YISHUN SECONDARY SCHOOL
PRELIMINARY EXAMINATION 2024
SECONDARY 4 EXPRESS

CANDIDATE NAME					
CLASS				INDEX NUMBER	

PHYSICS **6091/02**
Paper 2 **19 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 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** the 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.

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.

This document consists of **23** printed pages.

Section A

Answer **all** questions.

1 Fig. 1.1 shows an object hanging from the ceiling. The object has a weight of 20 N and it is pulled by a force of 16 N. The figure is not drawn to scale.

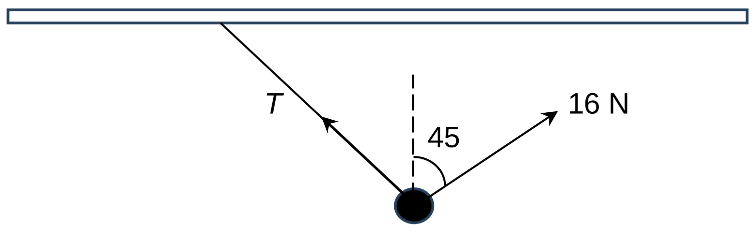


Fig. 1.1

Using a scale of 1.0 cm : 2.0 N, draw a labelled vector diagram to determine the magnitude of the tension *T*, in the string.

magnitude of tension *T* = ... [3]

[total: 3]

2 Fig. 2.1 shows the velocity-time graphs of an object falling in vacuum and in air. The object is dropped from the same height.

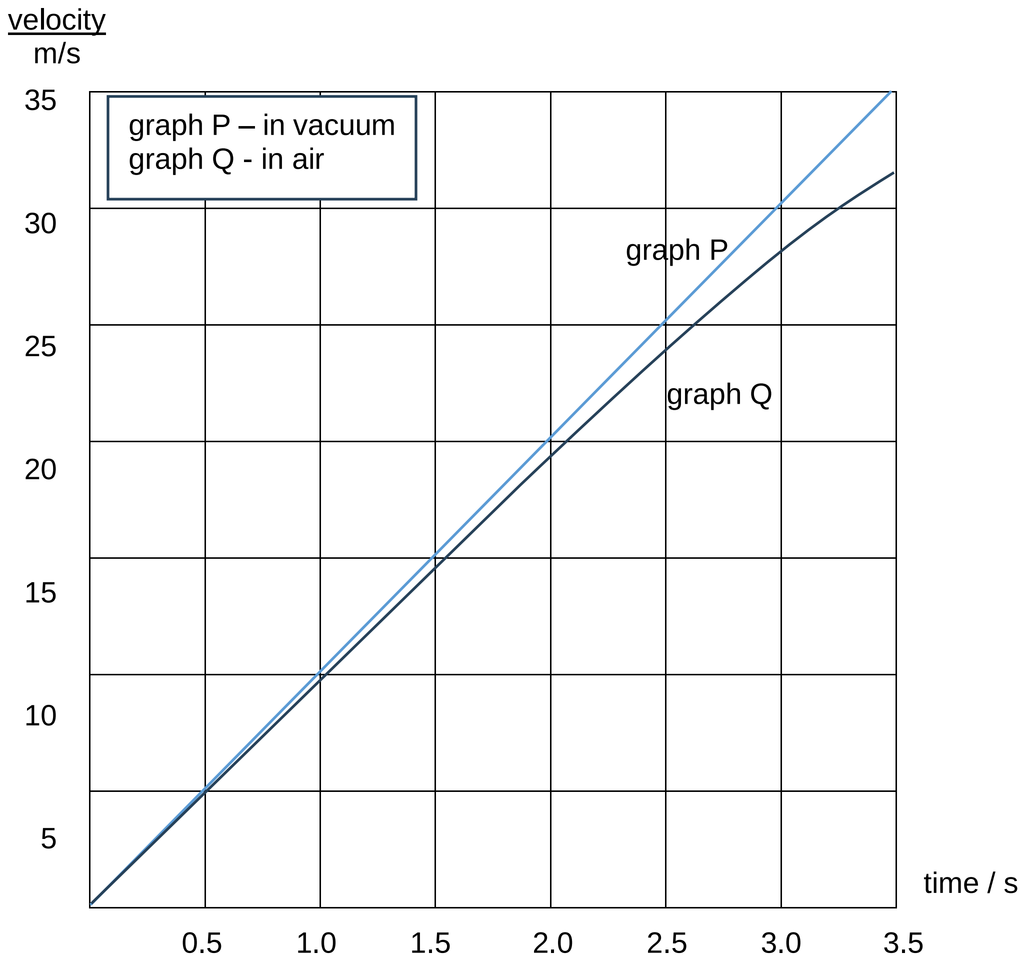


Fig. 2.1

(a) Define *velocity*.

....

.... [1]

(b) Calculate the displacement of the falling object in vacuum from t = 1.0 s to t = 1.5 s.

displacement = ... [2]

(c) The two graphs have different shapes.

(i) Describe the acceleration of the object when it is falling in air.

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

(ii) Explain, using forces acting on the object, the motion of the object you described in **(i)**.

………………………………………………………………………………………………………

………………………………………………………………………………………………………

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

(d) State the medium, in vacuum or in air, in which the object has the higher energy in the gravitational potential and kinetic store at t = 3.5 s.

higher energy in the kinetic store: ……………………………………………………………….. [1]

higher energy in the gravitational potential store: ……………………………………………. [1]

[total: 8]

3 Fig. 3.1 shows a Yishunite on a Ferris wheel. The Ferris wheel has eight carriages and has a diameter of 9.6 m. It moves at a uniform speed and it takes 2.0 minutes to make one complete rotation.

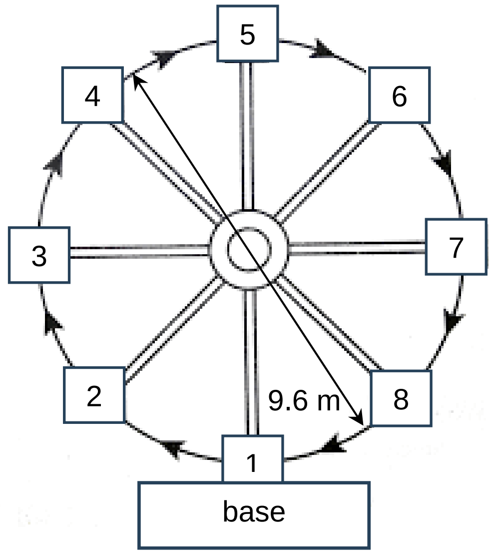


Fig. 3.1

(a) The Yishunite has a mass of 65 kg.

When the Yishunite moves from the lowest to the highest point of the Ferris wheel, determine the change in the energy in the kinetic store, if any, of the Yishunite.

change in the energy in the kinetic store = ... [1]

(b) Calculate the maximum moment of the weight of the Yishunite about the centre of rotation of the Ferris wheel during the ride. Take g = 10 N/kg.

maximum moment of the weight = ... [2]

(c) To ensure the Ferris wheel is stable when it is in operation, the Ferris wheel has a heavy base.

Explain how a heavy base improves stability of the Ferris wheel.

………

………

…… [2]

[total: 5]

4 Fig. 4.1 shows an optical fibre used to transmit data by total internal reflection. A ray of light is seen travelling in the optical fibre.

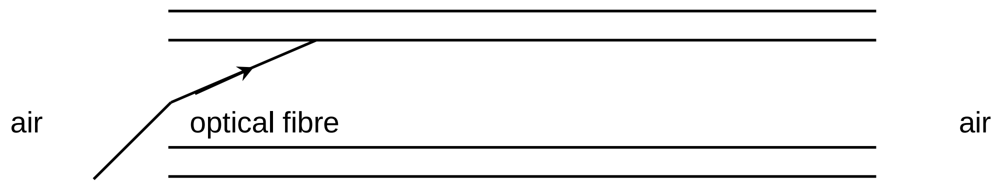


Fig. 4.1

(a) State the two conditions for total internal reflection to occur.

………

………

………

…… [2]

(b) On Fig. 4.1, complete the path of the ray of light until it emerges at the other end. [1]

(c) The optical fibre is light and cheap to produce.

State **two** other advantages of using optical fibres over copper wires in telecommunication.

………

………

…… [2]

[total: 5]

5 Fig. 5.1 shows three rays of light from the top of an object incident on a converging lens.

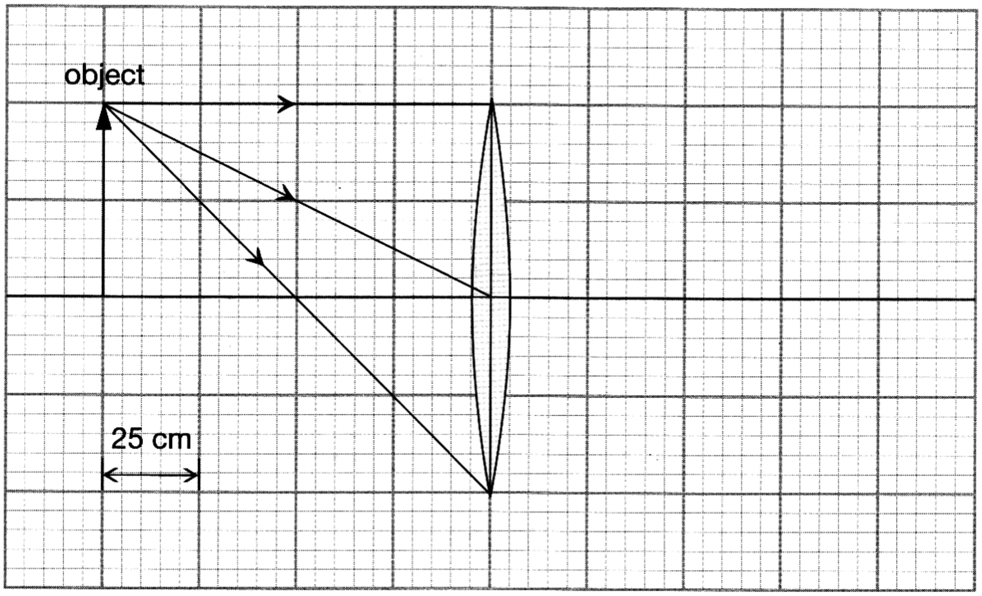


Fig. 5.1

A sharp image of the object is formed 125 cm on the right side of the lens.

(a) On Fig. 5.1, complete the paths of the three incident rays after passing through the lens and draw the sharp image of the object formed. Label the image I. [2]

(b) Determine the focal length of the lens.

focal length = ……………………….……… [1]

(c) The tip of the object emits rays of light in all direction. Some of them enter the lens.

Most of the rays of light that enter the lens bend at the boundary between air and the lens. However, some rays of light do not bend.

Explain why some of the rays of light do not bend when they enter the lens.

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

[total: 4]

6 Fig. 6.1 shows the cooling curves of two metal saucepans. The saucepans contain the same mass of hot water at the same initial temperature. Pan A is white and pan B is black, but otherwise the two saucepans are identical. Both saucepans are uncovered and cool under the same conditions.

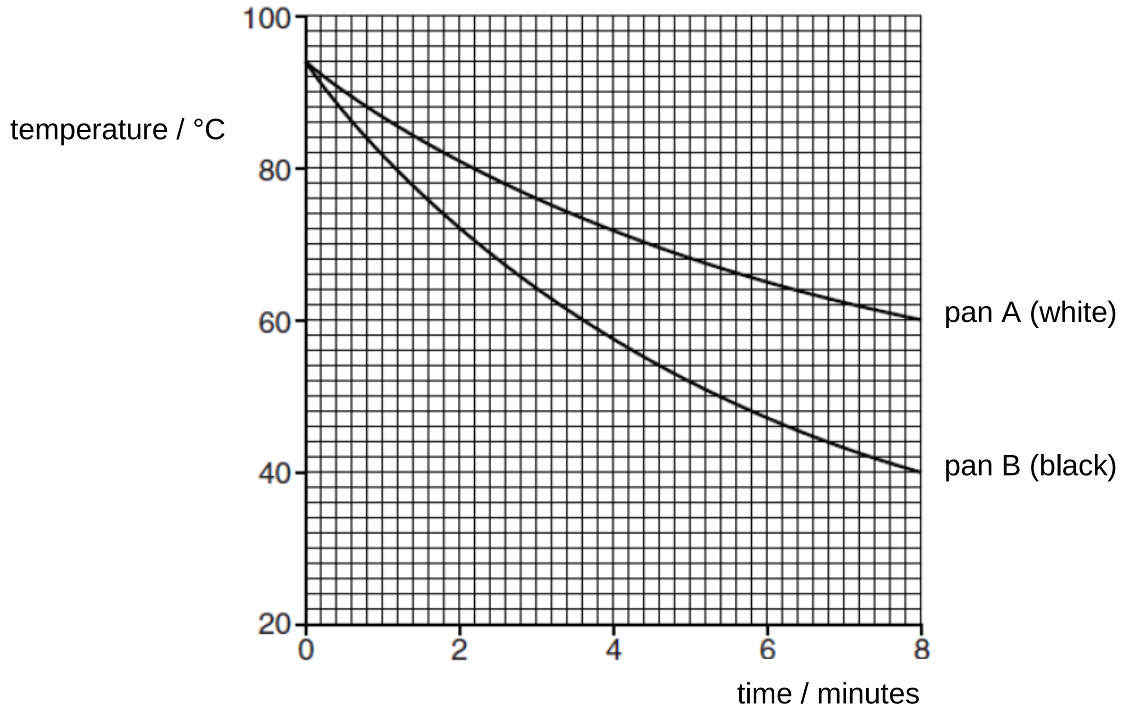


Fig. 6.1

(a) Explain why pan B cools faster than pan A.

....

.... [1]

(b) Describe and explain how Fig. 6.1 will be different when the pans are covered and the experiment is repeated.

....

....

....

.... [2]

(c) Explain what is meant by the *specific heat capacity of water is 4200 J/(kg °C)*.

....

....

.... [1]

(d) The specific heat capacity of water is very high.

Suggest one disadvantage of this when water is used for cooking.

....

.... [1]

(e) The water in pan A cools for 8 minutes, as shown in Fig. 6.1. During this time, the water transfers an average of 9000 J of energy per minute to the internal store of the surroundings.

Calculate the mass of water in pan A.

mass = ... [2]

[total: 7]

7 Fig. 7.1 shows a coil of wire connected by flexible leads to a switch and a battery.

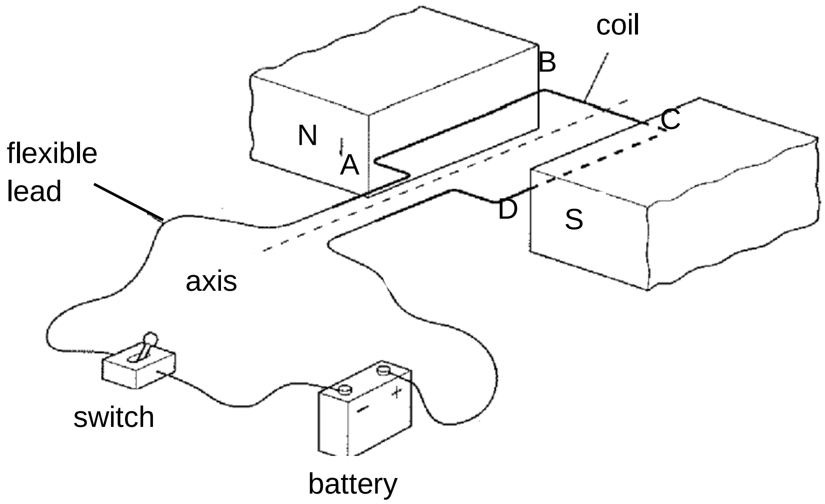


Fig. 7.1

The coil is placed between the poles of a permanent magnet and is free to turn about the axis. When the switch is closed, induced forces due to the current and magnetic field act on the sides of the coil. The coil starts to turn.

(a) On Fig. 7.1, draw the forces that act on sides AB and CD of the coil. [1]

(b) Describe how you determined the direction of the forces on sides AB and CD of the coil.

....

....

....

.... [2]

(c) Explain why the turning effect of the forces on the coil is zero when it is vertical.

....

.... [1]

(d) A split-ring commutator is connected between the battery and the coil.

Explain how the split-ring commutator enables the coil to rotate continuously.

....

....

.... [2]

[total: 6]

8 Fig. 8.1 shows the setup of an experiment to test the free fall of a magnet through a metre long pipe made of half plastic and half copper.

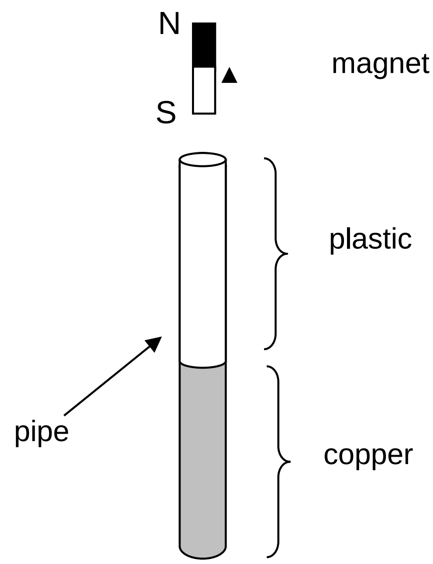


Fig. 8.1

A student dropped the magnet through the pipe and observed that the magnet fell with constant acceleration through the plastic portion of the pipe but fell with a smaller acceleration through the copper portion of the pipe.

(a) State what is meant by *Lenz's Law*.

....

.... [1]

(b) Using Lenz's law, explain the student's observations in this experiment.

....

....

....

.... [2]

(c) The student then inverted the magnet and repeated the experiment.

Suggest what the student would observe.

....

....

.... [1]

[total: 4]

9 Isotope X is radioactive. It decays by alpha-particle emission to a stable isotope.

(a) State **two** ways how a nucleus of X changes when it emits an alpha-particle.

....

....

....

.... [2]

(b) A sample of isotope X is placed close to a radiation detector in a laboratory. There are no other radioactive samples in the laboratory. A counter records the count rate.

Fig. 9.1 shows the graph of the count rate plotted against time.

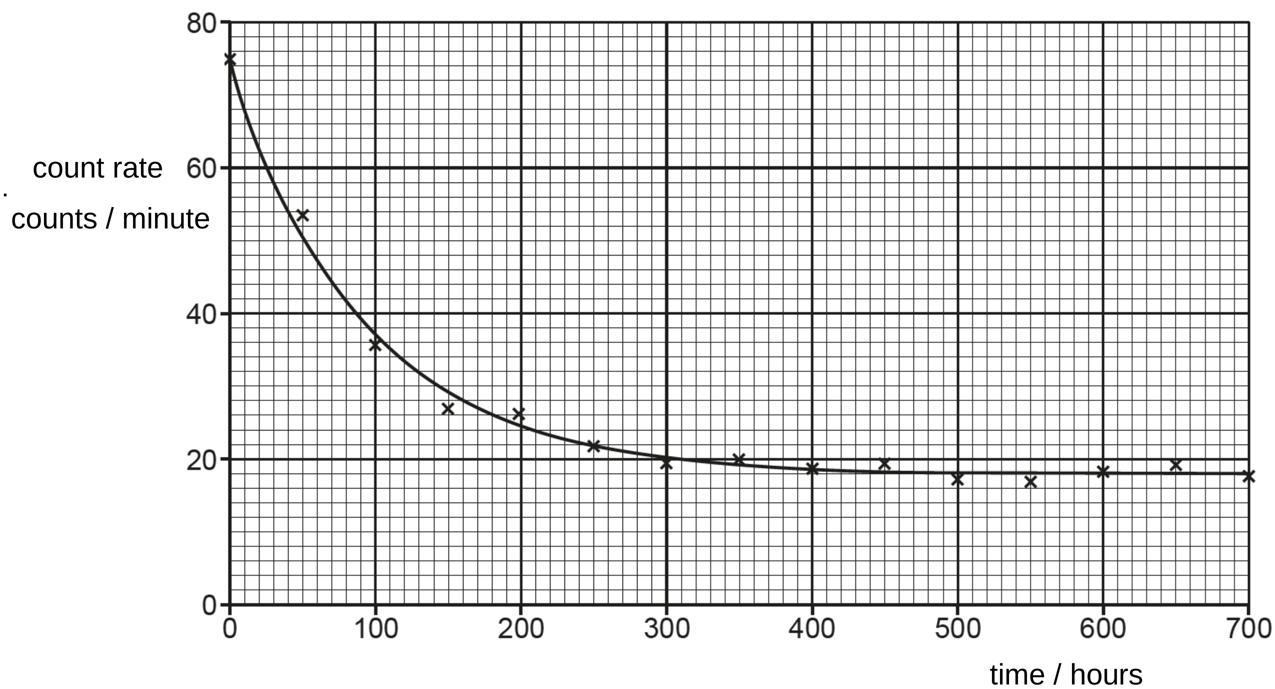


Fig. 9.1

(I) Using Fig. 9.1, determine the average background count rate.

average background count rate = ... [1]

(ii) Suggest one origin for the background count.

.... [1]

(iii) Determine the half-life of isotope X. Show how the answer is obtained.

half-life = ………………………… [2]

(iv) Explain why many of the points plotted in Fig. 9.1 do not lie on the best-fit line.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(v) State one way to control exposure to ionising radiation.

…………………………………………………………………………………………………

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

[total: 8]

10 A tsunami warning system is used to detect tsunamis in advance and issue warnings to prevent loss of life and damage.

Part of the warning system uses seabed bottom pressure recorder (BPR) and surface buoys. BPR detects pressure changes at the seabed and transmit the information to the surface buoys. The surface buoy then transmits the received information to the ground stations via the satellite.

At the ground stations, the information received on the pressure changes are converted to seabed to surface height.

Fig. 10.1 shows how the information is transmitted.

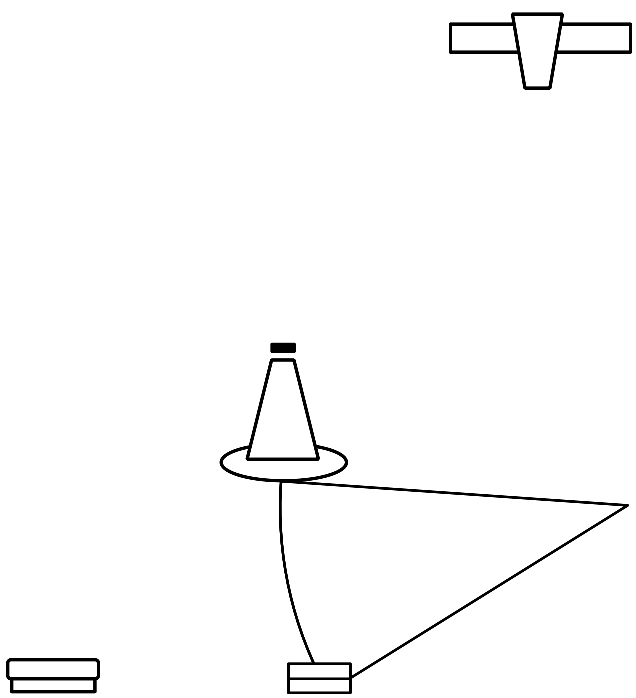


Fig. 10.1

surface buoy

BPR

seabed

transmission

transmission

transmission to ground stations

anchor

satellite

seabed to surface height

(a) Electromagnetic waves are used in the transmission of signals between the surface buoy, the satellite and the ground stations.

Electromagnetic waves are transverse waves where the vibration is perpendicular to wave propagation.

State **two** other common properties shared by all transverse waves.

………

………

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

(b) Fig. 10.2 shows how the seabed to surface height varies with time.

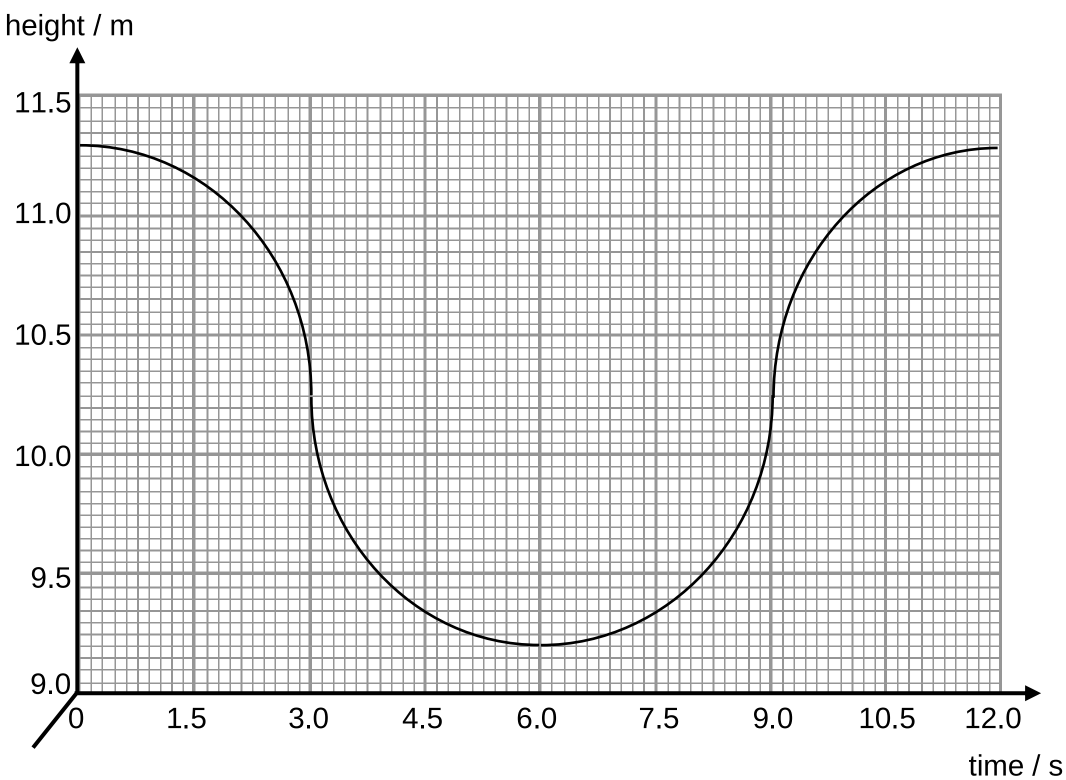


Fig. 10.2

Using the graph in Fig. 10.2, calculate

(i) the seabed to surface height when the sea is calm (when there are no waves), height = ………………… [1]

(ii) the frequency of the sea waves,

frequency = ………………… [1]

(iii) the wavelength of the sea waves, given that the speed of the sea waves is 7.0 m/s.

wavelength =…………………………… [2]

(c) As the sea waves travel towards the shore, its speed decreases.

State the changes, if any, to the following properties of the sea waves as its speed decreases.

wavelength: .... [1]

frequency: .... [1]

(d) If the amplitude of the sea waves is too high, a tsunami alert is broadcasted by the ground stations to the nearby homes using sound waves.

Describe how sound is transmitted from the ground stations to the nearby homes.

……………………………………………………………………………………………………

……………………………………………………………………………………………………

……………………………………………………………………………………………………

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

[total: 10]

11 Fig. 11.1 shows a circuit diagram. The circuit uses a light-dependent resistor (LDR) and a fixed resistor of resistance 5.0 kΩ.

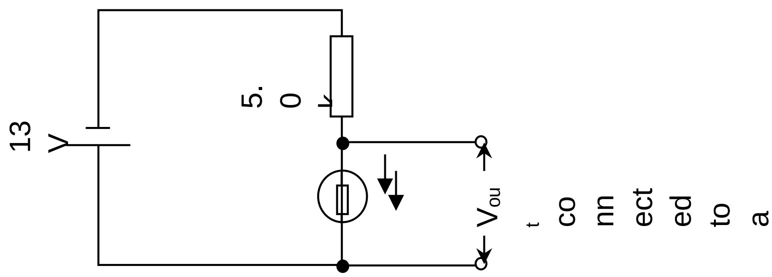


Fig. 11.1

The output voltage, V_{out} is connected to a lamp.

Fig. 11.2 shows the values of V_{out} and the status of the lamp at different time on a particular day.

time	V_{out} / V	status of lamp	current flowing in the lamp / mA
6:20 am	8.0	Switched on	0.050
6:30 am	7.8	Switched on	0.048
6:40 am	7.5	Switched on	0.042
6:50 am	5.0	Switched on	0.020
7:00 am	4.5	Switched off	0
7:10 am	2.0	Switched off	0
7:20 am	2.0	Switched off	0

Fig. 11.2

(a) At 6:50 am, calculate the

(I) current flowing in the fixed resistor,

current = ... [2]

(ii) resistance of the LDR.

resistance = ... [2]

(b) The lamp will be switched off whenever V_{out} is less than 5.0 V.

(i) Explain why the lamp switches off after 7:00 am.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

(ii) On another day, the lamp switches off only at 7:30 am although the same circuit was used.

Suggest what could have caused this.

…………………………………………………………………………………………………

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

(iii) The fixed resistor is replaced by a 10 Ω resistor and the same 13 V battery is used.

Explain the effect of this change on the battery life.

…………………………………………………………………………………………………

…………………………………………………………………………………………………

…………………………………………………………………………………………………

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

[total: 10]

Section B

Answer **one** question from this section.

12 Fig. 12.1 shows the main parts of a typical pressure cooker. The sealed pot is heated and the internal pressure is increased during cooking. This enables the food to be cooked in a shorter time than conventional cooking methods.

Fig. 12.1

The pressure regulator and vent pipe allow us to regulate the pressure in the sealed pot. The overpressure plug releases steam in case the vent pipe becomes clogged and pressure cannot be adjusted normally.

(a) The air pressure in the pot is adjusted such that it is 1.0 kPa higher than atmospheric pressure.

(i) Define *pressure* and state whether it is a vector or scalar quantity.

…………………………………………………………………………………………………..

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

(ii) If the gravitational field strength is 10 N/kg and the density of mercury is 13600 kg/m^3, calculate 1.0 kPa in mHg.

pressure = ……………………. [2]

(iii) The cover of the cooker has an internal surface area of 0.12 m^2 and has a weight of 20.0 N

State whether the cover will remain closed if it is not locked to the body.

Show your working clearly to support your answer.

…………………………………………………………………………………………………

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

(b) The vent pipe gives off sound when the steam in the pot escapes into the air through it.

Fig. 12.2 shows the air particles at their original undisturbed positions at t = 0 s and the same air particles in the new positions at t = 1.0 s when the sound passes through air.

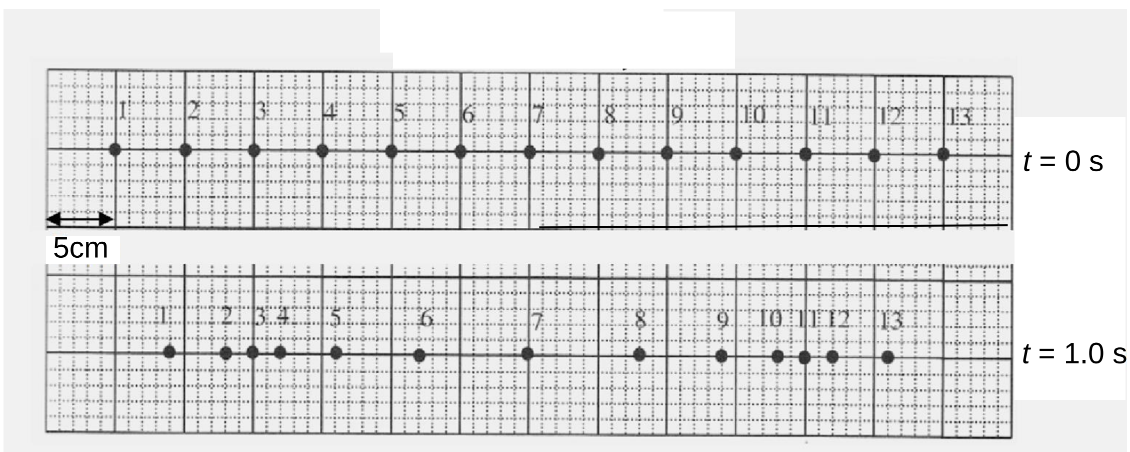


Fig. 12.2

(i) Determine the amplitude of the sound waves.

amplitude = ………………………… [1]

(ii) Label the position of the centre of rarefaction at t = 1.0 s.

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

(iii) The period of the sound waves is 0.2 s.

State the time, after t = 1.0 s, where the position mentioned in **(ii)** is the position of the next centre of compression.

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

(iii) Sound with a frequency above 20 kHz cannot be heard by humans.

State one application of such high frequency sound.

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

[total: 10]

13 Fig. 13.1 shows an ideal transformer. The transformer is not drawn to scale.

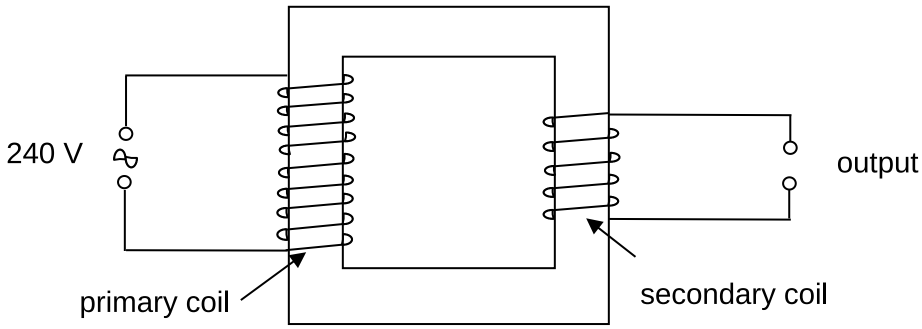


Fig. 13.1

The maximum input potential difference is 240 V. The maximum output potential difference is 10.0 V. There are 200 turns of wire on the secondary coil.

(a) State what is meant by *Faraday's law of electromagnetic induction*.

....

....

.... [1]

(b) Calculate the number of turns on the primary coil.

number of turns = ... [1]

(c) The output is connected to a bulb rated 12 W, 10 V. The bulb operates at its normal brightness.

Calculate the current in the input supply if the efficiency of the transformer is 50%.

current = ... [3]

(d) Suggest, with a reason, if thicker or thinner wires should be used in the secondary coil as compared with the primary coil.

……

……

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

(e) State **two** reasons why an iron core is needed in the transformer.

1. …...………………………………………………………………………………………………

………………………………………………………………………………………………………...

2. …...………………………………………………………………………………………………

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

(f) Explain why real transformers become hot when in use.

……

……

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

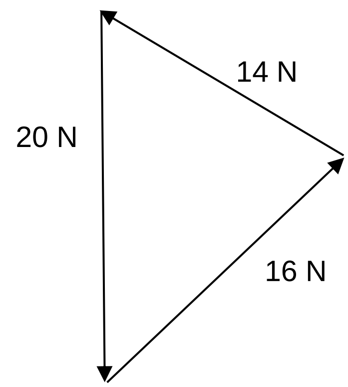
[total: 10]

End of Paper

Answers

Section A

1



Correct vector diagram with direction [1]
Correct scale drawing [1]
Answer = 14 N ± 0.2 N [1]

2 **(a)** Rate of change of displacement or change of displacement per unit time. [1]

(b) displacement = area under the graph = ½ (10 + 15 m/s) (0.5 s) [1] = 6.3 m [1]

(c) **(i)** Acceleration is decreasing. [1]

(ii) As object accelerates, the air resistance acting on it increases. [1]
The resultant force acting on the object decreases. [1]

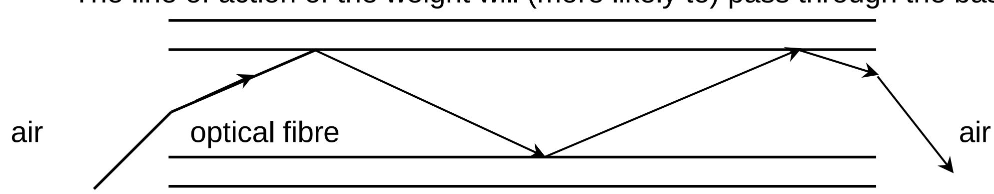
(d) higher energy in the kinetic store: in vacuum (because it has a higher speed) [1]
higher energy in the potential store: in air (because it has travelled a shorter distance and thus is higher from the ground) [1]

3 **(a)** change in the energy in the kinetic store = 0 J [1] because the speed and mass of the Yishunite remains constant.

(b) maximum moment of the weight = F × d = (65 kg × 10 N/kg) × 4.8 m [1] = 3100 Nm [1]

(c) The C.G. of the Ferris wheel will be lower. [1]
The line of action of the weight will (more likely to) pass through the base (when tilted). [1]

4

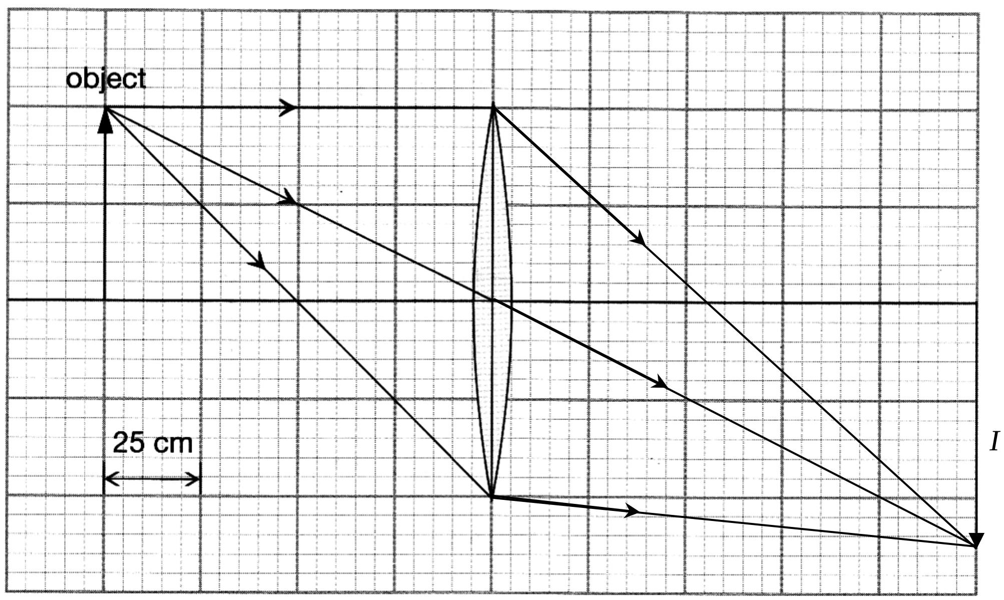


(a) Ray of light must be travelling from a medium of higher optical density to the boundary with a lower optical density. [1]
Angle of incidence must be higher than critical angle. [1]

(b) See above. [1]

(c) Less degradation of signal during transmission or Multiple signals can be sent at the same time or Information is sent at a higher speed. [1 + 1]

5



(a) See above. [1 + 1]
(b) focal length = 56 ± 1.5 cm [1]
(c) Ange of incidence is 0° [1]

6 **(a)** Pan B is black which is a better emitter of radiation compared to white. [1]
(b) The rate of cooling will be lower
OR temperature will take a longer time to drop to the same temperature. [1]
This is because the cover will reduce energy transfer by convection. [1]
(c) There is a change of 4200 J of energy for 1kg of water to change its temperature by 1°C. [1]
(d) It will require a high amount of energy (or require a longer time of heating) to raise the temperature of water for cooking. [1]
(e) $Q = mc\Delta\Theta$
$9000\ J \times 8\ min = m \times 4200\ J/kg°C \times (94^0C – 60^0C)$
$m = 0.504$ kg [1]

7 **(a)** Upward force drawn on AB and downward force drawn on CD. [1]
(b) Using Fleming's left hand rule, [1]
point the forefinger in the direction of the magnetic field and middle finger in the direction of the current. The thumb gives the direction of the force. [1]
OR
Based on the direction of the magnetic field due to the current in the wire and direction of the magnetic field due to the magnets,
we are able to determine that the force will act along the stronger magnetic field towards the weaker magnetic field.
(c) The perpendicular distance from the axis (pivot) to the line of action of the forces is zero, hence there is zero moment. [1]
(d) The split-ring commuter ensures that the current direction changes at every half turn. [1]
When the switch is closed, AB experiences an upward force and CD experiences a downward force. At the vertical position, current is cut off but due to inertia, AB passes the vertical position and now experiences a downward force. The coil continues to rotate in a clockwise direction about the axis OR
This changes the direction of the induced force at every half turn. [1]

8 **(a)** Lenz's law states that the direction of the induced e.m.f. and hence the induced current in a closed circuit, is always such that its magnetic effect opposes the motion or change producing it. [1]

(b) The magnet drops down with acceleration in the plastic portion of the pipe due to gravity. [1]
As it drops down the copper portion of the pipe, it causes a change in magnetic field which induces a current that produces an opposing magnetic force [1] according to Lenz's law.
This force causes the acceleration of the magnet to decrease.

(c) There will be no changes as the magnetic field induced by the copper tube will still be opposing the magnet.

9 **(a)** Any two:
number of protons decreases by two OR number of neutrons decreases by two
OR number of nucleons decreases by four [1 + 1]

(b) **(i)** 18 counts / min [1]

(ii) rocks/radon gas in the air/food high in potassium-40/any appropriate answer [1]

(iii) Initial count rate of radioactive material = 74 – 18 = 56 [1]
Count rate after 1 half life = 56 ÷ 2 = 28
Count rate on graph = 28 + 18 = 46
From graph, half life = 65 hours [1]

(iv) Radioactive decay is random [1]

(v) Reduce exposure time OR shielding by wearing lead-lined clothes OR store radioactive materials in sealed container that absorb radiation from the source or increase distance between source and us [1]

10 **(a)** They obey laws of reflection, obey law of refraction, do not carry charges, they transfer energy without the bulk movement of the medium etc. [1 + 1]

(b) **(i)** height = ½ (11.3 + 9.2 m) = 10.3 m [1]

(ii) frequency = 1 / 12.0 s = 0.083 Hz [1]

(iii) wavelength = v ÷ f = 7.0 m/s ÷ 0.083 Hz [1] = 84 m [1]

(c) wavelength: decreases [1]
frequency: remains constant [1]

(d) The air particles next to the ground stations vibrate and collide with neighbouring particles. This disturbance (energy) is transferred to other air particles. [1]
The vibration is parallel to the sound (energy) propagation and thus sound is transmitted in a series of compression and rarefactions. [1]

11 **(a)** **(i)** Current in fixed resistor = 8 / 5000 [1]
= 0.0016 A [1]

(ii) Resistance of LDR = 5.0 / (0.0016 – 0.000020) [1]
= 3160 Ω [1]

(b) **(i)** At 7:00 am, the light intensity increases. This leads to a decrease in the resistance of the LDR. [1]
Potential difference (pd) across the fixed resistor increases, leading to a drop in the pd across the LDR. (using potential divider formula) [1]
When the pd across the LDR is less than 5.0 V, V_{out} of the lamp will be less than 5.0 V, hence it switches off. [1]

(ii) The sky could be cloudy/the sun rises at a later time. [1]

(iii) The effective resistance of the circuit will decrease. [1]
This will lead to a larger current to flow in the circuit. Hence the battery life will shorten. [1]
OR
LDR will be switched on for longer period each day or permanently on since $R_{LDR} > R_{10\Omega}$, $V_{LDR} > 5.0$ V. Battery will be drained out faster.

Section B

12 **(a)** **(i)** Force acting per unit area. [1] It is a scalar quantity. [1]

(ii) 1000 Pa = ρgh = 13600 kg/m^3 × 10 N/kg × h [1]
h = 0.0074 m

P = 0.0074 mHg [1]

(iii) force by internal pressure acting on the cover = 1000 Pa × 0.12 m^2 = 120 N [1]
The cover will not remain closed because the force is greater than the weight of the cover. [1]
No mark for lack of working or evidence.

(b) **(i)** amplitude = 4 cm [1] (look at particle 1)

(ii) 7 [1]

(iii) 1.1 s [1] half a period later.

(iii) Prenatal check or check on depth of seabed etc [1]

13 **(a)** It states that the magnitude of the induced e.m.f. in a circuit is directly proportional to the rate of change of magnetic flux in the circuit. [1]

(b) The voltage goes from 240 V to 10 V. The voltage drops by 24x
The ratio of the primary coil to secondary coil is the same.
200 x 24
= 4800 [1]

(c) There is 12 W of power in the secondary coil.
If it was 100% efficiency in the transformer, the primary coil would also have 12 W, as energy is conserved.
If 12 W = 50%
100% = 12W x 2 = 24 W of power in the primary coil. [1]
Primary coil current = P/V = 24/240 [1]
= 0.10 A [1]

(d) Thicker wires [1]
Current in the secondary coil is higher than primary coil. Thicker wires have lesser resistance, so less energy is transferred to the internal store of the wire and surroundings . [1]

(e) 1. Iron is a magnetic material that concentrates the magnetic field from the primary coil to the secondary coil, thus improving the magnetic flux linkage between the coils. [1]
2. Iron is a soft magnetic material that can magnetise and demagnetise easily. The changes in the magnetic field of the primary coil can effectively induce current in the secondary coil. [1]

(f) Due to the effects of eddy currents, some energy is transferred to the internal store of the wire and surroundings. [1]