NGEE ANN SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2020
SECONDARY 4 EXPRESS
PHYSICS 6091
PAPER 1

MARK SCHEME

1	**A**
2	**B**
3	**D**
4	**B**
5	**B**
6	**A**
7	**C**
8	**A**
9	**B**
10	**B**
11	**A**
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13	**C**
14	**C**
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20	**C**

21	**C**
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NGEE ANN SECONDARY SCHOOL

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PRELIMINARY EXAMINATION

PURE PHYSICS **6091/02**

PAPER 2 **24 August 2020**

1 h 45 min

MARK SCHEME

This document consists of **19** printed pages (including this cover page).

Section A (50 marks)

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

1 Fig. 1.1 is the speed-time graph for a rocket from the moment that the fuel starts to burn at time $t = 0$.

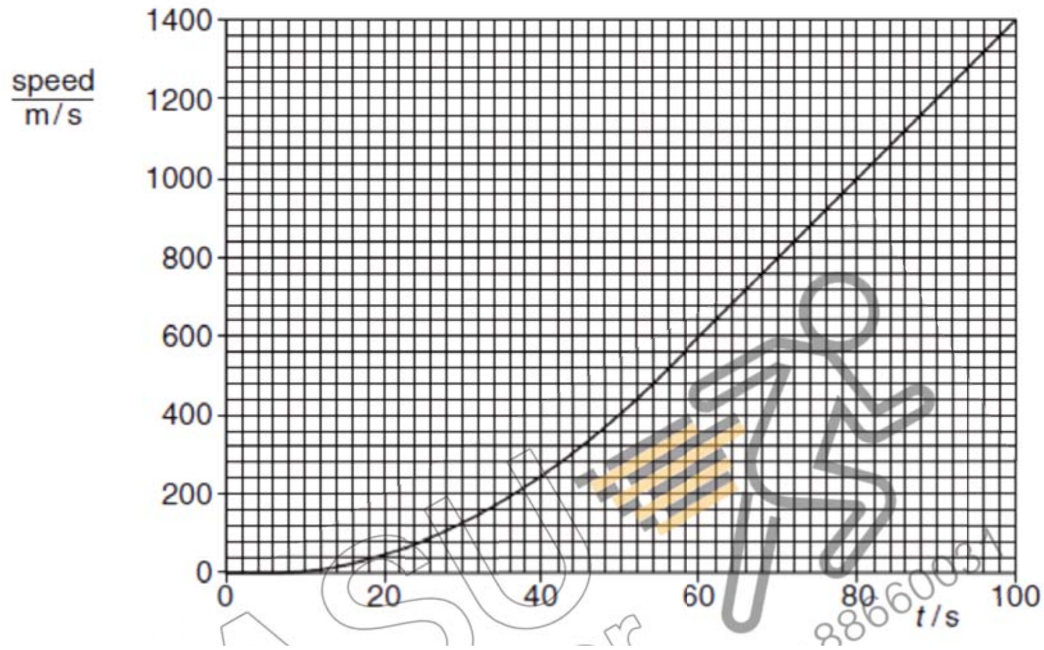


Fig. 1.1

(a) (i) State what happens to the acceleration of the rocket between $t = 5$ s and $t = 80$ s.

*It **increases** and **eventually reaches a constant value**. [1]*

(ii) Calculate the acceleration of the rocket at $t = 80$ s.

***Acceleration** = gradient of speed-time graph*
= (1400 – 400) / (100 – 50) [1]
= 20 m/s² [1]

(iii) The total mass of the rocket at $t = 80$ s is 1.6×10^6 kg. Calculate the upward force on the rocket at this time, caused by the burning fuel.

***Net force = ma** = $1.6 \times 10^6 \times 20$*
= 3.2×10^7 N [1]

***Upward force** = $3.2 \times 10^7 + (1.6 \times 10^6 \times 10)$*
= 4.8×10^7 N [1]

(b) As the rocket burns fuel, it ejects hot gas downwards. Name a pair of action and reaction force.

The upward force on the rocket by the gas

The downward force acting on the hot gas by the rocket. ***[1]***

2 Fig. 2.1 illustrates the journey of a cyclist from point A to point B. Points A and B are at the same height.

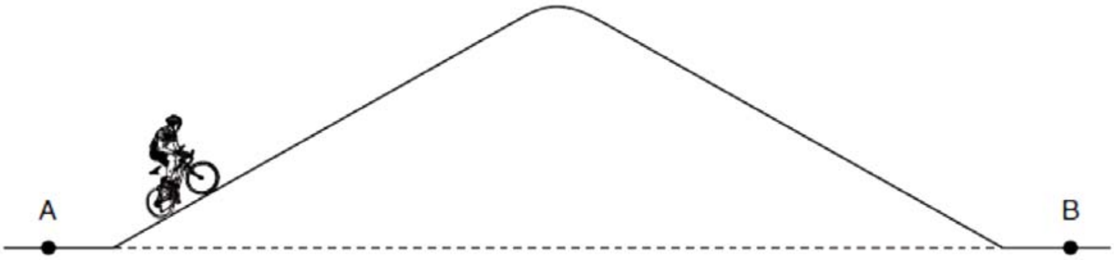


Fig. 2.1

The cyclist starts from rest at A and pedals up and over a hill. Near the bottom of the hill, she starts to brake and comes to rest at B.

(a) Describe the energy changes that take place as she pedals up the hill at constant speed.

Chemical potential energy *in the cyclist is* ***converted to gravitational potential energy*** *as she pedals* ***up the hill****. [1]*

Some of it is also ***converted to thermal energy/heat*** *due to* ***friction*** *on the road. [1]*
(if KE is mentioned, an idea of no net gain in KE must be conveyed)

(b) Explain how the law of conservation of energy applies to the complete journey from A to B.

From A to B, ***all the chemical potential energy*** *used by the cyclist is* ***converted to thermal energy / heat****. [1]*

Since the ***total energy remains constant from A to B****, the law of conservation of energy applies to this journey. [1]*

(c) At one point in the journey, the gravitational potential energy of the cyclist has increased by 5400 J. The mass of the cyclist is 60 kg.

Calculate the height above A of the cyclist at this point.

Using GPE = mgh,

5400 = 60 x 10 x h [1]

h = 9.0 m [1]

3 A student conducts an experiment to verify the principle of moments using a set-up shown in Fig. 3.1.

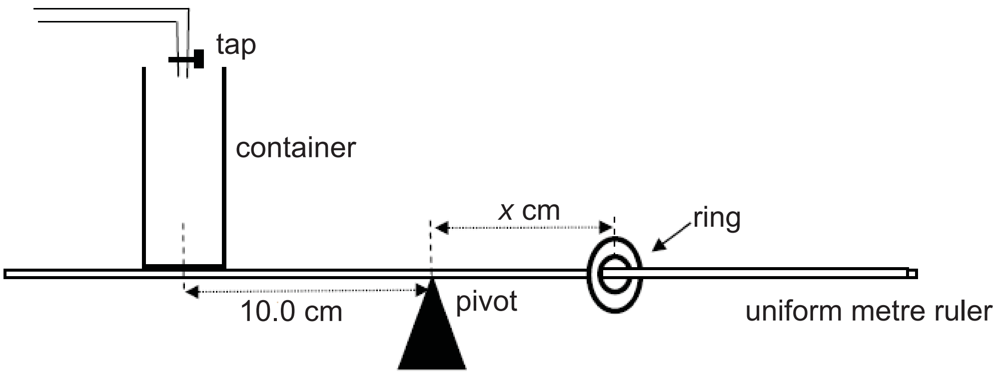


Fig. 3.1

A container of negligible mass is placed on a uniform metre ruler which is pivoted at the 50.0 cm mark. Water of density 1.0 g/cm^3 is released into the container at a constant rate of 50.0 cm^3 per minute. In order to balance the metre ruler, a ring of mass 55 g is hung on the ruler and its position is adjusted accordingly by the student.

(a) Define the moment of a force.

The product between a force and the perpendicular distance from line of action of force and pivot [1]

(b) Calculate *x* to balance the ruler after the tap is turned on for 3 min.

mass of water after 3 min = 1.0 × (50 × 3) = 150 g [1]

150 × 10 = 55 × x
x = 27.3 cm [1]

(c) If the force of pivot on the ruler is 3.0 N after the tap is turned on for 3 min, calculate the weight of the ruler.

Total upward force = total downward force
3 = weight + (0.150 + 0.055) × 10 [1]
weight = 0.95 N [1]

4 Fig. 4.1 shows a fully inflated balloon placed inside a sealed and transparent tank. The tank is connected to an oxygen cylinder. Initially, the inside of the tank is kept at atmospheric pressure. When the tap is opened, oxygen is released from the cylinder into the tank. The temperature inside the tank remains constant throughout the experiment.

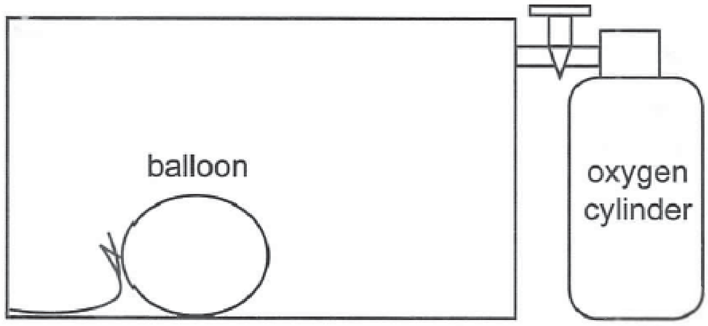


Fig. 4.1

The tap is now opened until a noticeable change is observed in the balloon.

(a) State how the volume and pressure inside the balloon will change.

Volume of balloon decreases [1]
and pressure in balloon increases. [1]

(b) Using kinetic model of matter, describe and explain the changes in pressure and volume observed in the balloon.

As pressure outside balloon is greater than the pressure inside the balloon, there is a net force which causes the balloon to decrease in volume. [1]

There is a greater number of gaseous molecules per unit volume and frequency of collisions of molecules with the inner wall of the balloon increases. [1]

This results in an increase in average force exerted by the gas molecules per unit area which leads to an increase in pressure inside the balloon. [1]

5 Fig. 5.1 shows a section of a solar heating system which helps to provide hot water for a house.

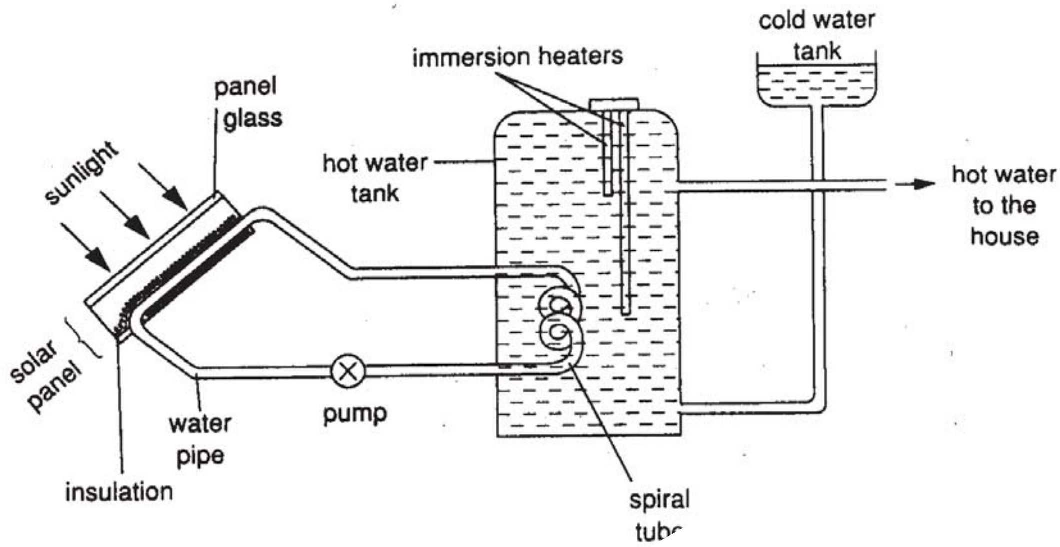


Fig. 5.1

It consists of a solar panel placed outdoor on a roof. Connected to this panel are water pipes. Heat from the Sun warms the water in these pipes which is then pumped to a hot water tank inside the house. Inside the hot water tank, the hot water transfers its heat, becomes cooled and circulates back to the solar panel.

Explain the purpose of the following features:

(a) the solar panel is covered with a sheet of glass,

Glass allows <u>infrared rays into solar panel</u> and <u>trap the heat</u> [1]

(b) there is an insulation for the water pipe in the solar panel, and

It <u>reduces heat loss from the water in the pipe by conduction to the solar panel</u> when the Sun is not shinning. [1]

(c) the water pipe in the hot water tank is spiral and painted black.

<u>Spiral increase surface area</u> to allow more heat to be transferred to water by conduction / radiation. [1]

<u>Black is a good emitter of infra-red radiation. These</u> <u>increase rate of radiation to water / enable water to be heated up quickly</u>. [1]

6 Fig. 6.1 shows circular wavefronts produced at the centre of a circular ripple tank.

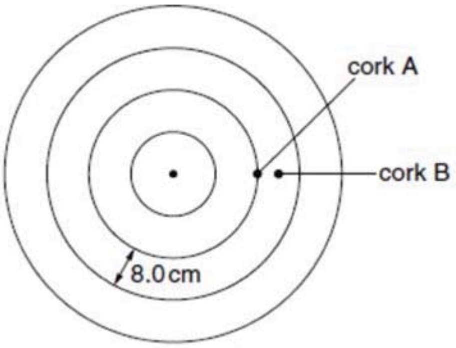
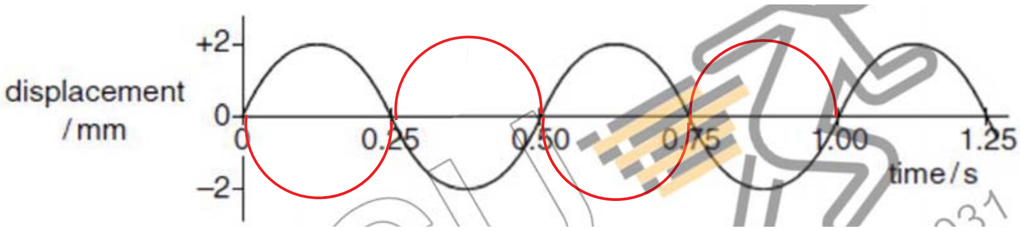


Fig. 6.1

Two corks, A and B, float on the water in the ripple tank. They move up and down on the surface of the water as the wave passes. The wavelength of the wave is 8.0 cm.

Fig. 6.2 shows how the displacement of A varies with time.



(a) Define what is meant by frequency of the wave.

Number of complete waves in one second. [1]

(b) **(i)** Use Fig.6.2 to determine the frequency of the wave.

f = 1/ T = 1 / 0.50 = <u>2.0 Hz [1]</u>

(ii) Hence, calculate the speed of the wave.

v = fλ = 2.0 x 8.0 [1]
= <u>16 cm/s or 0.16 m/s [1</u>

(c) The horizontal distance between A and B is half the wavelength of the wave.
On Fig. 6.2, sketch a graph to show how the displacement of B varies with time. Draw at least 2 complete waves.

[1] for 2 correct and complete waves drawn

7 Fig. 7.1 shows an object **O** placed in front of a converging lens **PQ**. The image of **O** is formed at **I**. A plane mirror is then inserted between the lens **PQ** and the image **I** as shown in the diagram.

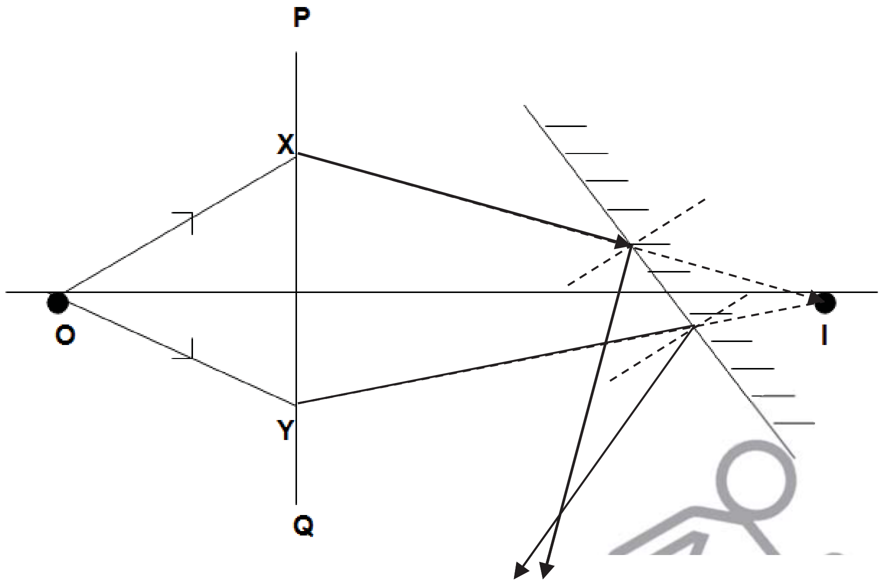


Fig. 7.1

(a) What do you understand by focal length of a lens?

The distance between the optical centre and the focal point [1]

(b) **(i)** On Fig. 7.1, complete the ray diagram to show how the two rays **OX** and **OY** are reflected by the mirror after they emerge through **PQ**.

Normal drawn and 1st correct reflected ray [1]
Normal drawn and 2nd correct reflected ray [1]
-1 if no arrow

(ii) Using evidence from your diagram in *(b)(i)*, explain whether an image formed will be virtual or real.

The image formed will be real [1] as the rays converge at a point [1]

8 The base of a storm cloud is negatively charged. Fig. 8.1 shows the cloud above flat ground.

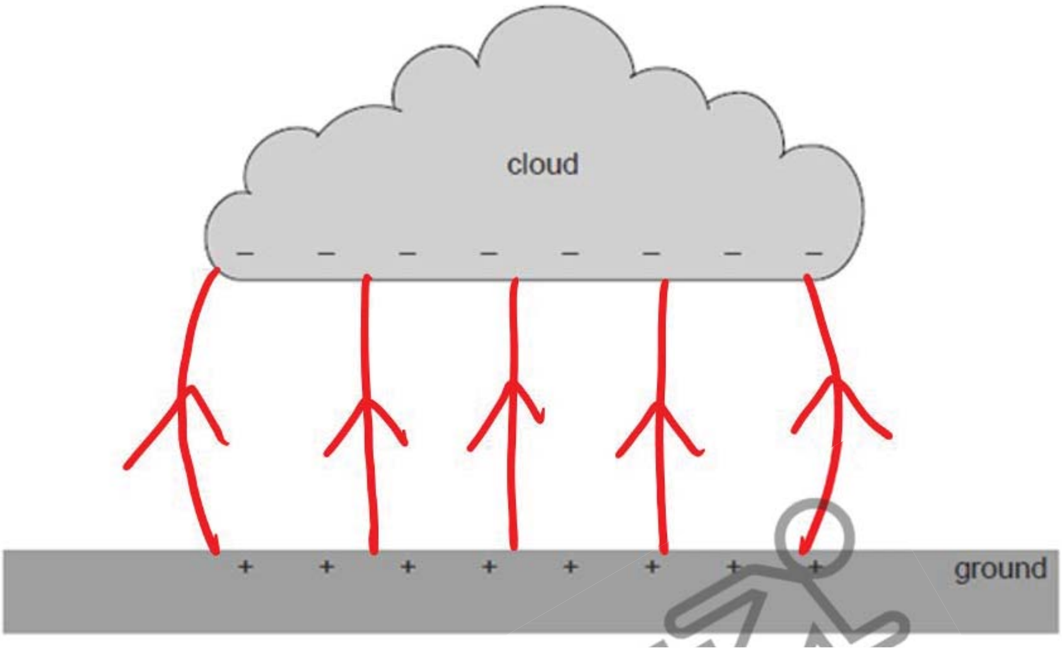


Fig. 8.1

(a) The cloud causes the ground beneath it to become positively charged.
Explain, in terms of the particles involved, how the ground becomes positively charged.

***Electrons on the ground are repelled** by the negatively-charged cloud, [1] as **like charges repel**. [1] This causes the ground to be positively charged.*

(b) In the space between the negative charge on the cloud and the positive charge on the ground, there is an electric field.

(i) State what is meant by an *electric field*.

***Region** where **electric charges** **experience an electrical force** [1]*

(ii) On Fig. 8.1, draw the electric field between the cloud and ground.

[1] for correct electric field drawn. [1]

9 Four resistors and a rheostat are connected as shown in Fig. 9.1. Each resistor has a resistance of **R.**

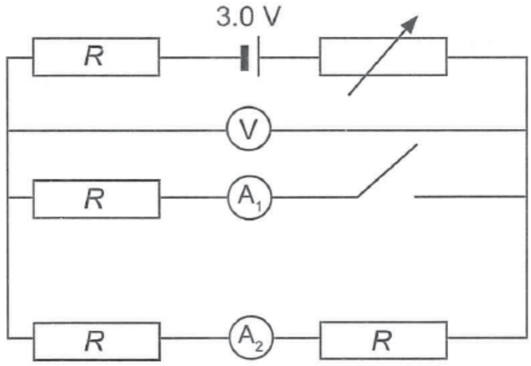


Fig. 9.1

Both the ammeters and the voltmeter used are ideal.

(a) When the switch is open and the rheostat is set to 1.0 Ω, the voltmeter reads 1.50 V. Calculate value of R.

$$V_R = \frac{1.50}{2} = 0.75V$$

$$V_{\text{variable resistor}} = 3.0 - (0.75 \times 3) = 0.75V$$ **[1]**

$$I = \frac{V}{R} = \frac{0.75}{1.0} = 0.75A$$ **[1]**

$$R = \frac{V}{I} = \frac{0.75}{0.75} = 1.0\Omega$$ **[1]**

(b) The rheostat is now set to a different resistance value so that when the switch is closed, ammeter A_1 reading is 0.36 A and ammeter A_2 reading is 0.18 A. Calculate the new resistance of the rheostat.

I_T = 0.36 + 0.18 = 0.54 A

1/R = 1/1 + ½ = 3/2
R = 2/3 = 0.667 Ω **[1]**

$$R_E = \frac{V_T}{I_T} = \frac{3.0}{0.54} = 5.56\Omega$$ **[1]**

$$5.56 - 1 - 0.667 = 3.89\Omega$$ **[1]**

10 Fig.10.1 shows the structure of a circuit-breaker that uses an electromagnet. The circuit-breaker operates when the current is 10 A.

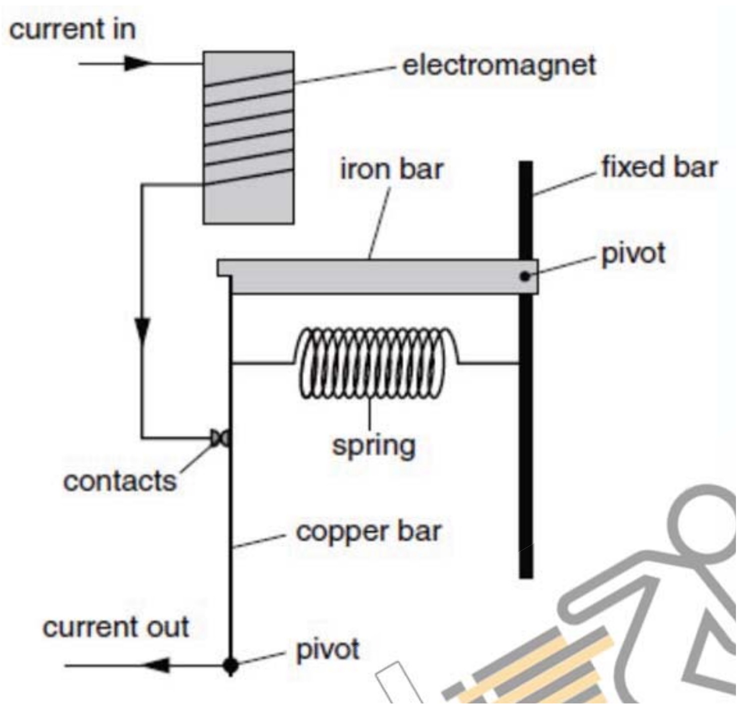


Fig. 10.1

(a) When the current is greater than 10 A, the circuit-breaker stops the current. Explain what happens in the circuit-breaker when this occurs.

When the current is greater than 10 A, the electromagnet becomes ***strongly magnetised*** *and* ***attracts the iron bar upwards****. [1]*
The ***spring contracts*** *and* ***pulls the copper bar****, breaking the contacts. [1] The* ***circuit*** *is now* ***open*** *and the* ***current stops flowing****. [1]*

(b) State how the electromagnet can be altered so that the circuit-breaker stops the current at less than 10 A.

Increase the number of turns *in the coil. [1]*

(This will increase the attractive force acting on the iron bar when the current is less 10 A.)

(accept other answers involving force on the iron bar)

Section B (30 marks)
Answer **all** questions in this section in the spaces provided.
Answer **only one** of the two alternative questions in **Question 13**.

11 **(a)** In an experiment to measure the specific heat capacity of water, an electric heater heats water in a glass beaker. The temperature of the water is measured at regular intervals of time. Fig. 11.1 shows how the temperature varies with time t.

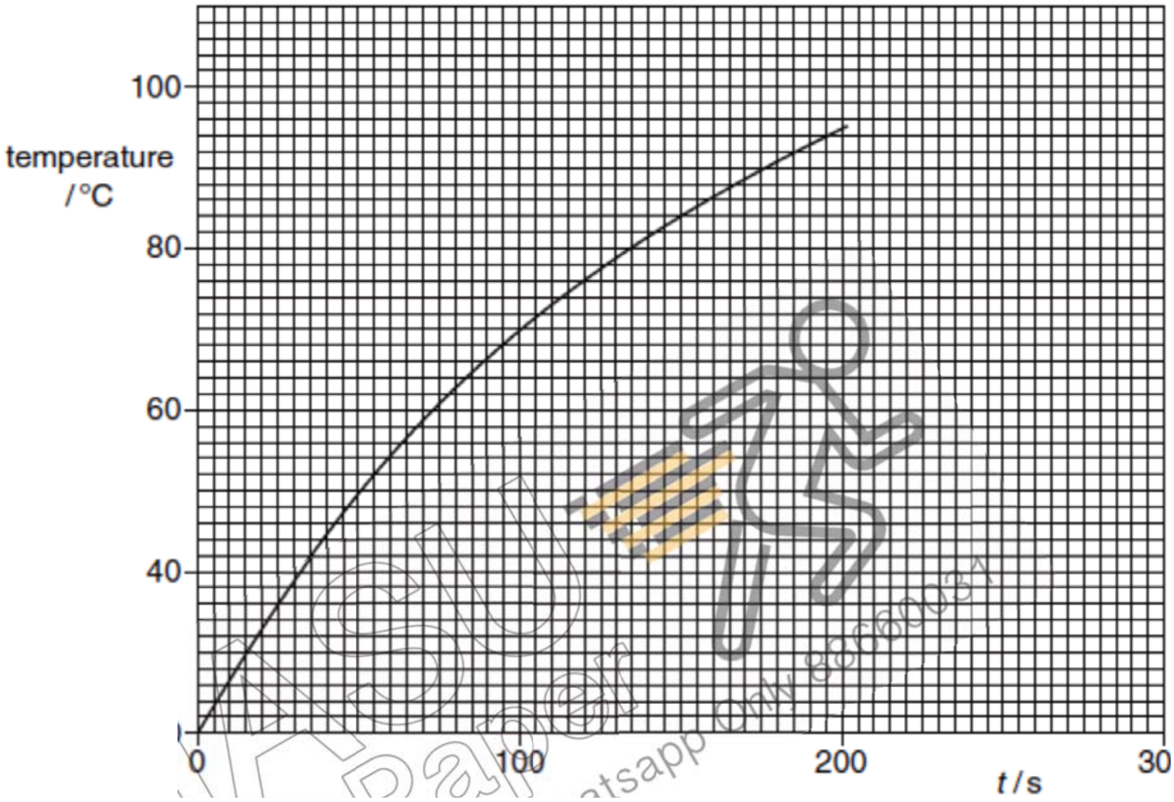


Fig. 11.1

(i) Use Fig. 11.1 to determine the change in temperature between

t = 0 and t = 100 s, change = ***50 °C***

t = 100 s and t = 200 s. change = ***25 °C [both for 1 mark]***

(ii) Explain why the values in **(i)** are different.

At higher temperature, the rate of temperature change decreases due to higher rate of evaporation [1]. More energy is used to overcome the intermolecular bonds then to increase the temperature of water [1]

(b) The experiment in **(a)** is repeated using 72 g of water. The heater supplies 7400 J of thermal energy to the water and the temperature rise of the water is 23 °C. Calculate the specific heat capacity of water.

$Q = mc\Delta\theta$
$c = 7400 / (72 \times 23)$ [1]

= ***<u>4.47 J / (g °C) or 4470 J / (kg °C)   [1]</u>***

(c) **(i)** A bullet of mass 72 g is fired from a gun at a speed of 450 m/s. Calculate the kinetic energy of the bullet.

KE = ½ mv^2
= ½ x 0.072 x 450^2 [1]
= <u>7290 J   [1]</u>

(ii) The amount of internal energy gained by the water and the amount of kinetic energy gained by the bullet are approximately equal.

Describe the change in the motion of the molecules of the water and of the molecules of the bullet caused by this addition of energy.

water:
The water molecules <u>move faster</u>. [1] However, the motion is still <u>random</u> as the molecules slide over each other in the liquid.[1]

bullet:

All the molecules of the bullet <u>move/vibrate faster about their fixed positions.</u> [1]

12 A racing car of mass 500 kg, including the driver but not fuel, decelerates from a speed of 50.0 m s^{-1} to 30.0 m s^{-1} when approaching a bend. While the brakes are applied, the driver steps on the clutch to disengage the engine transmission to the wheels. A constant resultant retarding force of 7000 N thus acts on the vehicle.

(a) Given that the capacity of the fuel tank of the racing car is 0.178 m^3 and the density of the fuel used is 720 kg m^{-3}, calculate the mass of the fuel needed to fill up the fuel tank.

Mass = density x volume = 720 x 0.178 [1]
= 128.16 kg = 128 kg (3 sf) [1]

(b) Calculate the total weight of the racing car when it is travelling with a full tank.

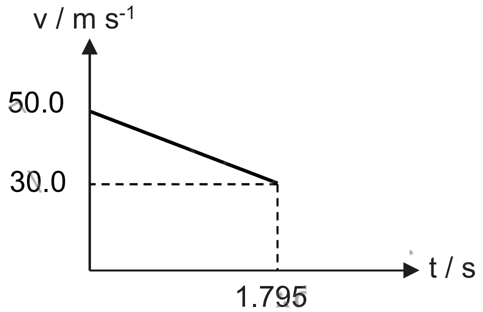
Total weight = m x g = (500 + 128.16) × 10 [1]
= 6281.6 N = 6280 N (3 sf) [1]

(c) Assuming that the racing car approaches the bend with a full tank and that the change in the mass of the fuel is negligible during the deceleration, calculate the time taken for the deceleration.

Deceleration experienced by the car = $\frac{F}{m} = \frac{7000}{628.16} \approx 11.14\,\text{m s}^{-2}$ **[1]**

$a = \frac{v-u}{t} \rightarrow t = \frac{v-u}{a} = \frac{30.0-50.0}{-11.14} \approx 1.795 \approx 1.80\,\text{s}$ (3 s.f) **[2]**

(d) Calculate the work done by the retarding force to decelerate the car from 50.0 m s^{-1} to 30.0 m s^{-1}. (Leave your answer to 3 s.f.)



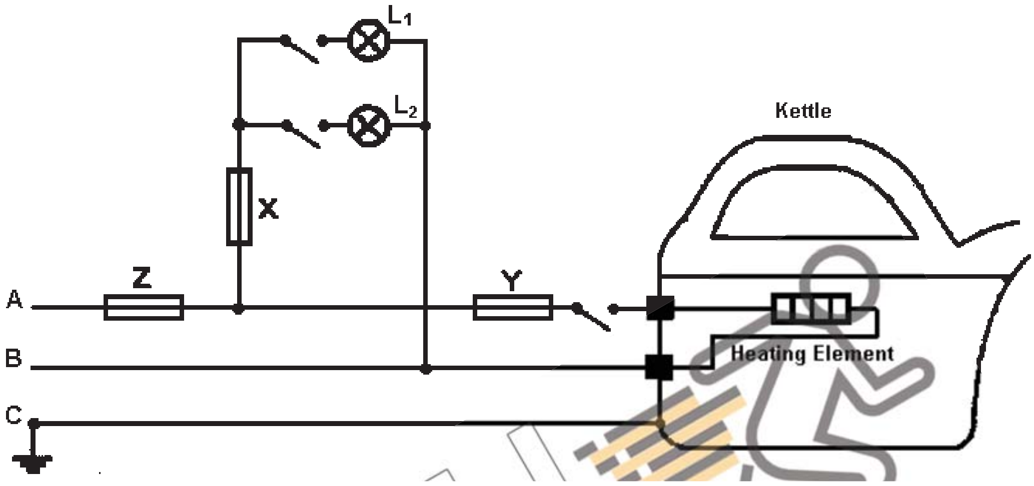
Distance travelled
= area under graph

$\frac{1}{2}(50.0+30.0)(1.795) = 71.8$ ***m [1]***

W.d = F x s
= 7000 × 71.8
= 502600 J [1]
= 503 000 J (3 s.f.) [1]

14 EITHER

Part of the mains electrical circuit in a house is shown in the diagram. Two lamps L_1 and L_2, each rated at 90 W, 240 V, are connected to the wire A through fuse X. An electric kettle, rated at 2.1 kW, 240 V is also connected to the wire A through fuse Y. Fuse Z protects the whole circuit. The electric kettle has a metal case that is connected to wire C. The mains supply voltage is 240 V and the maximum current of fuses X, Y and Z are 3 A, 9 A and 10 A respectively.



(e) State and explain the purpose of each wire A, B and C.

Wire A is a Live wire. It carries current from the mains to the kettle [1]

Wire B is a Neutral wire. It carries current from the kettle back to the mains [1]

Wire C is an Earth wire. It is a low resistance wire tied to the ***metal casing of the kettle. Should the metal casing accidentally becomes live, a large current will flow through the Earth wire*** *and blow the circuit fuse, hence protecting the user from an electric shock* ***[1]***

(f) Calculate the total current drawn from the mains when the electric kettle and both the lamps are switched on.

Let current drawn by one lamp, $I_1 = \frac{P}{V} = \frac{90\text{ W}}{240\text{ V}}$ ***= 0.375 A [1]***

Let current drawn by electric kettle, $I_2 = \frac{P}{V} = \frac{2100\text{ W}}{240\text{ V}}$ ***= 8.75 A [1]***

Total current drawn, I = (0.375 A x 2) + 8.75 A= 9.5 A [1]

(g) State and explain whether fuse X, fuse Y and fuse Z will blow if the owner decides to add another six more identical lamps to light up the house?

Fuse X will blow since current drawn by 8 lamps is 3 A and fuse is rated at exactly 3A [1].

Fuse Y will not blow since current drawn by electric kettle is still 8.75 A and is less than the fuse rating of 9A [1].

Fuse Z will blow because total current drawn is 11.75 A but it is rated at 10 A only [1]

(h) Give a reason why the heating element is inappropriately positioned.
<u>Convection currents cannot be set up</u> since the heating element is located at the top of the water.[1]

13 OR

A company claims that their product, which is an ultrasound mosquito repeller, can be used to repel mosquitoes. This repeller is an electronic appliance which has a power rating of 3.0 W and is used on a 230 V supply. The ultrasound produced by the repeller is between 28 kHz to 80 kHz and this range repels female mosquitoes.

(a) Explain if the ultrasound can be heard by humans.

No. Audible range for human is between 20 to 20kHz. [1]

(b) Describe how the repeller propagates the ultrasound and how this ultrasound travels through air.

*The repeller **vibrates** and air molecules **push and pull/collide** on the neighbouring molecules **<u>parallel</u> to the direction of wave travel**. [1]*
*This sets up regions of **<u>compressions</u>** <u>and</u> **<u>rarefactions</u>** of longitudinal ultrasound waves and longitudinal waves are formed [1]*

(c) The repeller is placed X metres from a wall and a mosquito hovers in the air a distance away from the repeller as shown in Fig. 13.2.

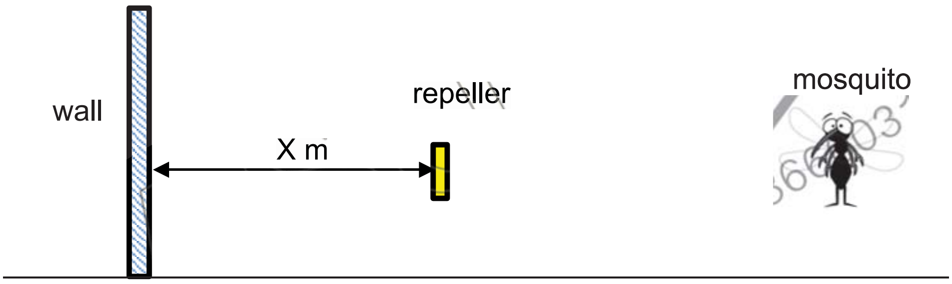


Fig. 13.2

If the ultrasound from the repeller hits the hovering mosquito twice with a time lapse of 0.10 s, calculate X. (Assume the speed of ultrasound in air is 330 m/s)

$\mathbf{t_2 - t_1 = 0.10 \rightarrow (d+X) / 330 - (d-X) / 330 = 0.10}$ **[1]**
$\mathbf{\rightarrow d + X - d + X = 0.10}$
$\mathbf{\rightarrow 2X = 33}$
$\mathbf{\rightarrow X = 16.5\ m}$ **[1]**

(d) State and explain the effect on the following when the repeller's frequency increases from 28 kHz to 80 kHz?

Pitch : The pitch increases as frequency increases. [1]

Speed : The speed remains the same as it is affected only by the medium and medium remains unchanged [1]

(e) The sound wave from the repeller travels from left to right through air. Fig. 13.3 is a scaled diagram that shows the actual positions of the air particles at a particular instance. Before the sound wave arrives, the particles are all spaced equally apart on

X **Y**

the vertical lines shown. At the instance shown, particles X and Y are passing through the original undisturbed position.

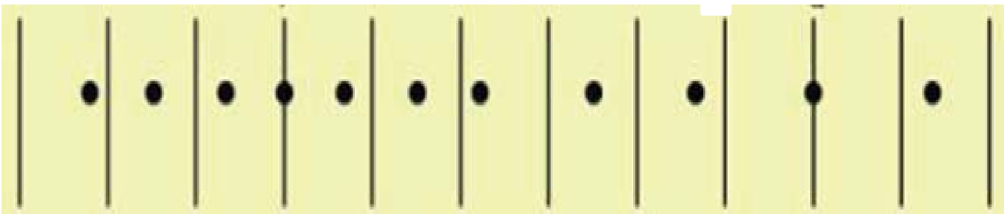
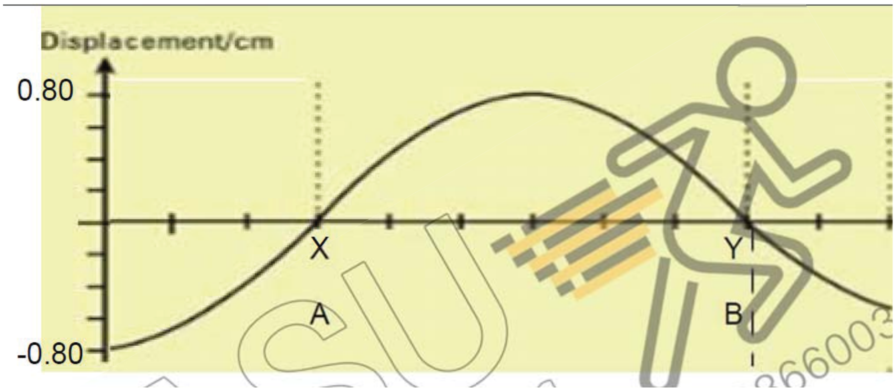


Fig. 13.3

(ii) For the instance shown in Fig. 13.3, sketch the displacement-distance graph of all the particles in the axes below. Label particles **X** and **Y** in your graph.



Shape [1] , value & label [1] : accept 0.80cm or 0.90cm

(ii) Indicate on the graph above the points where the pressure is the highest with a letter **A** and the point where the pressure is the lowest with the letter **B**.

Both A and B correctly labelled [1]

-- END OF PAPER --