FUCHUN SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY 4 EXPRESS

CANDIDATE NAME		CLASS	
CENTRE NUMBER	S	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 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 in 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
Paper 1	
Paper 2 Section A	
Paper 2 Section B	
Total	/120

Name of setter: Mrs Koh-Teh Yi Wen

Section A [70 marks]

Answer **all** questions.

1 Fig. 1.1 below shows a dripping tap and measuring cylinder. All the water droplets have the same volume. The droplets fall from the tap at equal time intervals.

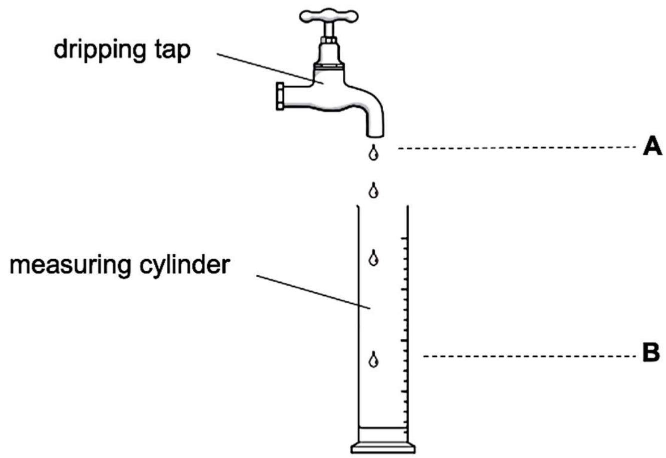


Fig. 1.1

(a) Explain how the Fig. 1.1 above shows that the water droplets are accelerating.

…………………………………………………………………………………………

………………………………………………………………………………………… [1]

(b) A student uses a stopwatch to measure the time taken for the tap to produce 200 droplets. Fig. 1.2 below shows the time reading on the stopwatch.

Fig. 1.2

(i) Determine the time, in seconds, for the tap to produce 200 droplets.

time = …………………………….. [1]

(ii) Determine the average time interval between each droplet when they are falling.

time interval = …………………………….. [1]

(iii) If the distance between **A** and **B** is 20 cm, calculate the average speed of the water droplets.

average speed = …………………………….. [2]

[Total: 5]

2 Fig 2.1 shows a car test just before impact. Fig 2.2 shows the car at rest after collision.

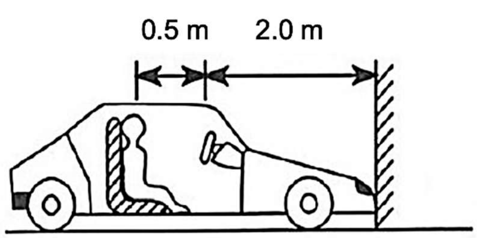


Fig. 2.1

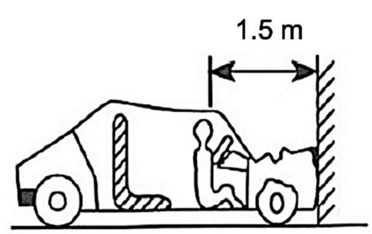


Fig. 2.2

The car crashes into the wall at a speed of 60 km/h. The total mass of the car and the dummy driver is 1500 kg.

(a) Calculate the kinetic energy store of the car just before the impact.

kinetic energy = …………………………….. [2]

(b) Work is done by a force acting on the car at the point of collision to slow it down.

Assuming no energy is lost to the surroundings, calculate the average force acting on the car during the collision.

average force = …………………………….. [2]

(c) Hence, calculate the time from the point of impact to the point when the car comes to rest.

time = …………………………….. [2]

(d) Using Newton's laws of motion, explain why the dummy continues to move forward upon impact.

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

……………………………………………………………………………………...

…………………………………………………………………………………… [2]

[Total: 8]

3 Fig. 3.1 shows a U-tube which contains mercury being used as a manometer to measure the pressure from a gas supply in a container. One end of the tube is connected to the gas supply and the other end is open.

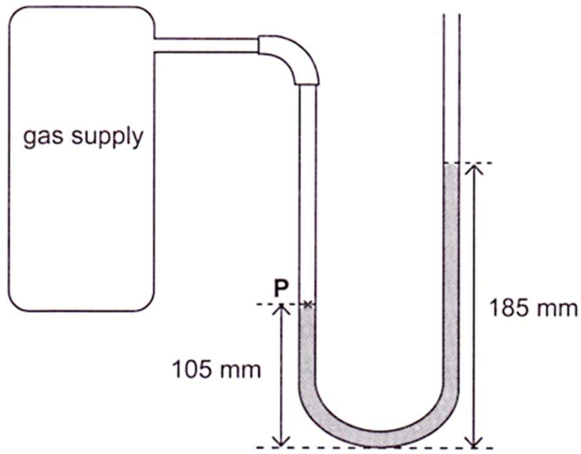


Fig. 3.1

(a) Describe how the gas molecules create a pressure.

....

....

.... [1]

(b) Explain why the mercury level moves down on the left side of the manometer when the gas supply is connected.

....

.... [1]

(c) Given that the density of mercury is 13 600 kg/m^3 and that the atmospheric pressure is 760 mm Hg, calculate the pressure of the gas supply in Pa.

pressure = ... [2]

(d) The gas supply is made to cool down to a lower temperature.

Describe and explain the effect on the difference in the mercury levels between the left and right side of the manometer.

....

....

....

....

.... [3]

[Total: 7]

4 A casserole is a French term for a deep bowl used for cooking a variety of dishes in the oven.

(a) A researcher carries out a series of experiments on different types of materials to select a new material that can be used for the casserole. Table 4.1 shows four possible materials and their properties.

Table 4.1

material	melting point / °C	specific heat capacity / J/(kg °C)
A	2350	900
B	950	480
C	1600	480
D	7800	130

(i) In one of the experiments, a 2 kg sample of material **A** is heated by an electrical heater of power 450 W.

The initial temperature of the sample is 25 °C.

Calculate the time taken for the temperature of the sample to rise to 100 °C.

time taken = ... [2]

(ii) Using the data in Table 4.1, suggest which material is the most suitable to be used as material for the casserole. Give two reasons to support your choice.

Material: ……………

Reason 1: …………………………………………………………………………..…

……………………………………………………………………………………….

Reason 2: ……………………………………………………………………………..

……………………………………………………………………………………… [2]

(b) 1.5 kg of hot water at boiling point is poured into the casserole.

3 380 780 J was supplied to convert all the water into steam at boiling point.

Calculate the specific latent heat of vaporisation of water.

specific latent heat of vaporisation = …………………………….. [1]

(c) The researcher then decides to try to place the casserole in a microwave oven to heat soup, as shown in Fig. 4.2. Microwaves created inside the oven are reflected by the metal walls.

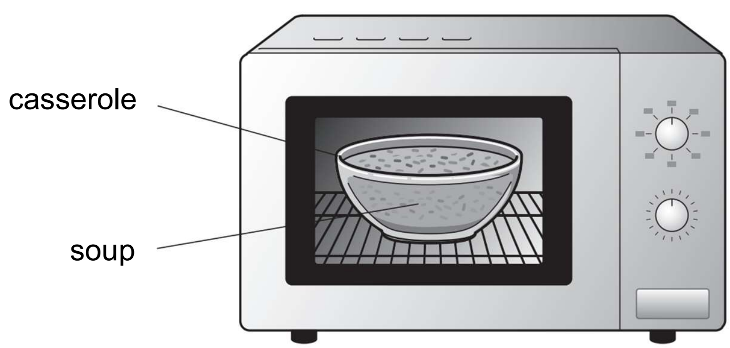


Fig. 4.2

The soup is mostly water.

Microwaves are completely absorbed by a few centimetres of water. As a result, microwaves do not reach the centre of the soup.

The instructions suggest that, after the microwave oven is turned off, the soup is not stirred and is left for some minutes so that the centre becomes hot.

State the name of and describe each of the two processes by which thermal energy transfers through the soup after the microwave oven is turned off.

name of first process ....

description ....

....

....

name of second process ....

description ....

....

.... [3]

[Total: 8]

5 Fig. 5.1 shows a straight dipper vibrating near the water surface of a ripple tank. Water waves forming crests and troughs are observed as a series of wavefronts moving away from the dipper.

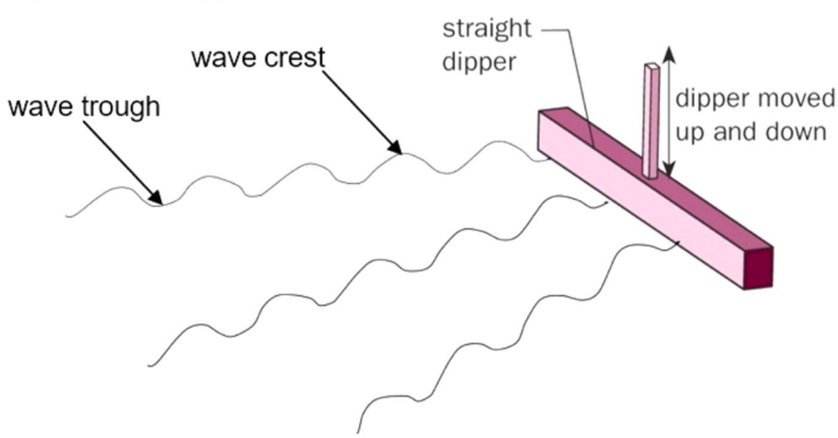


Fig. 5.1

(a) Explain what is meant by a *wavefront*.

....

.... [1]

(b) Using two dotted lines, draw two consecutive wavefronts in Fig. 5.1 [1]

(c) Two students conducting an experiment using the ripple tank to measure the speed of the water waves collected the following readings:

Average number of wave crests passing a point in 10 seconds = 5
Average distance between two consecutive wave crests = 8.0 cm
Average distance from the crest to the trough of the wave = 4.0 cm

(i) Determine the speed of the water wave.

speed = …………………………….. [3]

(ii) On Fig. 5.2, sketch a graph of displacement versus distance of the wave passing through the surface of the water, for a distance equal to twice of its wavelength.

Label both axes clearly and include measurements where possible.

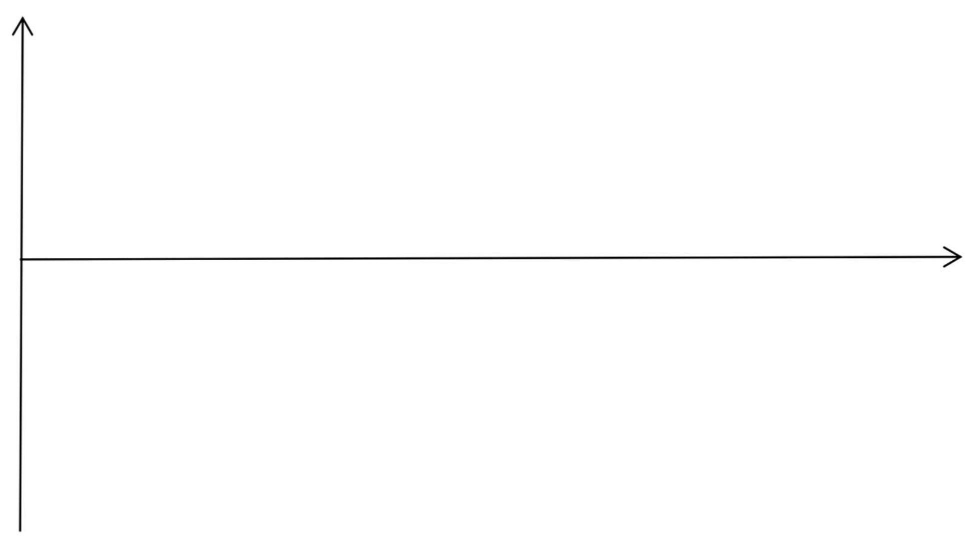


Fig. 5.2

[2]

[Total: 7]

6 Fig. 6.1 shows a negative charged metal plate X, an uncharged metal plate Y and a connection to earth.

Plate X and Plate Y are placed on insulating stands.

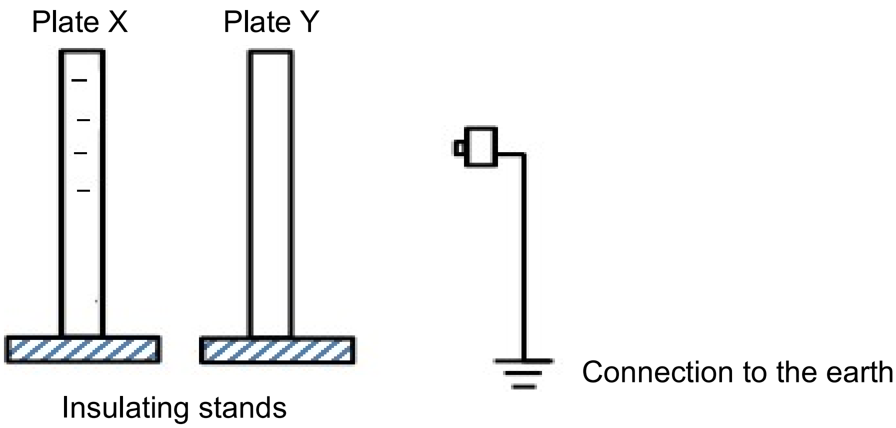


Fig. 6.1

(a) Explain what is meant by *electrostatic induction*.

....

.... [1]

(b) Explain why insulators cannot be charged by electrostatic induction.

....

.... [1]

(c) With the aid of the apparatus shown in Fig. 6.1, describe clearly the steps to obtain a positively-charged plate Y.

....

....

....

....

.... [2]

[Total: 4]

7 A circuit containing four resistors, **P**, **Q**, **R** and **S**, some meters and a battery of e.m.f. 18 V is connected, as shown in Fig. 7.1. The readings on the meters are shown beside them.

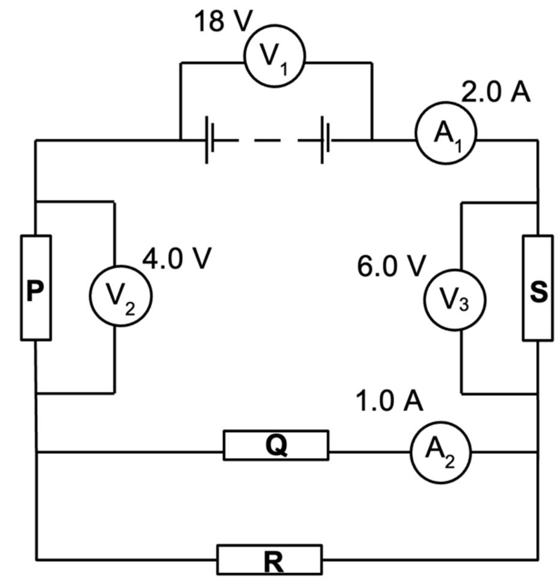


Fig. 7.1

(a) Calculate the current in resistor **R**.

current = ……………………………….. [2]

(b) Calculate the potential difference across resistor **R**.

potential difference = ……………………………….. [2]

(c) Calculate the effective resistance across the parallel arrangement of resistors **Q** and **R**.

resistance = ……………………………….. [2]

(d) An iPad is being charged using a charger with an output voltage of 18 V. In 2 hours, a total of 5000 C of charge is transferred to the iPad battery.

Calculate the energy that is transferred to the battery.

energy = …………………………….. [2]

[Total: 8]

8 Fig. 8.1 shows a magnet, two compasses and two nails.

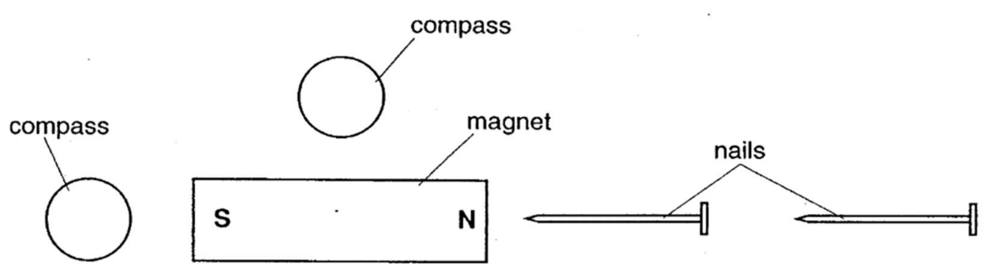


Fig. 8.1

(a) On Fig. 8.1, draw an arrow in each compass to show the direction of the magnetic field of the magnet at the two positions. [2]

(b) The magnet causes the nails to become magnetised by induction. Both ends of each nail become magnetic poles.

On Fig. 8.1, mark a **N** or a **S** at both ends of each nail to show the magnetic poles. [2]

(c) When the magnet is removed, the nails are still magnetised. Describe how to test whether the nails are still magnetised when they are away from the magnet.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

………………………………………………………………………………………… [2]

[Total: 6]

9 Fig. 9.1 is a half-scale diagram of a radioactive source stored in a safe way.

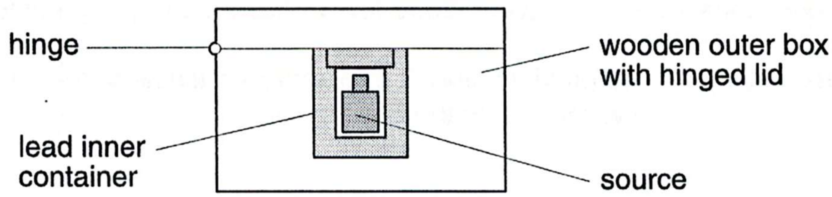


Fig 9.1

(a) The source emits alpha particles, beta particles and gamma rays.

A teacher handles the box.

Explain how the teacher is completely protected from the alpha particles and beta particles but only partially protected from the gamma rays.

....

....

.... [2]

(b) Describe and explain how the teacher should remove the source safely from the box.

....

....

.... [2]

(c) The source is brought near a radiation detector.

(i) Name a suitable detector.

.... [1]

(ii) Describe how you would use the detector to show that source emits particles at random.

....

....

.... [2]

[Total: 7]

10 An experiment to investigate the refractive indexes of four types of glass P, Q, R and S is conducted as shown in Fig. 10.1. Light is directed through a semi-circular glass prism to the midpoint O.

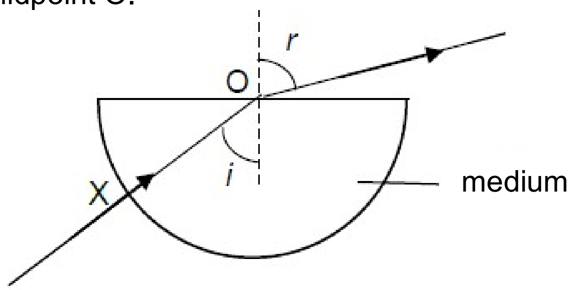


Fig. 10.1

The angle of refraction *r* for every corresponding angle of incidence *i* is recorded. The plots of sin *i* against sin *r* for each type of glass are shown in Fig. 10.2.

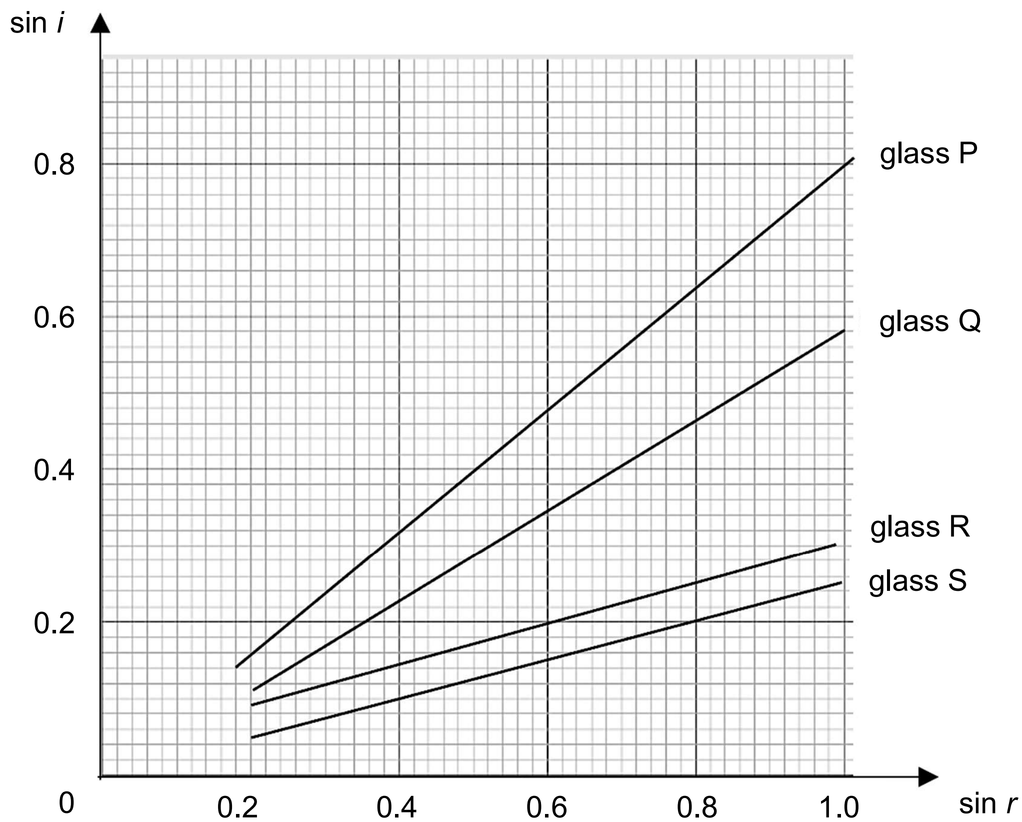


Fig. 10.2

(a) Explain why no refraction takes place at X.

....

.... [1]

(b) Using information from Fig. 10.2 but without any calculations, state and explain which type of glass, P, Q, R or S, causes the light to bend the most in the air.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[2]

(c) For glass Q,

(i) calculate the critical angle.

critical angle = …………………………….. [2]

(ii) hence determine the refractive index.

refractive index = …………………………….. [2]

(iii) given that the angle of incidence *i* is 47°, explain what would happen to a beam of light at O.

……………………………………………………………………………………

……………………………………………………………………………………

……………………………………………………………………………………

…………………………………………………………………………………… [2]

(d) Suggest and explain why the data collected for glass R is likely to contain some error.

…………………………………………………………………………………………

…………………………………………………………………………………………

…………………………………………………………………………………………[1]

[Total: 10]

Section B

Answer **one** question from this section.

11 There are different types of electrical conductors. Some obey Ohm's Law, some do not.

(a) Describe an experiment to determine the resistance of a metallic conductor using a voltmeter and an ammeter and make the necessary calculations.

In your account, you should:

- draw a diagram of the apparatus,
- describe the procedure,
- explain how to determine the resistance of the metallic conductor.

....

....

....

....

....

....

....

.... [4]

(b) A pupil studying potential dividers sets up the circuit as shown in Fig. 11.1.

The bulb has the rating of 3.5 V, 0.10 A.

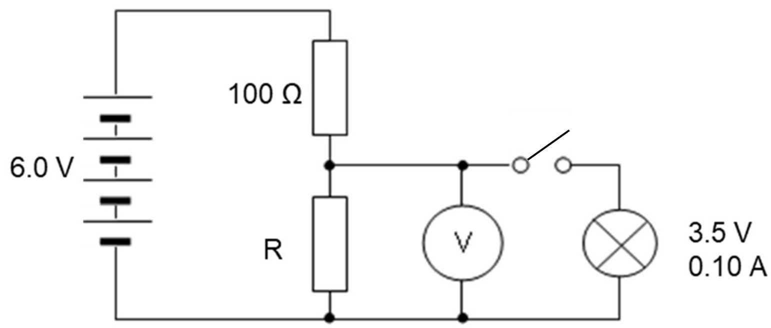


Fig. 11.1

(i) When the switch is not pressed, the voltmeter shows a reading of 3.5 V.

Calculate the value of R.

R = …………………………….. [2]

(ii) The pupil now closes the switch.

Calculate the reading shown on the voltmeter when the switch is closed.

reading = …………………………….. [2]

(iii) The circuit is now changed by replacing the 100 Ω resistor with a thermistor, and the switch is closed as shown in Fig. 11.2.

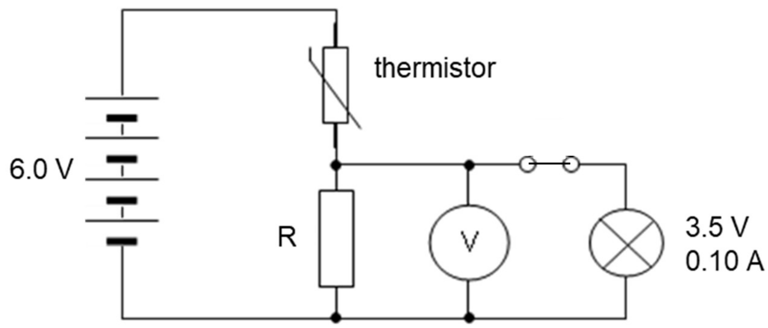


Fig. 11.2

Fig. 11.3 shows how the resistance of the thermistor varies with temperature.

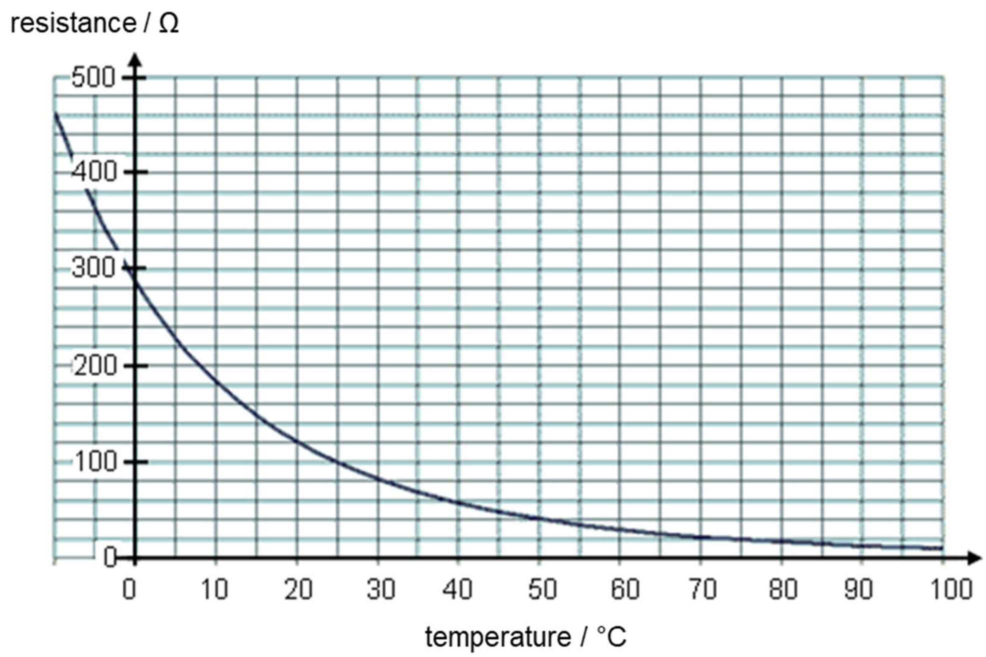


Fig. 11.3

Describe and explain how the brightness of the bulb in Fig. 11.2 will change as the temperature increases from 25 °C.

....

....

....

.... [2]

12 Fig. 12.1 shows the cross-section of a single coil DC motor when the coil is in a horizontal position.

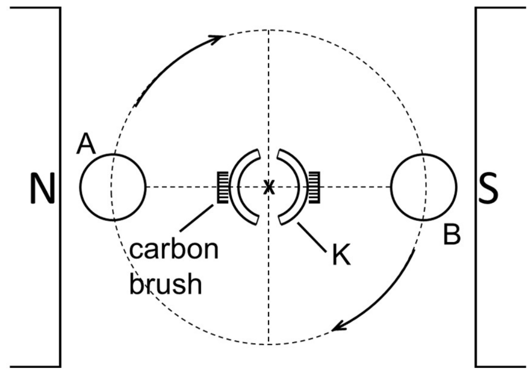


Fig. 12.1

The coil starts to turn clockwise when a current passes through wire A and B.

(a) (i) State the name of component K.

.... [1]

(ii) Describe the function of component K.

....

.... [1]

(b) (i) Explain why the wire coil turns when a current flows through wire A and B.

....

....

....

....

....

.... [3]

(ii) Describe the direction of current flowing through wire A and B.

wire A: ....

wire B: .... [1]

(c) **(i)** After some time, the coil turns 30° from the horizontal.

The distance between wire A and B is 0.40 m and the force acting on each wire is 12 N.

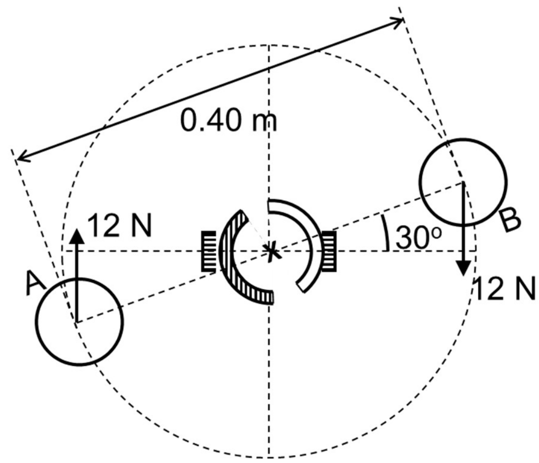


Fig. 12.2

Calculate the total clockwise moment about the axis of rotation.

total clockwise moment = …………………………….. [2]

(ii) Describe two ways to increase the total clockwise moment calculated in **(c)(i)**.

…………………………………………………………………………………………

…………………………………………………………………………………………

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

Fuchun Secondary School
Preliminary Examination 2024
Secondary 4 Express Physics 6091

MARKING SCHEME

Paper 2 Section A

1 (a) For the same time interval, the distance between the water drops increases. The increased distance per same time interval shows that the speed is increasing, hence accelerating. [1]

(b) (i) 3 min 46.5 s = 227 s (to 3 sf) [1]
(ii) Time interval = 227 / 199 = 1.14 s [1]
(iii) Average speed = (20/3) / 1.14 = 5.87 cm/s *allow ecf* M1, A1

2 (a) Kinetic energy = ½ mv^2 = ½ x 1500 x $((60 \times 10^3)/3600)^2$ = 208,000 J M1, A1

(b) WD = F x d = Loss in KE
F x 0.5 = 208,000 M1
F = 416,000 N *allow ecf* A1

(c) F = ma
- 416,000 = 1500 x a
a = 277.3 m/s^2 M1

$a = \frac{v - u}{t}$

$t = \frac{0 - 16.7}{277.3}$ = 0.0601 s A1

(d) Newton's first law states that the object will continue in its state of rest or uniform motion in a straight line unless a resultant force acts on it. [1]
Thus, the dummy will continue in its state of motion as there is no resultant force (no seat belt on) to stop/slow down its motion. [1]

3 (a) The gas molecules exert a force on the wall of the tube. [1]

(b) The gas pressure is higher than atmospheric pressure. [1]

(c) $P_{gas} = P_{Hg} + P_{atm}$
$P_{gas} = (\frac{80}{1000} \times 13600 \times 10) + (\frac{760}{1000} \times 13600 \times 10)$ M1
P_{gas} = 114,000 Pa A1

(d) When the gas is cooled down, the average kinetic energy of the molecules decreases. [1]
The gas molecules bombard the wall of the tube less frequently and less forcefully. Hence, the gas pressure decreases. [1]
This causes the difference in the mercury level to reduce. [1]

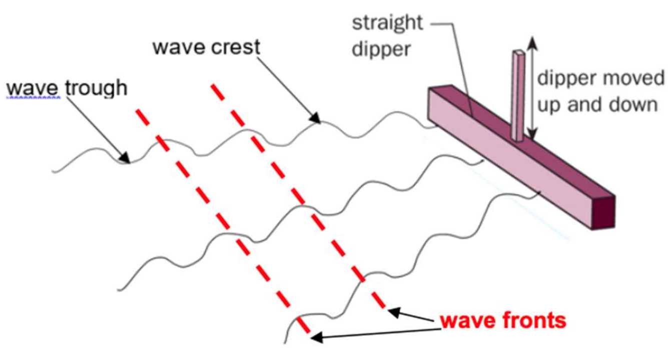
4 (a) (i) Heat gained by material = Heat lost by heater
$mc\Delta\theta = Pt$ M1
$2 \times 900 \times (100 - 25) = 450 \times t$ A1
time taken = <u>300 s</u>
(ii) material D
1. Highest melting point so it can withstand the heat / won't melt so easily. [1]
2. Smallest specific heat capacity so temperature will rise the fastest for the same amount of thermal energy supplied [1]

(b) $Q = ml$
$3\,380\,780 = 1.5 \times l_v$
$l_v = 3\,380\,780 / 1.5$
l_v = <u>2,250,000 J/kg</u> A1

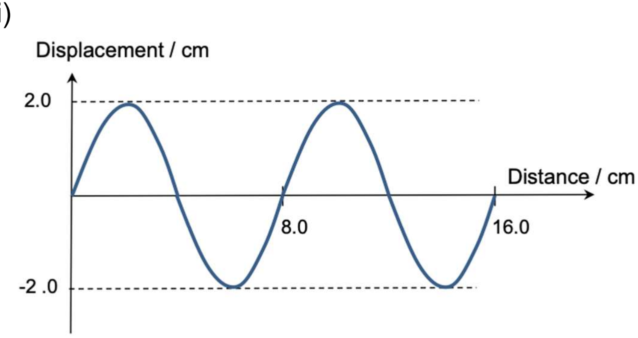
(c) convection and conduction – *both process correctly identified to get one mark* [1]
Convection – hot liquid rises as it is less dense [1]
Conduction – energy passes through collision of molecules [1]

5 (a) Imaginary line on a wave that joins all adjacent points that are in phase. [1]

(b) [1]



(c) (i) frequency = 5 / 10 = 0.5 Hz M1
Wavelength = 8.0 cm M1
speed = $f\lambda$ = 0.5 x 8 = <u>4 cm/s</u> A1
(ii)



[1]
[1]

[1]: two wavelengths drawn + correct labelling of x-axis
[1]: correct labelling of y-axis

6 (a) Electrostatic induction is the process of charging a conductor without contact between the charging body and the conductor. [1]

(b) The electrons inside the insulators cannot move even in an electric field, so they cannot be charged by induction. [1]
OR
Insulators have no mobile electrons.

(c) 1. Bring Plate X near to but not touching Plate Y, connect the earth wire to Plate Y. [1]
2. Disconnect the earth wire and bring Plate X far away from Plate Y. [1]

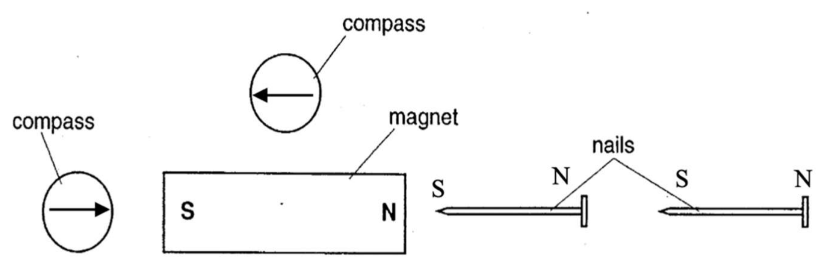
7 (a) Current in R = 2 – 1 = 1.0 A M1, A1

(b) Voltage in R = 18 – 4 – 6 = 8.0 V M1, A1

(c) R = V/I = 8 / 2 = 4 Ω *allow ecf* M1, A1

(d) Energy = VQ = 18 x 5000 = 90,000 J M1, A1

8 (a) [1] [1] [1] [1]



[1] for correct arrow in each compass
[1] for each correct pair of N-S

(c) Test the nails with another magnet, using two sides of the magnet. [1]
The nails are only magnetised, when it is repelled by another magnet. [1]

9 (a) Alpha particles can be absorbed by a thin piece of paper and beta particles are absorbed by a thin piece of aluminium. [1]
Gamma rays can pass through most materials are absorbed by lead that is a few centimetres thick; thus, the teacher is only partially protected from the gamma rays. [1]

(b) Teacher can use a long tong or remote-controlled device to increase the distance between radioactive materials and body. [1]
Teacher can wear a lead suit while handling the radioactive material. [1]

(c) (i) Geiger Muller Counter [1]
(ii) Put the counter near the radioactive source. [1]
If the counter shows counts that is constantly changing, this shows that the emission of particles is random. [1]

10 (a) The angle of incidence at X is zero. [1]

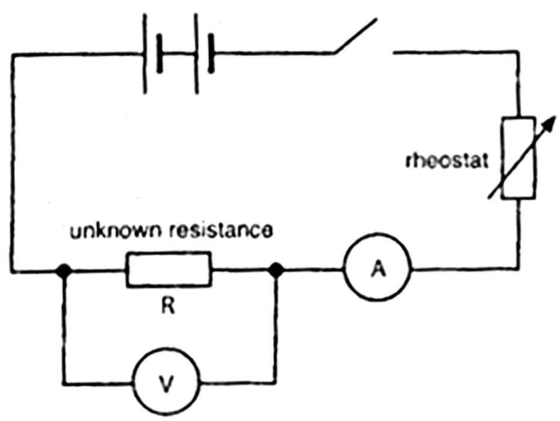
(b) Glass S [1]
Refractive index is equivalent to the inverse of gradient of the graph.
Since line for glass S has the lowest gradient, this indicates that it has the highest refractive index. Hence, light will bend the most in air in glass S. [1]

(c) (i) When sin r = 1, sin i = 0.58 M1
Thus, i = $\sin^{-1}$ (0.58) = 35.5 ° A1
(ii) refractive index = 1 / sin c = 1 / sin 35.5 = 1.72 M1, A1
(iii) As angle of incidence in the optically denser medium is greater than critical angle, [1]
Total internal reflection will occur. [1]

(d) R is the only line that does not pass through the origin, suggesting that it does not have a proportional relationship which is not true. [1]

Paper 2 Section B

11 (a)



[1]

1. Set up the circuit as shown above and set the rheostat to the maximum resistance. [1]
2. Close the circuit and adjust the rheostat slowly until a small current I is shown on the ammeter.
3. Record this ammeter reading I and the corresponding voltmeter reading V. [1]
4. Adjust the rheostat to allow a larger current to flow in the circuit. Record the values of I and V.
5. Repeat step (4) to obtain 4 more sets of I and V readings.
6. Plot a graph of V against I. The gradient of the graph is the resistance of the resistor R. [1]

(b) (i) V = $\frac{R_1}{R_1+R_2} \times 6$

$3.5 = \frac{R_1}{R_1+100} \times 6$

350 = 2.5 R M1

R = 140 Ω A1

(ii) resistance of bulb = V / I = 3.5 / 0.1 = 35 Ω M1

Effective resistance = $(\frac{1}{35} + \frac{1}{140})^{-1}$ = 28 Ω A1

Reading = $\frac{28}{28+100} \times 6$ = <u>1.3V</u>

(iii) When the surrounding temperature increases from 25 °C, the resistance of the thermistor decreases. Thus, there is a <u>decrease in the potential difference</u> across the thermistor. [1]

This i<u>ncreases the potential difference</u> across the bulb, causing the <u>brightness of the bulb to increase</u>. [1]

12 (a) (i) Split ring commutator [1]

(ii) It will reverse the direction of the current flowing through the coil every 180° of rotation so that the coil will rotate in one direction.

(b) (i) The magnetic field of the permanent magnet will [1]

interact with the magnetic field produced by the current-carrying conductor. [1]

The interaction will induce a force that turns the coil. [1]

(ii) wire A: out of the paper [1]

wire B: into the paper

(c) (i) Total clockwise moment = 2 x 12 x (0.2 cos 30) = 4.16 Nm M1, A1

(ii) Increase the number of turns in the coil [1]

Increase the current [1]

Adding a soft iron cylinder

Increase the magnetic strength of the magnet

Any two of the above