COMPASSVALE SECONDARY SCHOOL
Secondary Four Express / Five Normal (Academic)
Preliminary Examination 2024

NAME											
CENTRE NUMBER	S					CLASS				INDEX NUMBER	

PHYSICS **6091/02**

Paper 2 Structured and Free Response **26 August 2024**

1 hour 45 minutes

Candidates answer on the Question Paper

No Additional Materials are required.

READ THESE INSTRUCTIONS FIRST

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

Section A
Answer **all** questions.
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.

Set by: Mr E Chng

[Turn over

Section A

Answer **all** questions.

1 Fig. 1.1 shows an oil tank.

A small crack appears in an oil tank and a stream of oil is pushed out through the crack. The oil hits the floor at P where a puddle of oil starts to form.

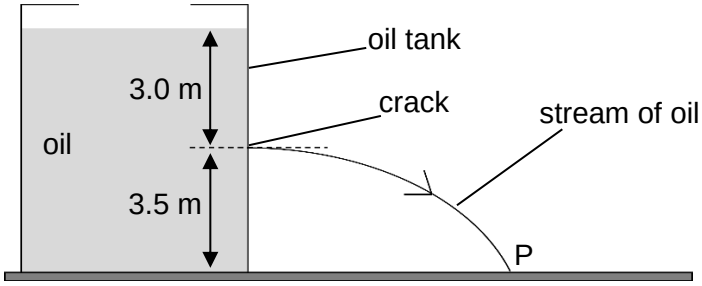

Fig. 1.1

The gravitational field strength is 10 N/kg. Atmospheric pressure is 101 kPa.

(a) The density of the oil is 950 kg/m^3.

Calculate the total pressure exerted on the oil at the level of the crack.

total pressure = ... [2]

(b) As time passes, the point where the oil hits the floor moves away from P.

State how the oil moves and explain why this happens.

……

……

……

…… [2]

[Total: 4]

2 Fig. 2.1 shows a painter standing on a wooden plank, directly above the right-hand support.

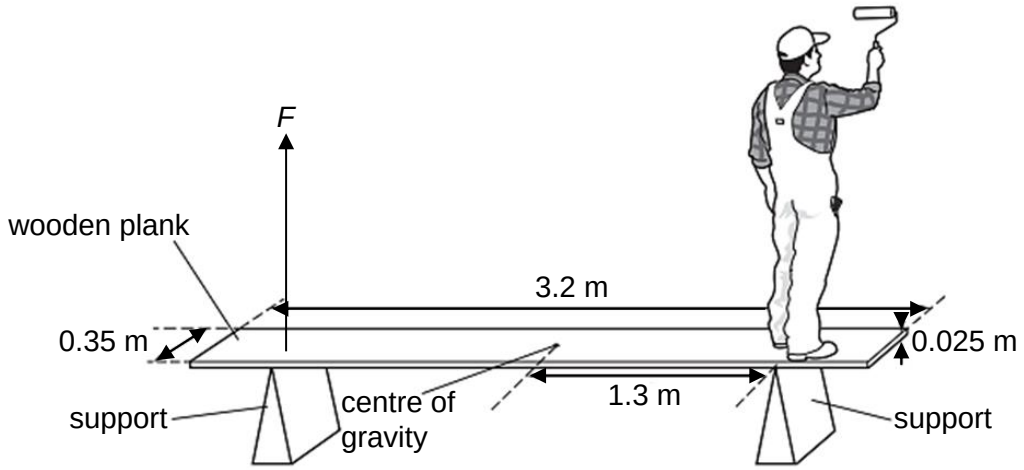

Fig. 2.1

The gravitational field strength is 10 N/kg and the mass of the plank is 24 kg.

(a) Determine the density of the wood from which the plank is made.

density = ... [2]

(b) The centre of gravity of the plank is in the middle of the plank at a distance of 1.3 m from each of the supports.

By considering the moments about the right-hand support, determine the value of the force *F*.

F = ... [3]

(c) The man begins walking further to the right.

Describe and explain what happens to the wooden plank as he does so.

……

……

…….... [2]

[Total: 7]

[Turn over

3 Ultrasound waves are used in medical imaging.
To produce the image of an unborn child, an ultrasound emitter and receiver are placed close together on the mother's skin as shown in Fig. 3.1.

Fig. 3.1

(a) Ultrasound waves are a form of longitudinal waves.

Explain what is meant by *longitudinal waves*.

……

……

…… [2]

(b) Suggest why ultrasound waves are used instead of sound waves in the audible range.

……

…… [1]

(c) Fig. 3.2 shows the pulses detected by the receiver. Pulse A is the original pulse emitted and pulse B is the pulse detected after some time.

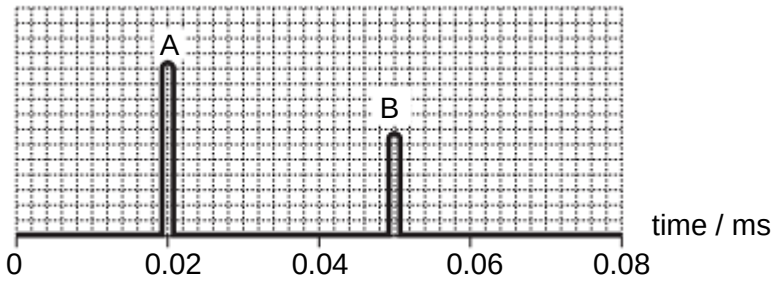

Fig. 3.2

The average speed of ultrasound in human tissue is 1500 m/s.

Calculate the distance between the emitter and the child.

distance = ... [2]

[Total: 5]

4 **(a)** Fig. 4.1 shows the path of a ray of red light through a piece of glass.

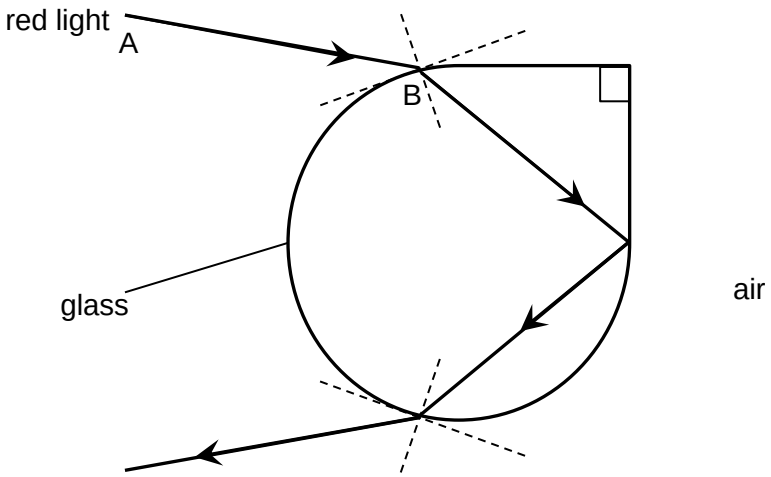

Fig. 4.1

(i) Given that the critical angle of red light is 38°, calculate the speed of red light in the piece of glass.

speed = ... [2]

(ii) The refractive index of blue light in glass is greater than that of red light.

On Fig. 4.1, draw a possible path for a ray of blue light through the piece of glass. Assume that the ray of blue light is also incident along AB. [1]

(b) Fig. 4.2 shows a scaled diagram of rays from the top of a distant object brought to focus by a converging lens, L, made from the same glass.

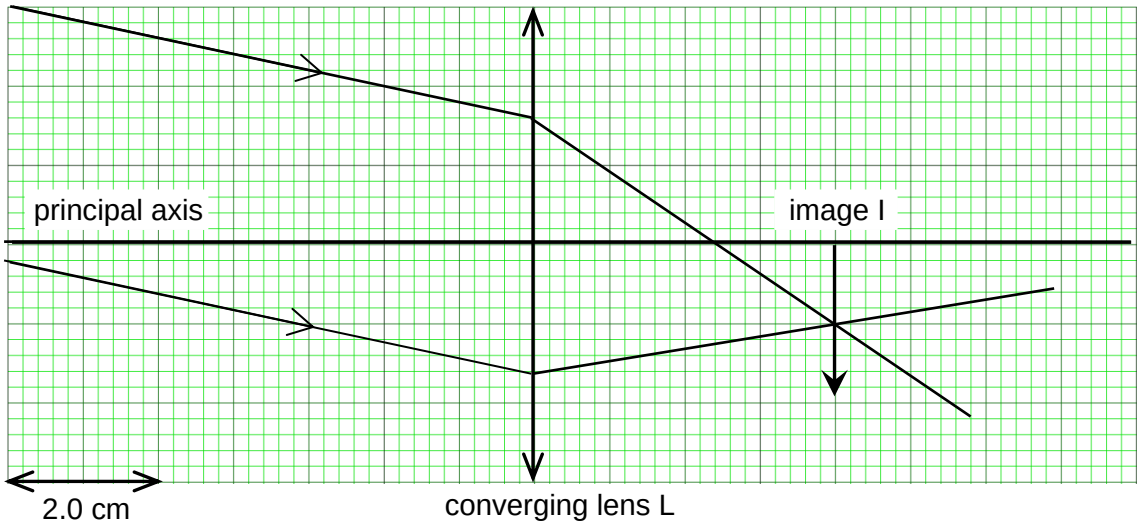

Fig. 4.2

(i) Explain how Fig. 4.2 shows that the object is a long distance away from the lens L.

……

…….. [1]

(ii) **On Fig. 4.2,**

1. mark clearly with a letter F, the position of the principal focus of the lens. [1]

2. draw two rays to show how the top of the image I is formed by the lens L. [2]

[Total: 7]

5 Fig. 5.1 shows the structure of a water cooler that is used to supply cold water in an office.

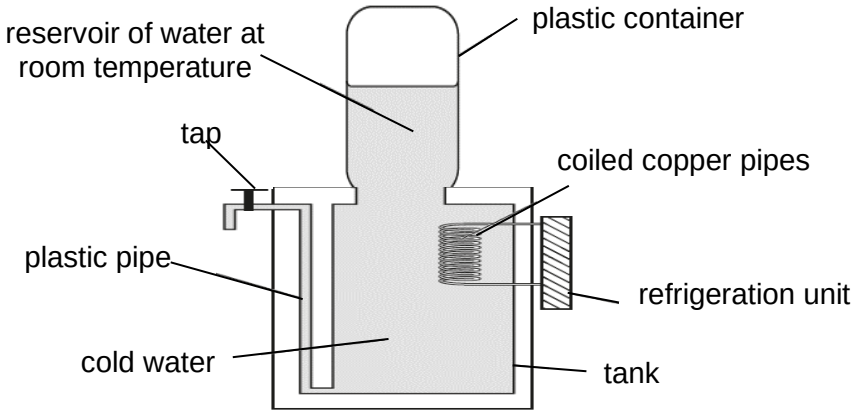

Fig. 5.1

(a) When the tap is opened, water at room temperature from the reservoir in the plastic container flows down into the tank. Cold water from the tank flows through the plastic pipe and out of the tap.

Cold liquid from the refrigeration unit is pumped through the copper pipes and thermal energy passes through the copper to this liquid.

(i) Explain why the pipe is made from copper.

……

…….. [1]

(ii) Explain why coiled pipes are used instead of a straight pipe.

……

…….. [1]

(iii) As the water near the pipe cools, it begins to mix with the rest of the water in the tank.

Explain how this happens.

……

……

…….. [2]

(b) The tap is opened and water at 25 °C flows from the reservoir into the tank.
The specific heat capacity of water is 4200J /(kg°C).

Calculate the energy that is removed from the internal store of 250 g of this water to reduce its temperature to 10 °C.

energy removed = ... [2]

(c) The water is poured into a cup and left on a table for some time. It was observed that some of the water evaporated.

By considering the molecules in the water, explain how some of the water evaporated.

…….....

…….....

…….....

……..... [2]

[Total: 8]

6 Fig. 6.1 shows a potential divider made from a light-dependent resistor (LDR) and a 6.0 kΩ resistor. The potential divider is connected in series with a 12 V d.c. power supply and a voltmeter is connected across the 6.0 kΩ resistor.

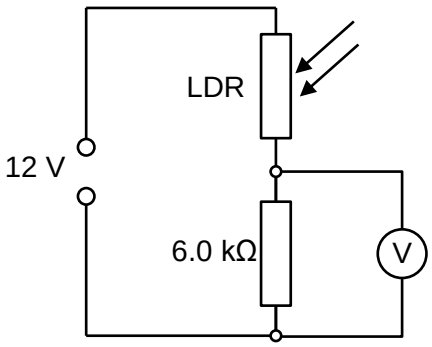

Fig. 6.1

The resistance of the LDR ranges from 200 Ω to 2.0 kΩ.

(a) At first, no light shines on the LDR.

Calculate

(i) the current in the LDR,

current = ... [2]

(ii) the reading on the voltmeter.

reading = ... [1]

(b) A light now shines on the LDR and its brightness is gradually increased. The resistance of the LDR changes from one end of its range to the other end.

Describe and explain what happens to the reading on the voltmeter.

……

……

……

…… [2]

[Total: 5]

7 Fig. 7.1 shows a circuit in which a voltmeter is connected across the black box.

The black box is also connected in series with an ammeter and a 30 Ω resistor as shown.

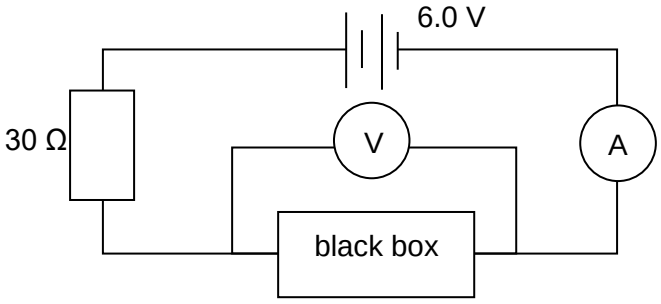

Fig. 7.1

(a) The ammeter has a reading of zero.

State the reading on the voltmeter.

……..... [1]

(b) Suggest a possible circuit element that may be found in the black box, giving a short explanation for your choice.

…….....

…….....

……..... [1]

(c) The polarities of the 6.0 V d.c. supply are reversed. The ammeter now shows a reading of 0.40 A.

(i) Calculate the potential difference across the 30 Ω resistor.

potential difference = ... [2]

(ii) Hence, deduce the identity of the circuit component inside the black box.
Explain your deduction.

…….

…….

……... [1]

[Total: 5]

8 Fig. 8.1 shows a relay used to switch on a car headlamp.

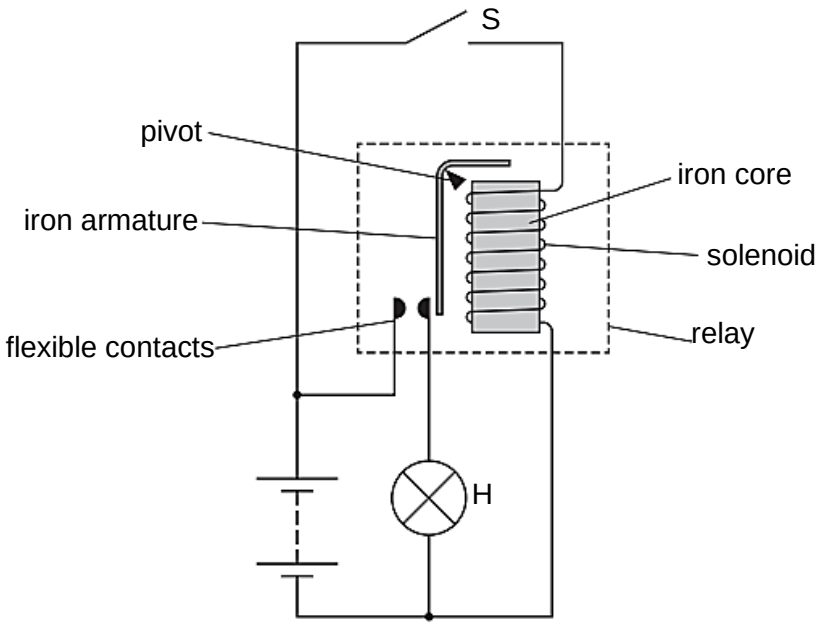

Fig. 8.1

(a) Explain why headlamp H lights up when switch S is closed.

……

……

……

……

……

……[3]

(b) Suggest and explain the difference to the operation of the headlamp if a steel armature is used instead.

……

……

……[1]

[Total: 4]

9 Fig. 9.1 shows part of a torch. The torch does not contain a battery.

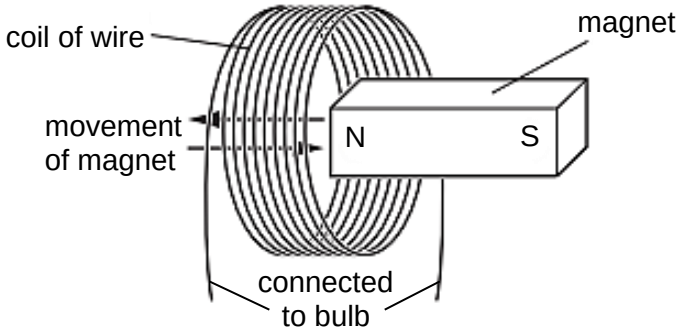

Fig. 9.1

The torch is shaken, causing the magnet to move backwards and forwards through the coil. This causes a bulb in the torch to light up.

(a) Explain why shaking the torch causes bulb in it to light up.

……

……

……

……

…… [3]

(b) It is observed that the bulb on the torch does not produce a steady stream of light.

Explain why the bulb does not produce a steady stream of light.

……

…… [1]

(c) State the differences to the light produced, if any, as the user shakes the torch more quickly.

……

…… [1]

(d) The wires connected to the bulb are disconnected and instead connected to a multimeter to measure the output voltage.

In the space below, sketch a graph of the output voltage observed over time. Label the maximum output voltage as *V*. [2]

[Total: 7]

10 Plutonium-239 is a radioactive isotope. It decays by the emission of an alpha-particle (symbol α) to an isotope of uranium (symbol U). The half-life for this decay 2.4×10^4 years.

(a) **(i)** State one similarity and one difference between the atoms of two isotopes of the same element.

similarity ……..…….

……..

difference ……..…….

……... [1]

(ii) Complete the equation for this decay.

$$^{239}_{94}Pu \longrightarrow \text{.....}^{\text{.....}}_{\text{.....}}U + \text{.....}^{\text{.....}}_{\text{.....}}\alpha$$

[2]

(iii) The count rate measured due to a pure sample of plutonium-239 is 6400 counts / second.

Calculate the count rate after a period of 1.2×10^5 years has elapsed.

count rate = ... [2]

(b) In a nuclear reactor at a power station, plutonium-239 is made to undergo nuclear fission.

(i) State what is meant by *nuclear fission*.

……

……... [1]

(ii) State one advantage of generating electricity in a nuclear power station rather than using a gas-fired power station.

……

……... [1]

[Total: 7]

11 A block of weight 15 N hangs by a wire from a remotely controlled aircraft, as shown in Fig. 11.1.

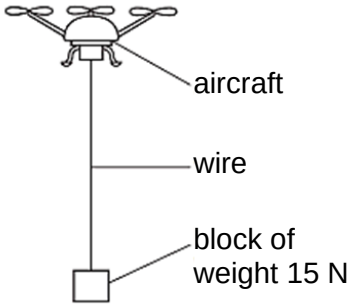

Fig. 11.1

The aircraft is used to move the block on Earth only in a vertical direction.
Fig. 11.2 shows the change in the velocity v of the block with time t. The aircraft is initially moving downwards at $t = 0$ s.

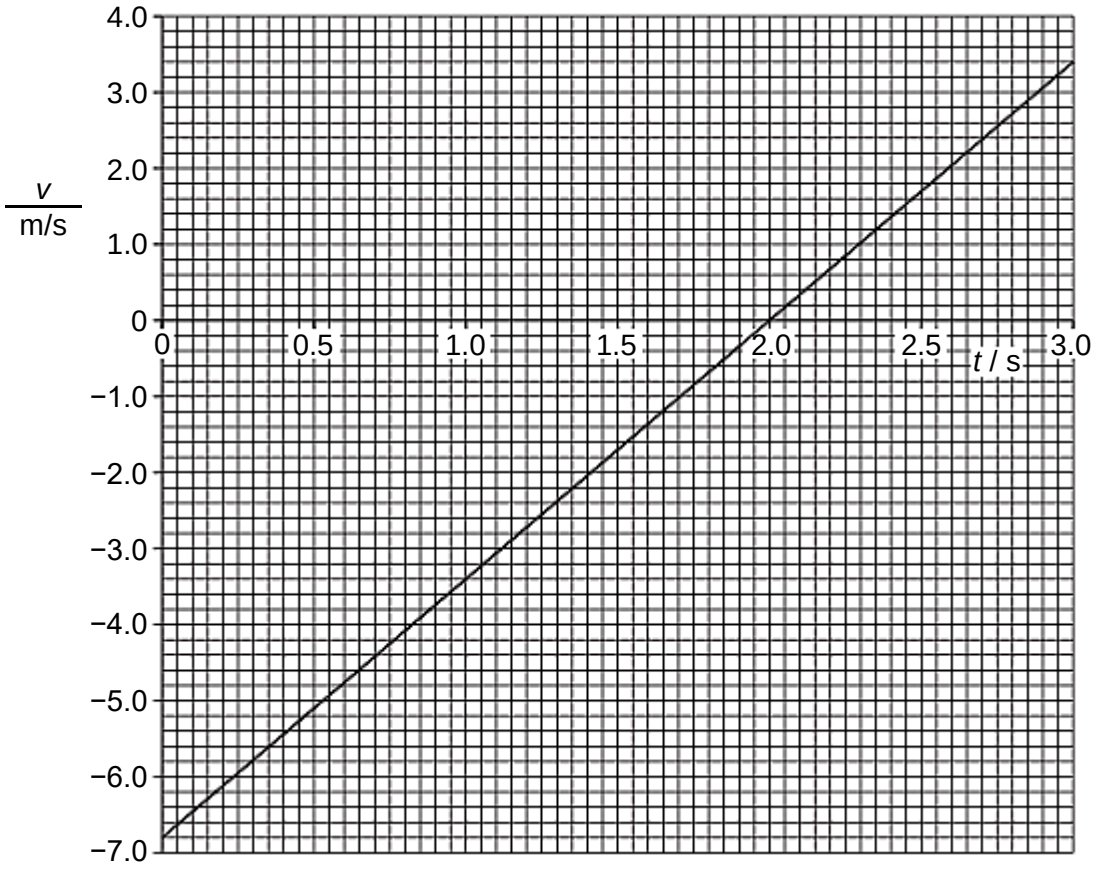

Fig. 11.2

(a) Explain how Fig. 11.2 shows that the aircraft did **not** experience significant air resistance.

……

…… [1]

(b) Determine, for the block,

(i) the displacement from t = 0 s to t = 3.0 s,

magnitude of displacement = ...

direction = ... [3]

(ii) the magnitude of acceleration at t = 2.0 s.

acceleration = ... [2]

(c) In addition to the weight, there is an upward force T acting on the block at t = 2.0 s.

Using your answer from **(b)**, determine the magnitude of the force T.

T = ... [2]

(d) At some time after t = 3.0 s, the force T has a constant value of 15 N.

Using Newton's Laws, describe and explain the motion of the block at this time.

……

……

…… [2]

(e) The force T and the weight are **not** a Newton's Third Law action-reaction pair.

Describe the other force that is the part of the action-reaction pair with the weight and state the body on which it acts.

……

…… [1]

[Total: 11]

Section B

Answer **one** question from this section.

12 Fig. 12.1 shows the dam and reservoir of a hydroelectric power station.

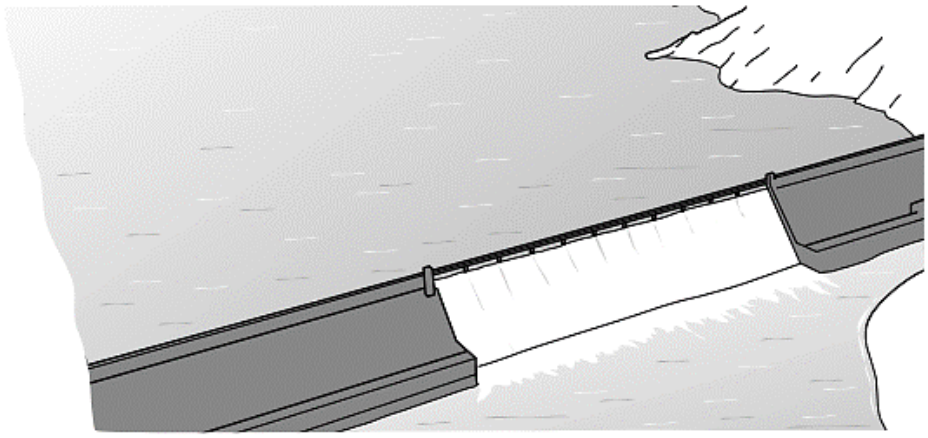

Fig. 12.1

A hydroelectric power station is a renewable energy source that is not suitable for Singapore's use.

(a) **(i)** State what is meant by *renewable* energy.

……

…….. [1]

(ii) Explain why a hydroelectric power station is **not** suitable for Singapore's use.

……

…….. [1]

(b) When the power station operates at full capacity, the electrical power output is 6.4×10^9 W.

(i) **1.** Calculate the electrical energy output of the power station if it operates at full capacity over a full day.

energy output = ... [1]

2. Suggest why, in practice, the power station cannot operate at full capacity at all times.

……

…….. [1]

(ii) The water surface in the reservoir that supplies the hydroelectric power station is at a vertical height of 170 m above the turbines.

In one hour, 1.6×10^{10} kg of water flows from the reservoir through the turbines.
The gravitational field strength is 10 N/kg.

1. Calculate the energy transferred out of the gravitational potential store in one hour.

energy transferred = ... [2]

2. Calculate the efficiency of the power station when operating at full capacity.

efficiency = ... [2]

3. Suggest **two** reasons why the efficiency of the power station is less than 100%.

1. ……

2. ……
[2]

[Total: 10]

13 Fig. 13.1 below shows a part of the mains electrical circuit in a house.
Three lamps A, B and C, each rated at '60 W, 220 V' are connected in the parallel circuit.
An electrical fan with a maximum capacity rated at '1000 W, 220 V' is connected to the mains circuit as well.
The mains supply is 220 V.

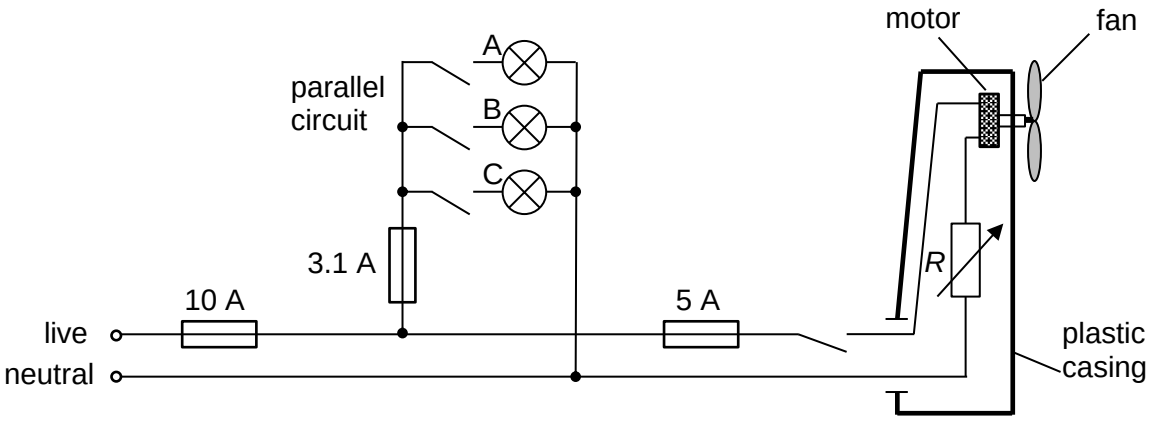

Fig. 13.1

(a) Explain how the circuit shown allows for the fan's speed to be controlled.

……

……

……

…… [2]

(b) The fan is set to operate at its maximum capacity. All the appliances are turned on for four hours every day.

Given that the unit cost of electricity is 32 cents, calculate the weekly cost of operating the appliances.

weekly cost = ... [2]

(c) Describe the function of a fuse and explain why it is connected to the live wire.

……

……

……

…… [2]

(d) The homeowner wishes to connect more lamps to the parallel circuit.

With the use of suitable calculations, determine how many more lamps the homeowner can safely connect to the parallel circuit.

number of lamps = ... [2]

(e) In recent years, Singapore has phased out the use of incandescent light-bulbs in favour of LED bulbs.

LED bulbs are said to be more energy efficient as compared to incandescent light-bulbs.

(i) State what is meant by *energy efficient*.

……

…… [1]

(ii) Explain why using more energy efficient bulbs is better for the consumer.

……

…… [1]

[Total: 10]

- END OF PAPER -

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