



Geylang Methodist School (Secondary) Preliminary Examination 2020

PHYSICS

6091/01

Paper 1

Sec 4 Express

Answers

1 A	2 B	3 C	4 B	5 B	6 A	7 C	8 A	9 B	10 C
11 D	12 C	13 B	14 B	15 C	16 B	17 C	18 C	19 C	20 A
21 A	22 C	23 B	24 A	25 B	26 A	27 D	28 A	29 C	30 B
31 A	32 B	33 D	34 C	35 B	36 C	37 C	38 B	39 C	40 B



Geylang Methodist School (Secondary) Preliminary Examination 2020

Candidate
Name

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Class

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Index Number

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PHYSICS

6091/02

Paper 2 Physics

Sec 4 Express

Additional materials : Writing Papers

1 hour 45 minutes

Setter : Mr Yip Cheng Hou

25 September 2020

READ THESE INSTRUCTIONS FIRST

Write your name, index number and class on all the work you hand in.

Write in dark blue or black pen on both sides of the paper.

Do not use staples, paper clips, highlighters, glue or correction fluid.

Answer **all** questions.

Write your answers to **Section A** in the spaces provided in the Question Paper.

Write your answers to **Section B** in writing papers provided unless stated otherwise.

Question 12 has a choice of parts to answer.

Candidates are reminded that all quantitative answers should include appropriate units.
You are advised to show all your working in a clear, orderly manner.

At the end of the examination, fasten all your work securely together.

The number of marks is given in brackets [] at the end of each question or part question.

Acceleration due to gravity, g , is assumed to be 10 m/s^2 unless otherwise specified.

For Examiner's Use	
Section A	/50
Section B	/30
Total	/80

This document consists of **20** printed pages and 1 blank page.

[Turn over

Section A

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

- 1 A man starts the engine of his boat. The engine produces a constant forward force of 1000 N. The total mass of the boat and man is 400 kg. Fig. 1.1 shows how the resistive force on his boat varies over time.

Resistive force / N

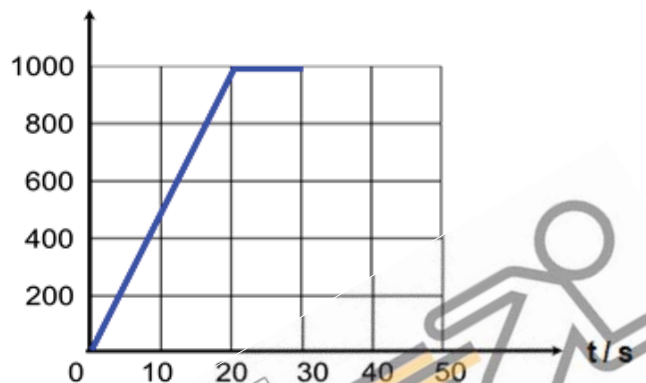


Fig. 1.1

He reaches a maximum velocity of 25 m/s at time $t = 20$ s.

- (a) Calculate the acceleration at time $t = 10$ s.

$$F_R = ma$$

$$1000 - 500 = 400a$$

$$a = 1.25 \text{ m/s}^2$$

OR

$$a = (v-u)/t$$

$$= (25 - 0) / 20$$

$$= 1.25 \text{ m/s}^2$$

acceleration = [2]

- (b) Explain why his velocity does not increase from $t = 20$ s.

forward force = resistive force, and hence resultant force = 0 or acc = 0

.....[1]

- (c) At $t = 30$ s, he switches off the engine completely. Assuming that the boat experiences a constant resistive force 1000 N, calculate the time taken for him to come to a stop.

$$F_R = ma$$

$$-1000 = 400a$$

$$a = -2.50 \text{ m/s}^2 \text{ (1)}$$

$$a = (v-u)/t$$

$$-2.5 = (0-25)/t$$

$$t = 25/2.5$$

$$= 10.0 \text{ s (1)}$$

time = [2]

- (d) Sketch the speed-time graph for his entire journey till he comes to a stop in Fig. 1.2 below. [2]

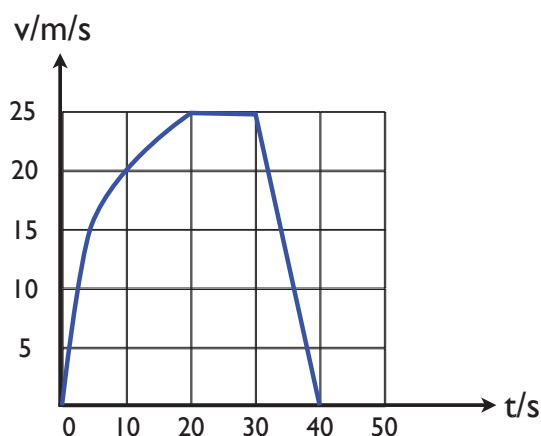


Fig. 1.2

- 2 An uniform ladder which is 5 m long and has a weight W of 400 N leans with its upper end against a smooth vertical wall and its lower end on a rough ground, as shown in Fig. 2.1.

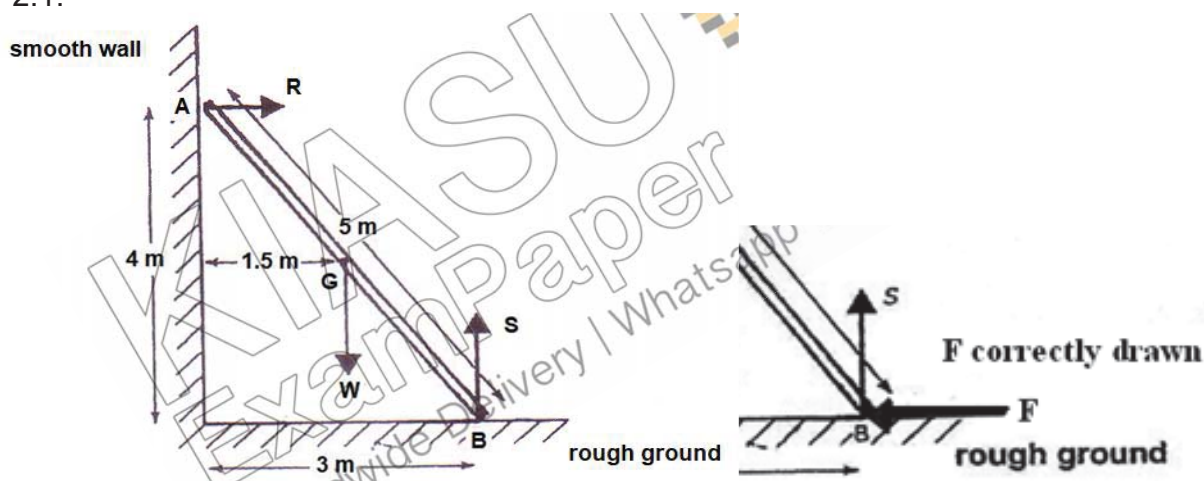


Fig. 2.1

R is the normal reaction force acting on the top of the ladder due to the wall and S is the normal reaction force acting on the bottom of the ladder due to the ground. A frictional force f (not shown on diagram) also acts at the bottom of the ladder due to the rough ground.

At this position, the ladder is in equilibrium.

- (i) On the diagram, indicate where the frictional force f would be acting. [1]

- (ii) State the value of **S** and explain your answer.

S = W = 400 N (1) ladder is in (vertical) equilibrium, the total upward forces equal total down forces [2]

- (iii) By taking moments about **A**, calculate the anti-clockwise moment due to the normal reaction force **S**.

ACW Moment due to S = 400 x 3 = 1200 Nm

Anti-clockwise moment = [1]

- (iv) Hence, by considering the total clockwise moments due to the frictional force **f** and the weight **W** of the ladder about **A**, find the value of the frictional force **f**.

According to Principle of Moments

Taking A as the pivot

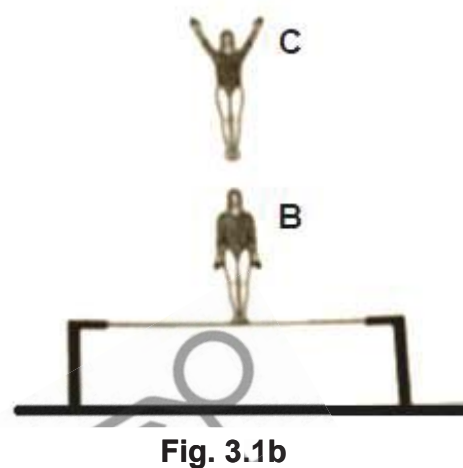
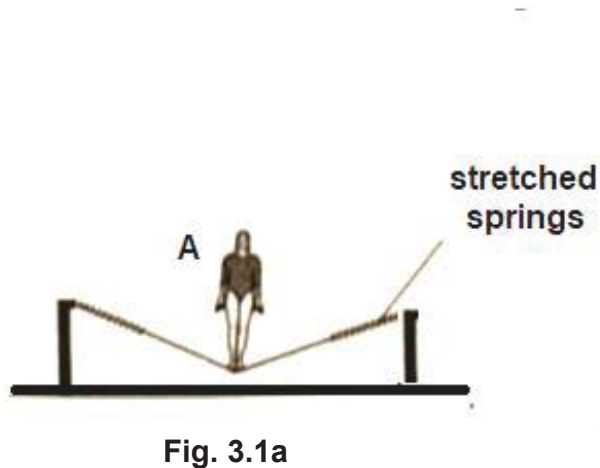
Total CW moments = Total ACW moments

(400)(1.5) + (F)(4) = 1200

F = 150 N

frictional force **f** = [2]

- 3 Fig. 3.1 shows a gymnast on a trampoline.
 At position **A** in Fig. 3.1a, the gymnast starts to rise.
 She passes through **B** in Fig. 3.1b and reaches her maximum height at **C**.



- (a) State the form of energy stored in the stretched springs in Fig. 3.1a.

Elastic Potential Energy [1/2 mark for E.P.E]

..... [1]

- (b) State the form(s) of energy gained from **A** to **B**.

Gravitational Potential Energy + Kinetic Energy
[1/2 mark for Potential Energy]

[1]

- (c) State the energy changes from **B** to **C**.

Kinetic Energy to Gravitational Potential Energy
[1/2 mark for abbreviations]

[1]

- 4 Two different kettles are used to heat water, as shown in Fig. 4.1.

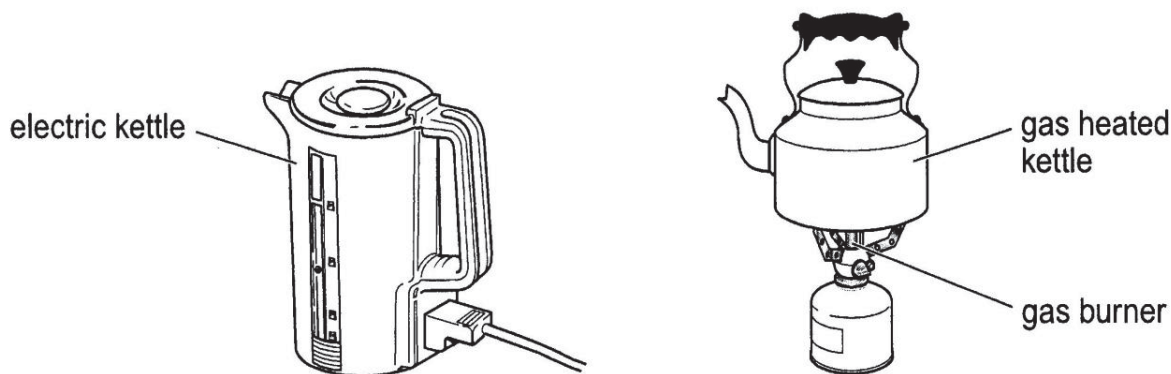


Fig. 4.1

Data for the two kettles is shown in Fig. 4.2.

type of kettle	energy supplied to the kettle in one minute / J	thermal energy supplied by the kettle to the water in one minute / J
electric kettle	120 000	95 000
gas heated kettle	130 000	90 000

Fig. 4.2

- (a) (i) Calculate the efficiency of **both** electric kettles.

$$\text{Efficiency} = \frac{\text{useful energy}}{\text{input energy}} \times 100\%$$

$$\text{Electric kettle} = \frac{95000}{120000} \times 100\% = 79.2\%$$

$$\text{Gas heated kettle} = 69.2\%$$

efficiency of electric kettle =

efficiency of gas heated kettle = [2]

- (ii) Explain the difference in efficiency in terms of thermal transfer.

Heat energy in the electric kettle is in direct contact with water (1)

However heat energy from the gas burner need to pass through the kettle by conduction before reaching water so energy is lost (1). [2]

- (b) A metal can and a plastic bottle, both containing liquid, are cooled by placing them in a jug of melting ice, as shown in Fig. 4.3.

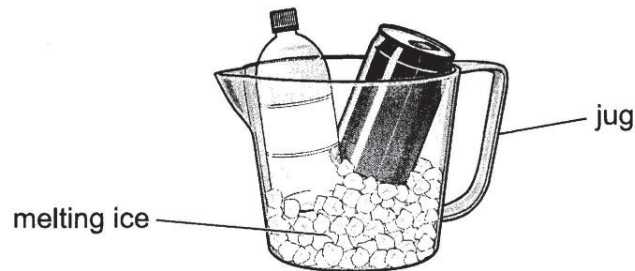


Fig. 4.3

The can and bottle each contains 330 g of the same liquid at 15 °C.
 The specific heat capacity of the liquid is 4.2 J / (g °C).
 The specific latent heat of fusion of ice is 336 J / g.

- (i) Calculate the thermal energy released when 330 g of the liquid at 15 °C is cooled to 2 °C.

$$\begin{aligned} Q &= m c \Delta \theta = 330 \times 4.2 \times (15 - 2) \\ &= 18018 \text{ J} \\ &= 18000 \text{ J (3sf)} \end{aligned}$$

energy = [2]

- (ii) When cold water at 0 °C is used in the jug, instead of the melting ice, the cooling is slower.

Explain why cooling is faster when melting ice is used in the jug rather than cold water at 0 °C.

Specific latent heat of fusion of ice is 336 J / g at 0 °C whereas the specific heat capacity of water is 4.2 J / (g °C). So ice absorbs more latent heat in order to break the intermolecular bonds and change from its solid state to liquid state at 0 °C. Hence cooling is faster when using melting ice rather than water at 0 °C.

[2]

- (iii) Explain why the liquid in the metal can cools down faster than the liquid in the plastic bottle in terms of electrons.

Metals has free moving electrons to conduct heat faster while plastics do not have. So heat loss is faster in metal.

[1]

- 6 Fig. 6.1 traced the paths of three incident rays, AO, BO and CO, as they enter a semicircular slab of transparent plastic. One of the rays undergoes **total internal reflection**.

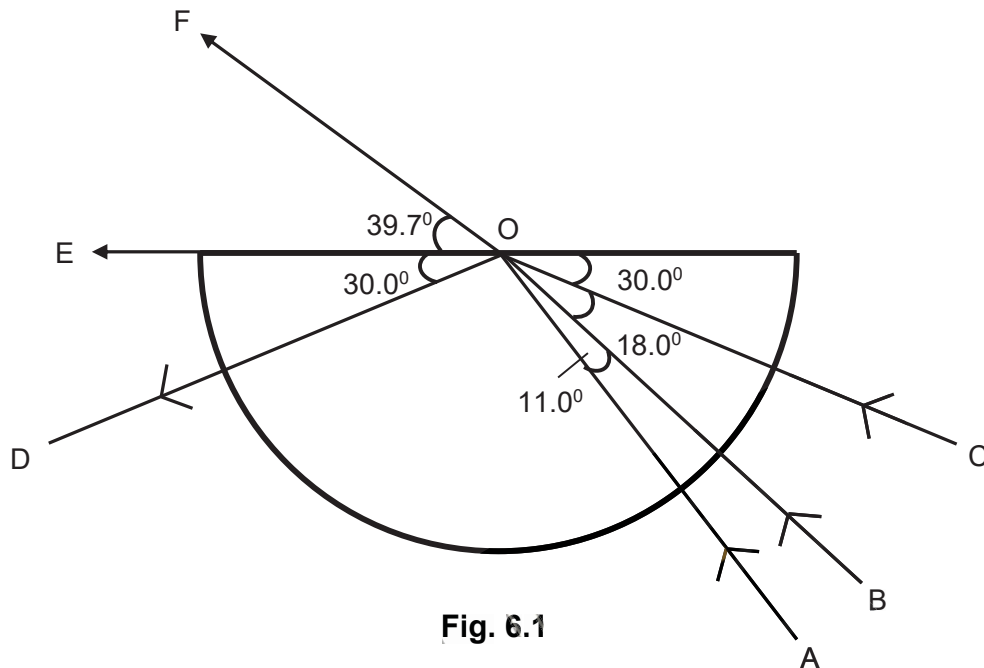


Fig. 6.1

- (a) What do you understand by **total internal reflection**?
Total Internal Reflection occurs when light travels from an optically denser medium to an optically less dense medium and the angle of incidence is greater than the critical angle. [2]
- (b) State the ray that undergoes total internal reflection.
Ray COD [1]
- (c) What is the critical angle for the plastic material?
42° [1]
- (d) Determine the refractive index of the plastic material. [2]
- $$n = \frac{1}{\sin 42^\circ}$$
- n = 1.49**

- 7 Fig. 7.1 represents the full scale diagram of the positions of particles of a medium at a particular instant when a sound wave passes through the medium. The dots represent the particles. The short lines represent the original undisturbed positions of the particles.

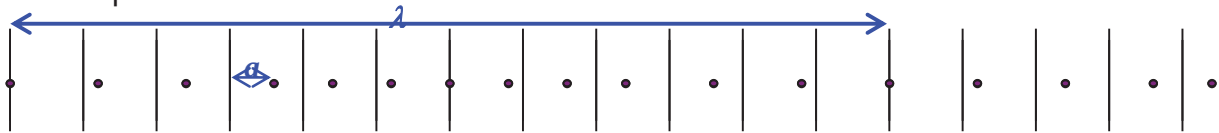


Fig. 7.1

- (a) Mark on the diagram the [2]
- wavelength of the wave using $\leftrightarrow$, label the distance as λ .
 - amplitude of the wave using $\leftrightarrow$, label the distance as a .
- (b) If each particle oscillates 3000 cycles per second, calculate the time taken to hear the echo of the sound reflected from a wall 2 km away. [3]

$$\begin{aligned}
 v &= f \times \lambda \\
 &= 3000 \text{ Hz} \times 11.8 \text{ cm} && [1] \\
 &= 3.54 \times 10^3 \text{ cm/s} \quad \text{or} \quad 354 \text{ m/s} && [1] \\
 \text{Time taken} &= 2 (2000\text{m}) / 354 \text{ m/s} = 11.3 \text{ s} && [1]
 \end{aligned}$$

- (c) Explain which of the above answers in (a) and (b) will change if the sound becomes softer as it travels.

Only the amplitude will become smaller.

..... [1]

- (d) This sound wave will be produced by a burglar alarm if a house is broken into by intruders at night. State another wave used by the burglar alarm to detect intruders and two differences of this wave from the sound wave.

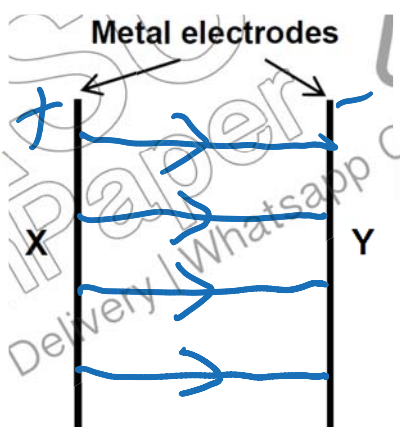
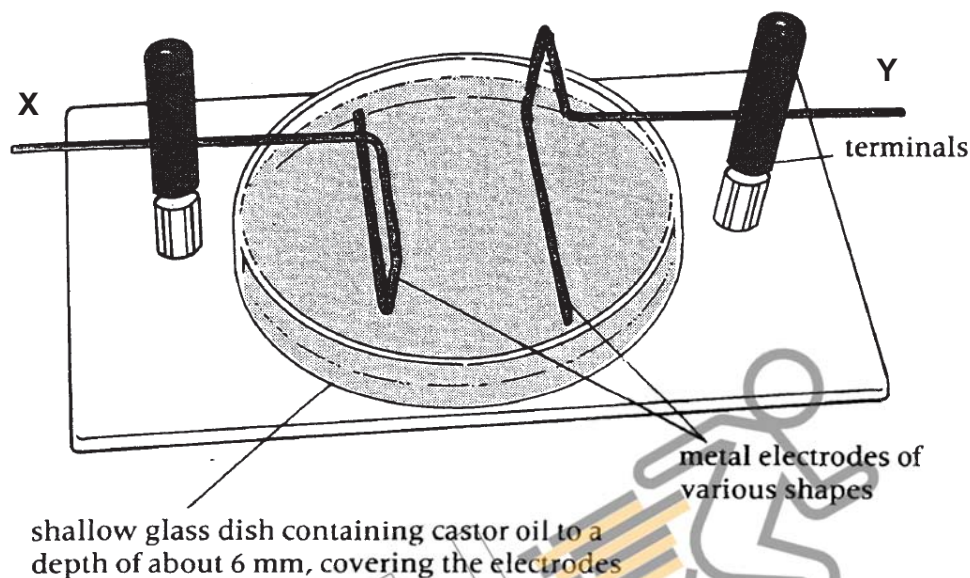
Infra-red wave

.....
Infra-red is a transverse wave while sound wave is longitudinal.

.....
Infra-red do not need a medium to travel but sound needs.

..... [3]

- 8 In an electrostatic experiment, two parallel metal electrodes are placed in castor oil in a petri dish as shown. The two metal electrodes X and Y are then connected to a battery; with X being connected to the positive terminal and Y connected to the negative terminal of the battery. Some light grass seeds are scattered on the castor oil.



- (a) On the figure above, mark the signs of charges formed on the two metal electrodes when they are connected to the battery. Hence draw the electric field pattern between the electrodes. [2]
- (b) Explain why the light grass seeds will line up in between the metal electrodes to reveal the shape of the electric field lines.

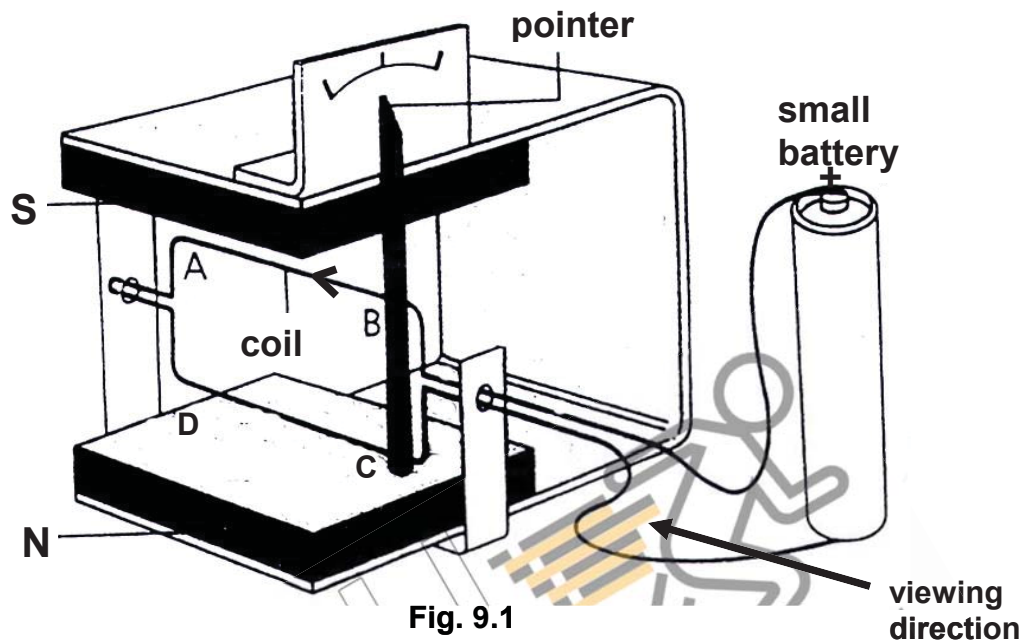
The end of the light grass seed nearer to X will be negatively charged

while the opposite end will be positively charged due to induction. [1]

Thus the light grass seed attracts each other in a line as unlike charges attract according to the electric field [1].

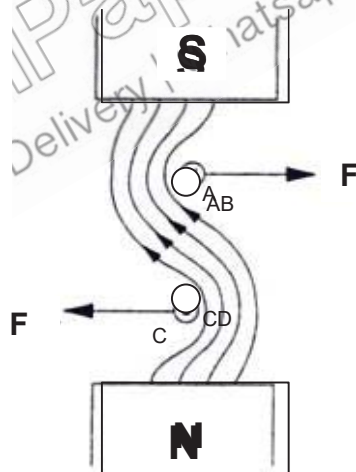
[2]

- 9 A student has made a battery tester shown in Fig. 9.1. It uses a magnet, wire that is flexible and springy, and a pointer. With it, she can check whether a battery is “live” or “dead”. When she connects a battery to the tester, the pointer moves to the right.



- (a) Explain, by drawing the magnetic field around the wires in the diagram below, to show why the pointer deflect. (The circles represent the cross-section of the wires **AB** and **CD** viewed in the direction shown)

[3]



When current flows in the coil, the magnetic field of the coil and that of the magnet will combine in such a way that it gives rise to the forces as shown by the diagram. This makes the coil and the pointer deflects.

- (b) State what would be observed on the pointer if the battery she connected delivered less current?

The pointer turns through smaller angle of deflection (1).

.....

..... [1]

- (c) The student wants to make the tester more sensitive so that the pointer can move through a greater distance when the battery is connected. State **two ways** that she change the design to make this happen?

(1) Increase the number of turns in the coil

.....

(2) use stronger magnet

..... [2]

END OF SECTION A

Section B

Answer **all** the questions from this section in writing papers provided unless stated otherwise.
Answer only one of the two alternative questions in **Question 12**.

10 Hand phones - the mobile approach

The last decade has seen an explosion in the use of mobile telephones. Before hand phones were invented, those who needed mobile communications installed a radio telephone in their car. In the radio-telephone system there was one central antenna tower per city and perhaps 25 channels available on that tower. The radio telephone in the car was a powerful transmitter.

In the modern system the city is divided into small cells and millions of people can use hand phones at the same time. The base station contains a fixed receiver and transmitter, connected to the normal telephone system. The hand phone and the base system use low power transmitters of 1-3W, which cannot be detected far outside each cell.

In one of the first systems, each hand phone works on two different frequencies at the same time, as a transmitter and as a receiver. A frequency band between 890MHz and 915 MHz is allocated for hand phones to transmit to the nearest base station and another band from 935 MHz to 960MHz for the phones to receive a transmission from the base station to the mobile. To transmit good quality signals, each complete signal is about 20kHz wide. Within the band available for transmission or reception, individual channels are set 25kHz apart to avoid overlap.

The implementation of mobile phones needed the development of small, efficient rechargeable batteries. Typically a battery may be able to supply 72000J of electrical energy before it needs to be recharged.

- (a) Explain what is meant by a frequency of 20 kHz. [2]

Frequency of 20 kHz means that within a unit time (1), there's 20 000 (1) waves/oscillation created.

- (b) Calculate the maximum wavelength that a hand phone uses to transmit a signal to the nearest base station. [2]

$$\text{Speed} = 3 \times 10^8 \text{ m/s}$$

$$v = f \lambda$$

$$3 \times 10^8 = 890 \times 10^6 (\lambda) \quad (\text{max } \lambda = \text{lowest frequency}) \quad [1]$$

$$\lambda = 0.337 \text{ m} \quad [1]$$

- (c) Calculate the number of individual hand phones that one base station can support. [2]

$$\text{Bandwidth} = 915 \times 10^6 - 890 \times 10^6 = 25 \times 10^6 \text{ Hz} \quad [1]$$

Each channel is $25 \times 10^3 \text{ Hz}$

$$\text{Number of channels} = 1000 \quad [1]$$

- (d) Estimate the minimum time that a battery will last if the hand phone is used for continuous transmission. [2]

Minimum time will use the highest power ie 3 W

$$\text{Power} = \text{Energy} / \text{time}$$

$$\text{Time} = \text{Energy} / \text{Power}$$

$$= 72\,000 / 1 \quad [1]$$

$$= 72\,000 \text{ s} \quad [1]$$

- (e) State one similarity and one difference between visible light rays and radio waves. [2]

Similarity: Both are transverse waves. [1]

difference: Visible light has a higher frequency than radio wave [1]

- 11 Fig. 11.1 shows an object O, placed at a distance from a thin converging lens L. An image I is formed. P and Q are light rays incident on the converging lens.

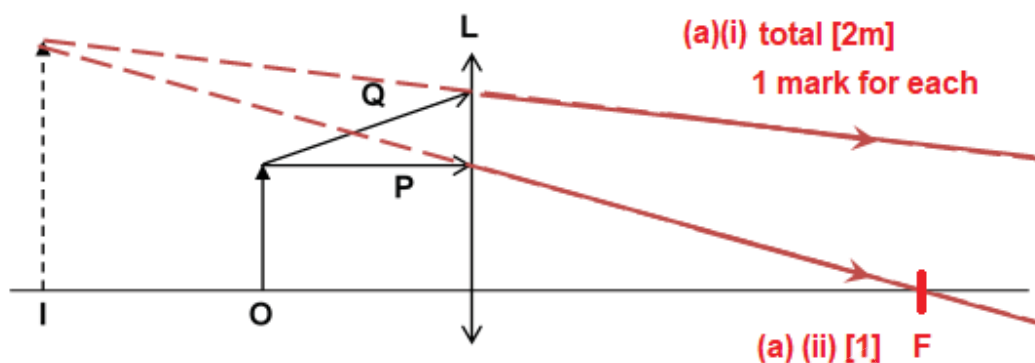


Fig. 11.1

- (a) On Fig. 11.1,
- (i) complete the ray diagram to show the paths of rays P and Q, [2]
 - (ii) locate the position of the focal point and label it as F. [1]
- (b) State three characteristics of the image formed. [2]
Virtual, upright and magnified
- (c) State an application for such lens arrangement. [1]
Magnifying glass
- (d) The object is moved closer to the lens. State two changes of the image formed. [2]
Image is smaller and nearer to lens
- (e) The lens is now moved away from the lens for more than twice its focal length.
- (i) State one change of the image formed, [1]
Image is smaller / real / inverted / formed at the other side of the lens
 - (ii) and one application for such lens arrangement. [1]
telescope / camera / eye

12 EITHER

Two containers, X and Y, filled with the same liquid are connected as shown in Fig. 12.1. The pressure at A is 100 000 Pa and the pressure at B is 160 000 Pa.

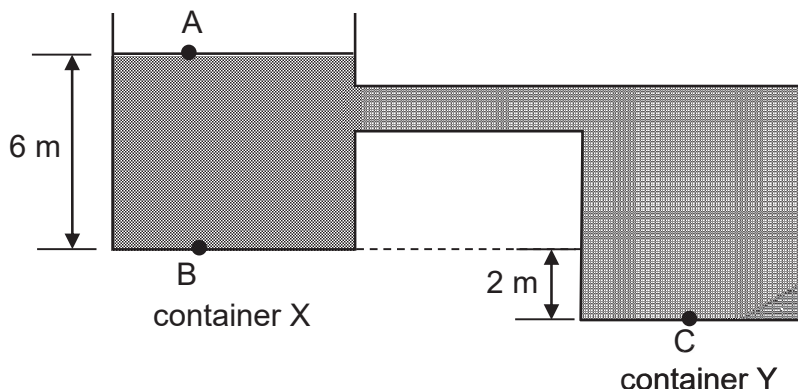


Fig. 12.1

- (a) Determine the density of the liquid. [2]

$$\begin{aligned} \text{Pressure} &= h \rho g \\ 160\,000 - 100\,000 &= 6 \times \rho \times 10 \\ \rho &= 1000 \text{ kg/m}^3 \end{aligned}$$

- (b) Calculate the pressure at C. [2]

$$\begin{aligned} \text{Pressure at C} &= 160\,000 + (2 \times 1000 \times 10) \\ &= 160\,000 + 20\,000 \\ &= 180\,000 \text{ Pa} \end{aligned}$$

- (c) A syringe contains trapped air, as shown in Fig. 12.2. The piston inside the syringe is free to move up and down in the syringe. When the syringe is placed in hot water, the piston is pushed upwards.

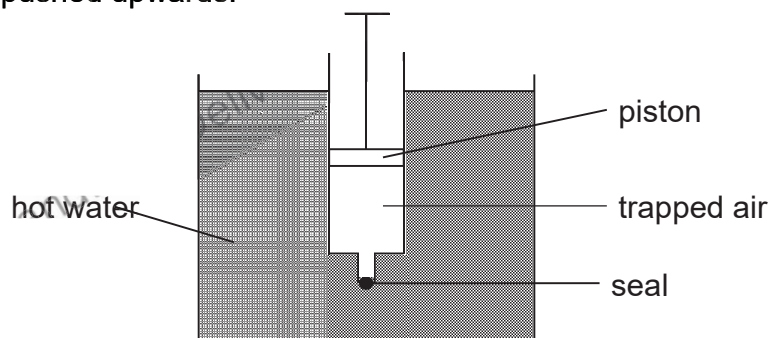


Fig. 12.2

Explain, in terms of the motion of the molecules, why the piston is pushed upwards. [2]

Heat is absorbed by the air and the air molecules move with a greater average kinetic energy and at higher speed. The force of collision and the rate of collision increases, and so the pressure inside the syringe increases / becomes greater than atmospheric pressure, causing the piston to move upwards.

- (d) Another syringe contains 60 cm^3 of trapped air at room temperature. The piston is slowly pushed inwards, compressing the air. Some information about the air inside the syringe is given in Fig. 12.3.

	before compression	after compression
volume of air	60 cm^3	15 cm^3
temperature of air	25°C	25°C
pressure of air	$1.0 \times 10^5 \text{ Pa}$	p

Fig. 12.3

- (i) Calculate the pressure p of the air after compression. [2]

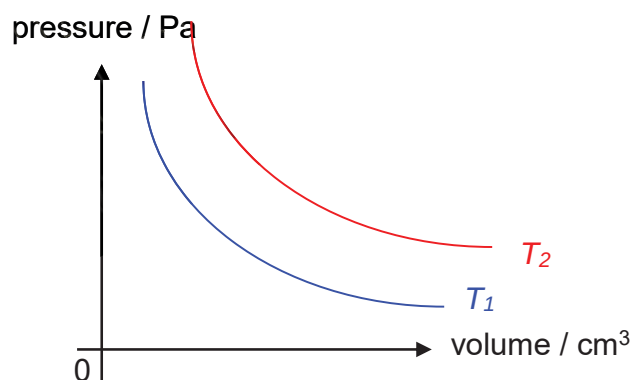
Since temperature is kept constant, $p \propto \frac{1}{V}$.

$$\frac{p_1}{p_2} = \frac{V_2}{V_1}$$

$$\frac{1.0 \times 10^5}{p} = \frac{15}{60}$$

$$p = 4.0 \times 10^5 \text{ Pa}$$

- (ii) Sketch a graph to show the variation of the pressure of the air against volume at temperature $T = 25^\circ\text{C}$. Label your graph as T_1 . [1]
- (iii) On the same axes, sketch the graph if the temperature of the air is kept constant at $T' = 50^\circ\text{C}$. Label your graph as T_2 . [1]



12 OR

In the potential divider circuit shown in **Figure 12.4** below, the battery has negligible internal resistance.

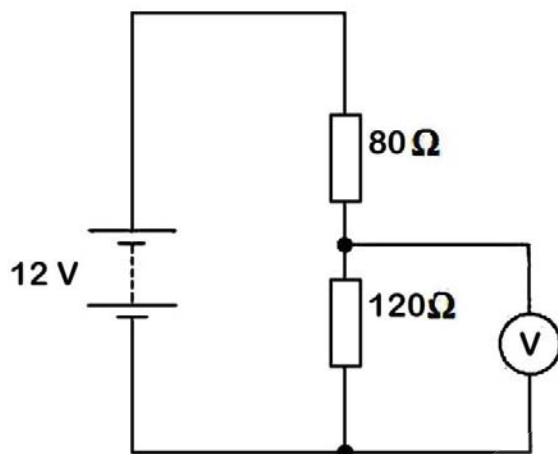


Fig. 12.4

- (a) Calculate the reading on the voltmeter.

[1]

The reading on the voltmeter = $\frac{120}{200} \times 12 = 7.2 \text{ V}$

- (b) The **voltmeter** in **Figure 12.4** above, is replaced by a **thermistor**, giving the circuit shown in **Figure 12.5** below.

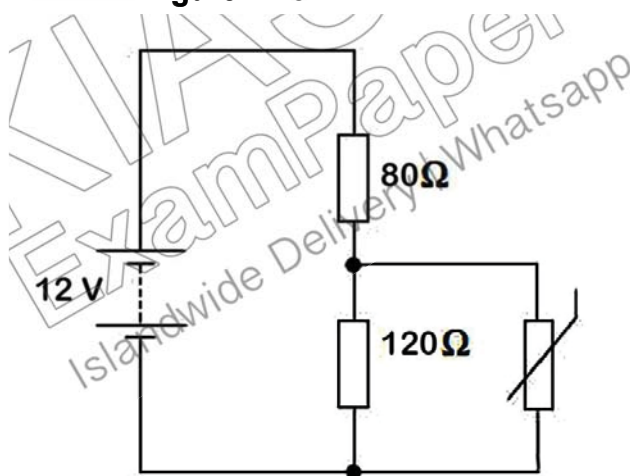


Fig.12.5

The resistance of the thermistor at 0 °C is 120 Ω. As the temperature increases, its resistance decreases. Explain, without calculation, whether the current through the battery increases or decreases as the temperature of the thermistor is increased from 0 °C.

[2]

The current increases(1), since the total resistance decreases(1).

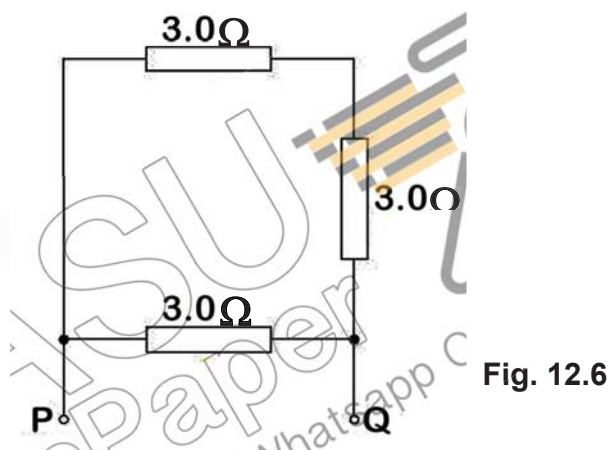
- (c) A square sheet of carbon-reinforced plastic, measuring 90 mm x 90 mm and 1 mm thick, has its two large surfaces coated with a highly conducting metal film. When a p.d. of 210 V is applied between the metal films a current of 1.4 mA passes through the plastic sheet. Calculate the resistivity of the plastic. [2]

Resistance of the plastic = $V/I = 210/0.0014 = 150\,000\ \Omega$ [1]

$$R = \frac{\rho L}{A}$$

$$\rho = \frac{RA}{L} = \frac{150000 \times 90 \times 90 \times 1000}{1 \times 1000 \times 1000} = 1,200,000\ \Omega\text{m} \quad [1]$$

- (d) Three resistors, each of resistance $3.0\ \Omega$, are connected as shown in the **Figure 12.6** below.



- (i) Calculate the total resistance between point **P** and point **Q** of this circuit. [1]

combined resistance = $(3.0 \times 6.0)/(3.0+6.0) = 2.0\ \Omega$

- (ii) The circuit in (d)(i) is now connected to two more resistors each of resistance $3.0\ \Omega$, as shown in **Fig. 12.7** below. [2]

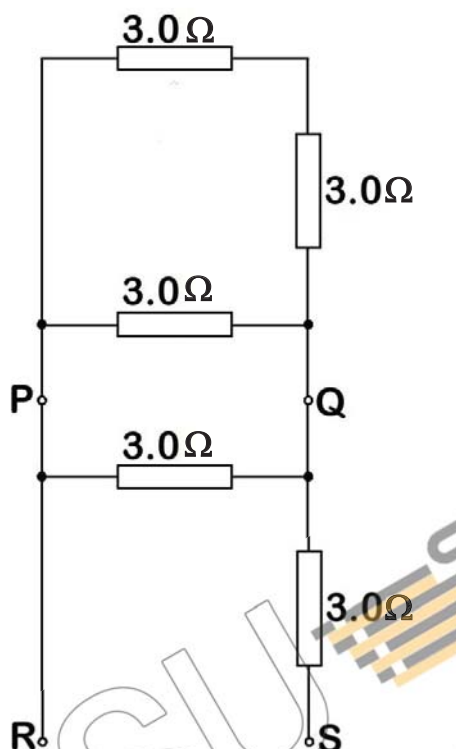


Fig.12.7

Using your answer in (d)(i), show that the total resistance between **R** and **S** is $4.2\ \Omega$.

$$\begin{aligned}
 &\text{Total resistance between R and S} \\
 &= (2.0 \times 3.0)/(2.0+3.0) + 3.0\ \Omega \quad [1] \\
 &= 4.2\ \Omega \quad [1]
 \end{aligned}$$

- (iii) One of the resistors in the circuit shown in **Fig. 12.7** becomes faulty. The resistance between **R** and **S** is found to be $5.0\ \Omega$. On the diagram in **Fig. 12.7** above, identify the faulty resistor by drawing a circle around it and state the nature of the fault. [2]

The horizontal resistor just above or below the terminals PQ.
The resistor has shorted / became zero resistance.

END OF PAPER 2

