-90 is 29 years.

- (i) Suggest why a radioactive source with a half-life of millions of years is unsuitable for use in the apparatus shown in Fig. 10.1.

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

- (ii) A pure source of strontium-90 emits  $1.6 \times 10^5$  beta-particles per second.

Calculate the number of beta-particles emitted per second by the source after 87 years.

number of particles per second = ..... [2]

[Total: 10]

## Section B

Answer **one** question from this section.

- 11 (a) A lamp is marked 24 V, 100 W.

Describe an experiment to check that the electrical power supplied to the lamp is 100 W when the potential difference (p.d.) across it is 24 V.

In your account, you should:

- include a circuit diagram
- state the readings that are taken
- show how the result is calculated from the readings.

.....

.....

.....

..... [4]

- (b) In Fig. 11.1, two lamps are connected in parallel to a 240 V mains supply.

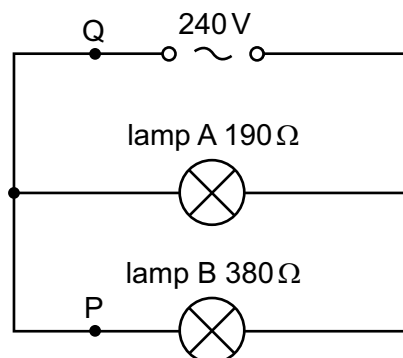


Fig. 11.1

Lamp A has a resistance of  $190\ \Omega$  and lamp B has a resistance of  $380\ \Omega$ .



(i) Calculate the current at points P and Q.

current at P = .....

current at Q = .....

[2]

(ii) Calculate the total resistance of the circuit.

resistance = ..... [2]

(c) In a house, all lamps are connected in parallel to the mains supply, not in series.

Suggest and explain **two** reasons for this.

1 .....

.....

2 .....

.....

[2]

[Total: 10]

- 12 Fig. 12.1 shows a thin sheet of metal suspended from a hole in one corner at A. The weight of the metal is 0.10 N and the centre of gravity is at B. The diagram is drawn full scale.

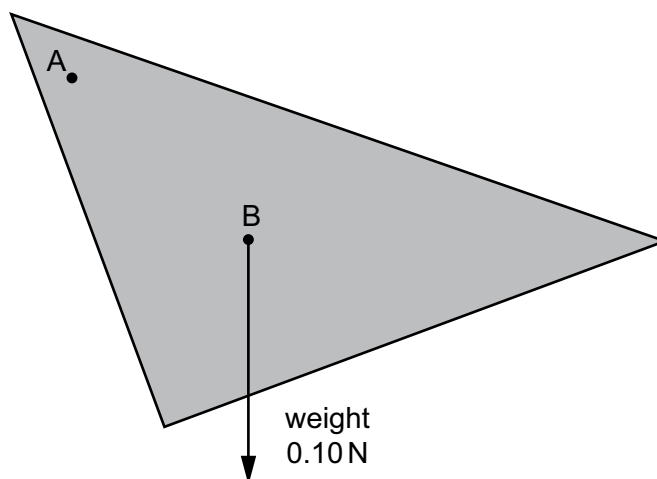


Fig. 12.1 (full scale)

- (a) Describe how you would determine the position of the centre of gravity of the sheet of metal.

.....

.....

.....

.....

.....

.....

..... [4]

- (b) The sheet turns because of the moment of the weight about point A.

Using a distance measured on Fig. 12.1, calculate the moment of the weight about point A.

State the distance that you measured and your final answer for the moment.

distance measured = .....

moment = .....

[3]

(c) Fig. 12.2 shows a thick piece of wood with one corner on a table.

Fig. 12.3 shows the same piece of wood balanced on the table. B is the centre of gravity.

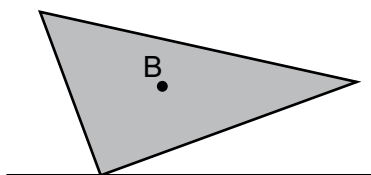


Fig. 12.2

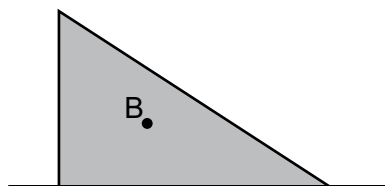


Fig. 12.3

(i) Explain why, in Fig. 12.2, the piece of wood falls to the right.

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

(ii) In Fig. 12.3, the piece of wood can topple into or out of the page.

Suggest and explain how the position of B affects the stability of the piece of wood.

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

[Total: 10]

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