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EAST SPRING SECONDARY SCHOOL

Towards Excellence and Success

Name: _____ ( )

Class: 3-1

Second Semester Examination 2016
Secondary Three Express

PHYSICS

Tuesday 11 October 2016

2 hours 15 minutes
0935 - 1150

Additional materials:
OTAS

INSTRUCTIONS TO CANDIDATES

Write your name, class and register number in the spaces provided above, and on all the work you hand in.
Write in dark blue or black pen.
You may use a soft pencil for any diagrams, graphs, tables or rough working.
Do not use staples, paper clips, highlighters, glue or correction fluid.
You may assume $g = 10$ m/s^2 whenever necessary, unless otherwise stated.
Calculators are allowed.

Section A [25 marks]
Answer **all** questions in soft pencil on the OTAS.

Section B [45 marks]
Answer **all** questions.
Write your answers in the spaces provided on the question paper.

Section C [30 marks]
Answer **any three** questions.
Write your answers in the spaces provided on the question paper.

At the end of the examination, hand in the OTAS separately.

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

Section	Marks
A	/25
B	/45
C	/30
Total	/100

17

This question booklet consists of 27 printed pages including the cover page.

Section A [25 Marks]

Answer **ALL** questions in soft pencil on the OTAS.

A1 Fig. A1.1 below shows the reading of the zero error of the micrometer screw gauge. Fig. A1.2 shows the reading of the same instrument when it is used to measure the width of an object.

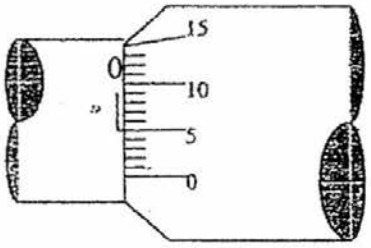


Fig. A1.1

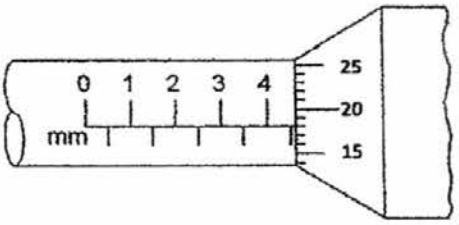
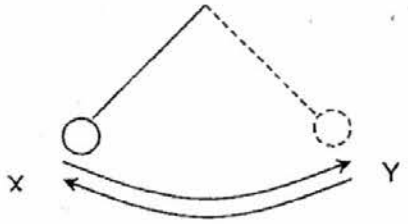


Fig. A1.2

What is the width of the object?

A 4.63 mm **B** 4.73 mm **C** 4.83 mm **D** 4.85 mm

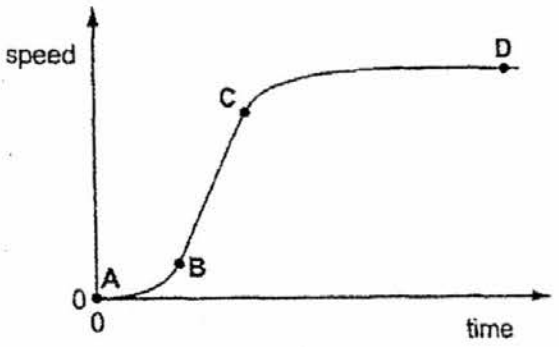
A2 It takes 20 s for a pendulum to swing from X to Y and back again 20 times.



What is the period of the pendulum if the mass is doubled?

A 0.5 S **B** 1 s **C** 2 s **D** 20 s

A3 The graph shows the speed of a weather balloon as it rises through the atmosphere.

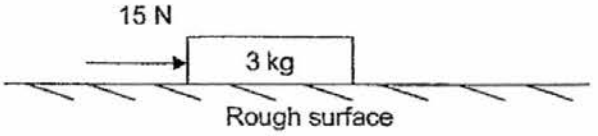


At which point (**A**, **B**, **C** or **D**) in the rise of the balloon does the acceleration start to decrease?

A4 A hammer hits a nail on a piece of wood with a speed of 6 m/s. If it drives the nail 0.1 m into the wood, what is the average deceleration of the hammer?

A 18 m/s^2 **B** 60 m/s^2 **C** 120 m/s^2 **D** 180 m/s^2

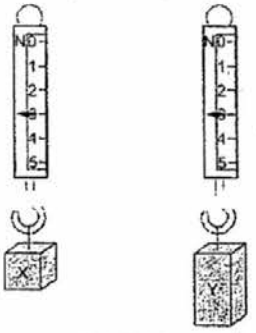
A5 When pushed with a force of 15 N, a 3 kg box accelerates at 2 m/s^2 across a rough surface.



What force would be needed for the box to move at a constant speed instead?

A 5 N **B** 6 N **C** 9 N **D** 15 N

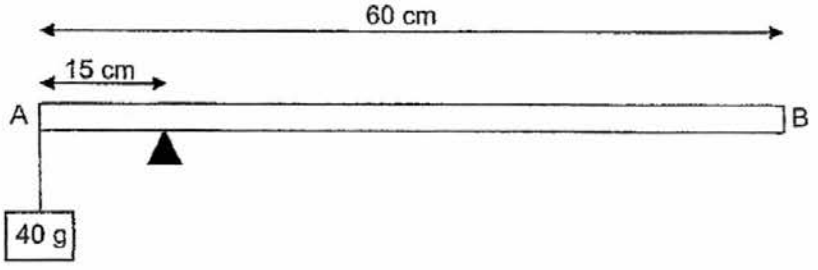
A6 Two blocks of metal X and Y hang from spring balances as shown in the diagram.



Which of the following statements (**A**, **B**, **C** or **D**) is true?

A They have the same mass and the same volume but different weights.
B They have the same mass and the same weight but different volumes.
C They have the same mass, the same volume and the same weight.
D They have the same weight and the same volume but different masses.

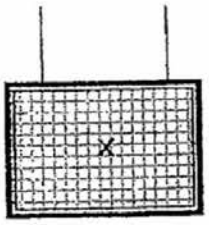
A7 A uniform plank AB of length 60 cm is balanced horizontally across a pivot placed 15 cm from A as shown below. A mass of 40 g is hung from the end A.



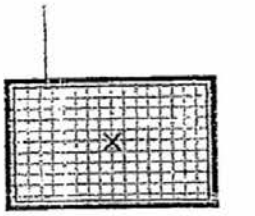
What is the weight of the ruler?

A 0.13 N **B** 0.40 N **C** 13 N **D** 40 N

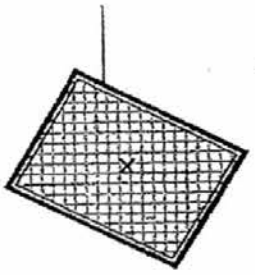
A8 A picture frame, with centre of gravity at X, hangs from two strings as shown in the figure below.



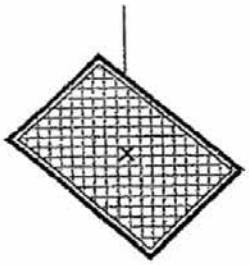
Which one of the following figures shows how the picture frame hangs when one of the strings breaks?



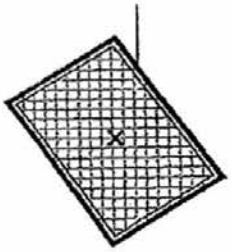
A



B

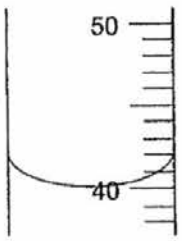


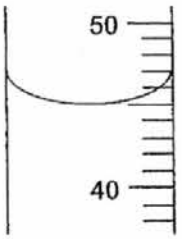
C



D

A9 The figures below show the difference in water level (cm^3) before and after a stone is submerged in a measuring cylinder.

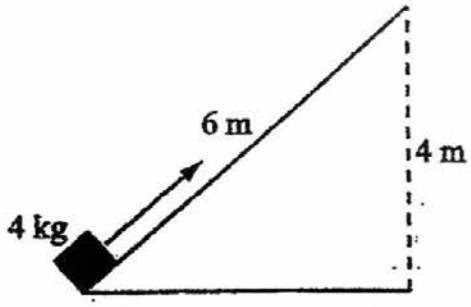




If the mass of the stone is 0.020 kg, what is the density of the stone?

A 0.004 g/cm^3 **B** 0.1 g/cm^3 **C** 0.25 g/cm^3 **D** 4 g/cm^3

A10 The diagram shows a box of mass 4 kg being pulled up a rough ramp from rest.



Given that the speed of the box is 2 m/s at the top of the ramp and the friction along the ramp is 5 N, how much work is done to move the box up the ramp?

A 30 J **B** 160 J **C** 190 J **D** 198 J

A11 A bodybuilder uses a chest expander with five springs. It takes a force of 200 N to extend one spring by 15 cm.

What is the average power needed to extend the chest expander by 15 cm in 10 seconds?

A 3 W **B** 15 W **C** 30 W **D** 150 W

A12 Molten iron is poured into a mould and allowed to cool. During the process when iron is changing from liquid to solid, the iron particles

A move slower.
B decrease in size.
C move closer to one another.
D move slower and closer to one another.

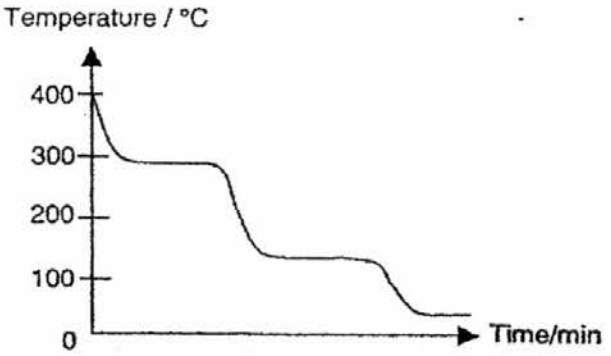
A13 Gas inside a sealed container of fixed volume is heated. Which of the following **does not** increase?

A The average distance between the gas molecules.
B The average kinetic energy of the gas molecules.
C The number of collisions per second by the gas molecules on the walls of the container.
D The force due to the collisions between the gas molecules and the walls of the container.

A14 A wooden chair feels warmer than a metal chair even when they are at the same temperature. Which of the following statements best explains this?

A Wood is a better absorber of radiant heat.
B Metal is a better emitter of radiant heat.
C Wood is a better conductor of heat.
D Metal is a better conductor of heat.

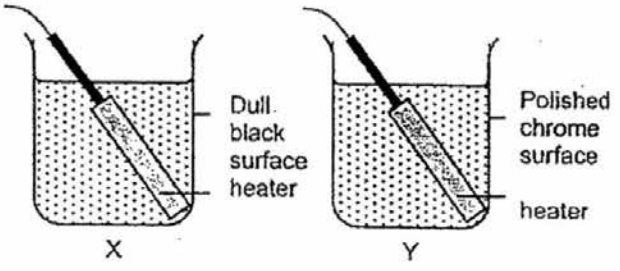
A15 A gaseous substance is cooled at a constant rate and its temperature is recorded every minute, as shown in the graph below.



At which of the following temperatures is the substance a liquid?

A 0 °C **B** 100 °C **C** 200 °C **D** 350 °C

A16 In the diagram below, two copper cans X and Y with outer surface of different texture are filled with the same amount of water at room temperature.



If both the cans are heated with heaters of the same power, which of the following statements is correct?

A Water in X boils faster because a dull black surface is a better insulator.
B Water in X boils faster because a dull black surface is a better radiator.
C Water in Y boils faster because a polished chrome surface is a poorer radiator.
D Water in Y boils faster because a polished chrome surface is a poorer conductor.

A17 A heater supplies 6800 J of thermal energy is to heat 30 g of ice at 0°C. The specific latent heat of fusion of ice is 340 J/g. How much ice remains after heating?

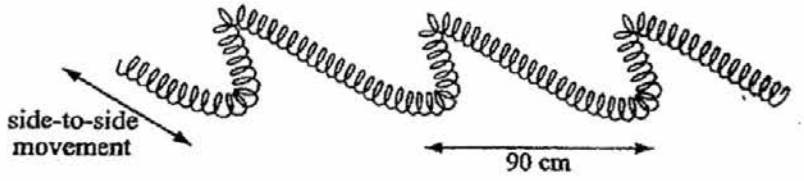
A 0 g **B** 10 g **C** 20 g **D** 30 g

A18 The lengths of mercury thread in the uniform tube above the bulb of a mercury thermometer are 20 mm in melting ice and 170 mm in steam directly above boiling water.

What is the temperature indicated by the thermometer when the length of mercury thread is 10 mm?

A – 6.7 °C **B** – 5.9 °C **C** 5.9 °C **D** 6.7 °C

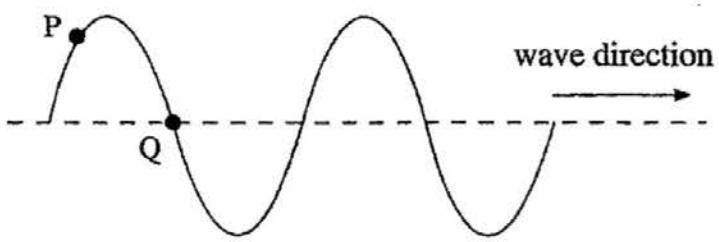
A19 A wave is made by shaking a coil of spring from side to side. The distance between two successive troughs is 90 cm, and 3 waves are produced in 1 second.



How long does the wave take to travel 4.5 m along the spring?

A 1.67 s **B** 13.5 s **C** 15 s **D** 60 s

A20 The diagram shows a wave on a string with two points P and Q marked. The wave is moving in the direction shown.



What will happen next?

A P will move up.
B P will move to the right.
C Q will move up.
D Q will not move.

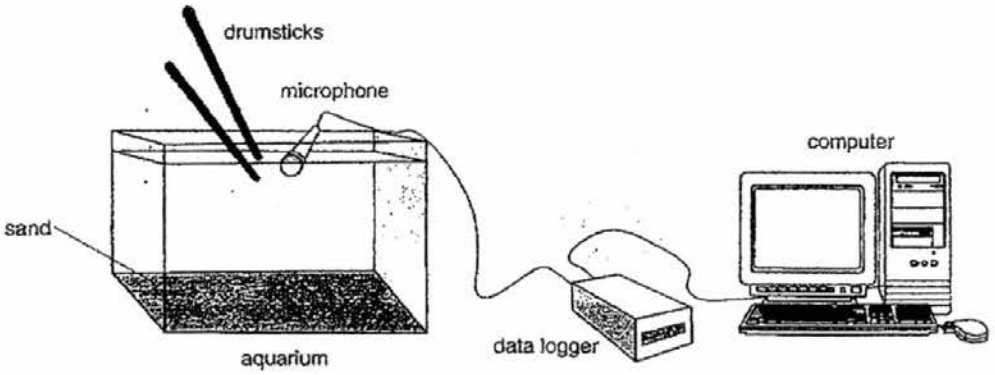
A21 Below are four statements on the uses of electromagnetic radiation.

X-rays are used in intruder alarms.
Microwaves are used in satellite TV.
Infra-red waves are used in sunbeds.
Gamma rays are used in ear thermometers.

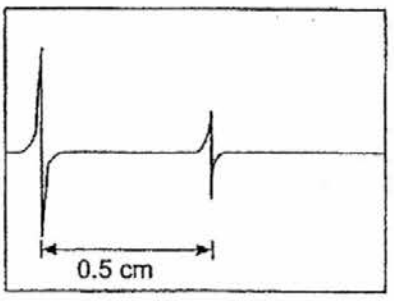
How many of these statements are correct?

A 0 **B** 1 **C** 2 **D** 3

A22 An experiment is carried out to measure the speed of sound in water as shown below. An aquarium with sand at the bottom is filled with water, and a microphone, wrapped in plastic, is placed near the water surface.



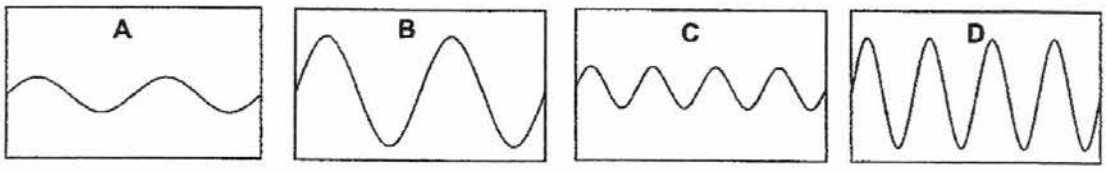
Two drumsticks, with their heads immersed in the water, are hit against each other to make one sharp sound pulse, and the sounds are detected by the datalogger and displayed on the screen as shown below.



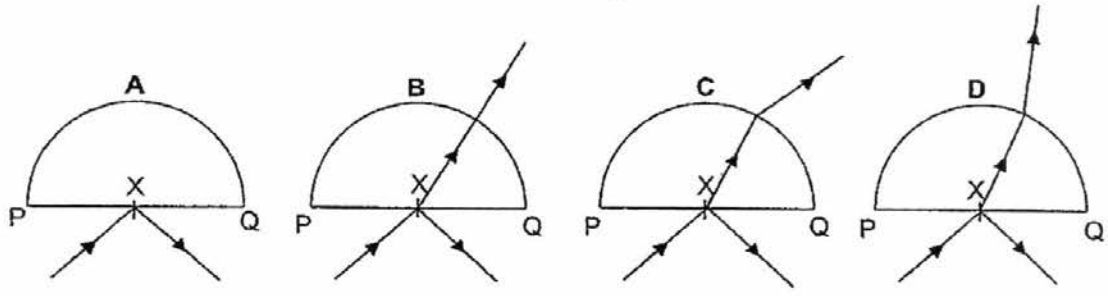
Given that 1 cm on the screen represents 1 ms of time, and the depth of water is 28 cm, find the speed of sound in water.

A 560 m/s **B** 1120 m/s **C** 1790 m/s **D** 3570 m/s

A23 Which of the following sound waves (**A, B, C** or **D**) is the softest with the highest pitch?

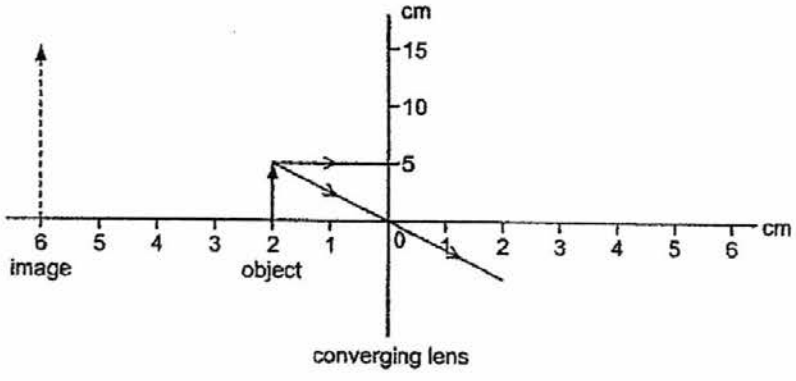


A24 X is the midpoint of the straight edge PQ. Which of the following best illustrates the path of light as it is shone onto a semi-circular glass block?



A25 An object 5.0 cm high is placed 2.0 cm from a converging (convex) lens which is being used as a magnifying glass.

The image produced is 6.0 cm from the lens and is 15 cm high.



What is the focal length of the lens?

A 2.0 cm **B** 3.0 cm **C** 4.0 cm **D** 6.0 cm

- End of Section A -

Section B [45 marks]

Answer **ALL** questions in the spaces provided.

B1 An object of mass 20 kg is initially at rest on a rough horizontal surface. A horizontal force F is then applied to it. Fig. B1.1 shows a graph of the variation of F applied with time. The object moves with an acceleration of 0.4 ms^{-2} in the first 12 s.

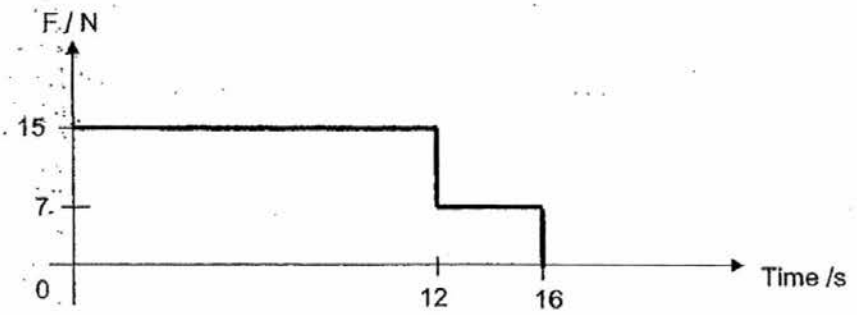


Fig. B1.1

(a) Calculate

(i) the speed of the object when the time t = 12 s.

speed = ...[2]

(ii) the distance travelled by the object in the first 12 s.

distance = ...[1]

(iii) Calculate the frictional force between the surfaces. Assume that air resistance is negligible.

frictional force = ...[2]

(b) In the presence of air resistance, the acceleration would change and not remain constant at 0.4 ms^{-2} in the first 12 s.

Explain, in terms of the forces acting on the object, why the acceleration would change.

.....

.....

.....

.....

..... [2]

B2 Fig. B2.1 shows a uniform beam of mass 100 kg being supported by two rollers. A student of mass 50 kg is standing in a position such that his centre of gravity (C.G) is 0.5 m away from point T.

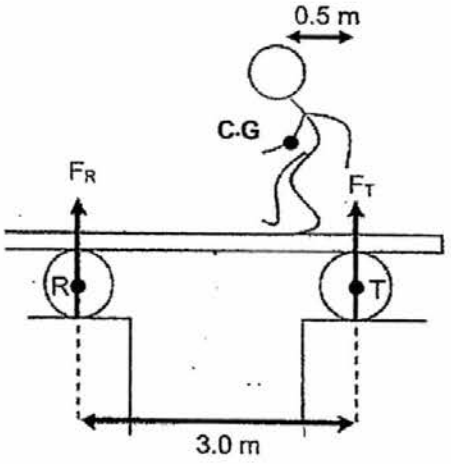


Fig. B2.1

(a) Describe one difference between *mass* and *weight*.

.....

..... [1]

(b) Calculate the weight of the beam. The gravitational field strength is 10 N/kg.

Weight = ... [1]

(c) On Fig. B2.1, draw the weight acting on the beam. [1]

(d) By taking moments about R, calculate the reaction force F_T.

F_T = ... [2]

(e) Hence, or otherwise, calculate the reaction force F_R.

F_R = ... [1]

(f) State how the reaction forces F_T and F_R will change as the student walks towards point R.

.....

..... [1]

B3 The G-Max Reverse Bungy at Clarke Quay uses a giant catapult to launch people seated inside a metal-framed capsule vertically upwards using elastic cords.

When the capsule is about to be launched, each cord applies a force of 1600 N and the cords are at 95° to each other as shown in Fig. B3.1.

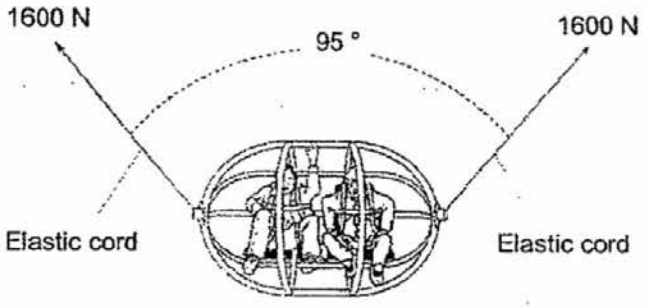


Fig. B3.1

(i) By drawing a scaled diagram, find the resultant of these two forces, indicating clearly its magnitude and its direction.

Magnitude = ...

Direction: .....

[3]

(ii) Calculate the minimum force required to hold the capsule in place prior to the launch, given that the weight of the capsule with its occupants is 1500 N.

Force: ..... [1]

B4 Fig. B4.1 shows a roller coaster of mass 400 kg being released from rest at **A**. It is assumed that the friction between the track and the roller coaster is negligible.

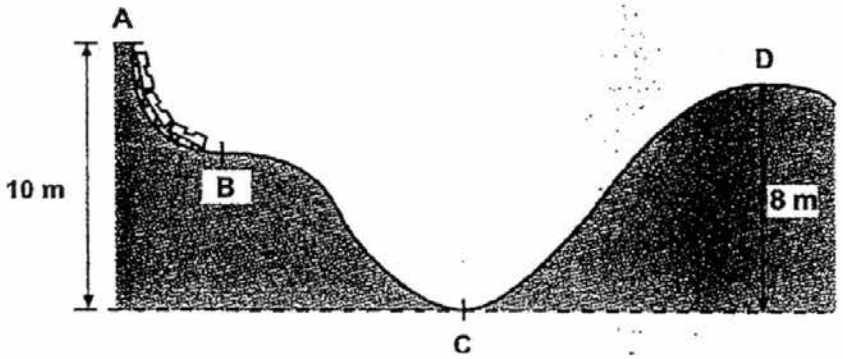


Fig. B4.1

(a) Describe how the energy of the roller coaster would change as it moves from A to B.

.....

.....

.....

..... [2]

(b) Calculate the gravitational potential energy of the roller coaster at point A.

Gravitational Potential Energy = ... [1]

(c) Calculate the speed of the roller coaster by the time it reaches point D.

Speed = ... [2]

B5 Fig. B5.1 below shows a ray of red and violet light passing into the surface of water.

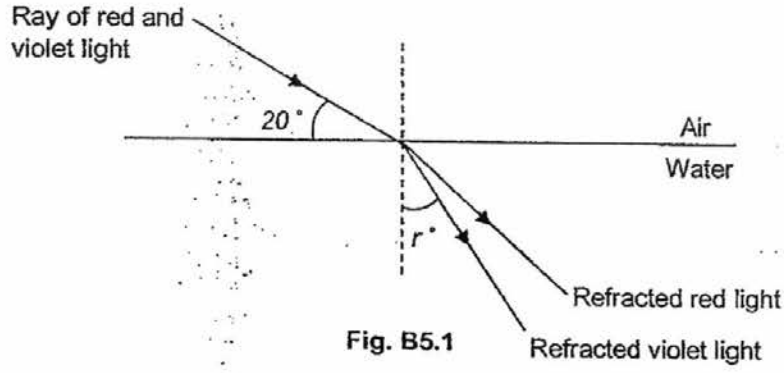


Fig. B5.1

(a) Explain what is meant by the term *refractive index*.

.....

.....

..... [1]

(b) The refractive index of water for red and violet light are 1.33 and 1.35 respectively.

Calculate the angle of refraction of the refracted violet ray.

Angle of refraction = ... [2]

(c) Describe how the speed, wavelength and frequency of the red light will change as it travels from air to water.

Speed: ..... Wavelength: .....

Frequency: ..... [1]

(d) Explain how Fig. B5.1 shows that the speed of the red light is higher than the speed of the violet light.

.....

..... [1]

B6 An object is placed in front of a thin converging lens and a real image is formed on the opposite side of the lens. The object distance is varied and the image distance is measured. A graph of the image distance against object distance is shown in Fig. B6.1.

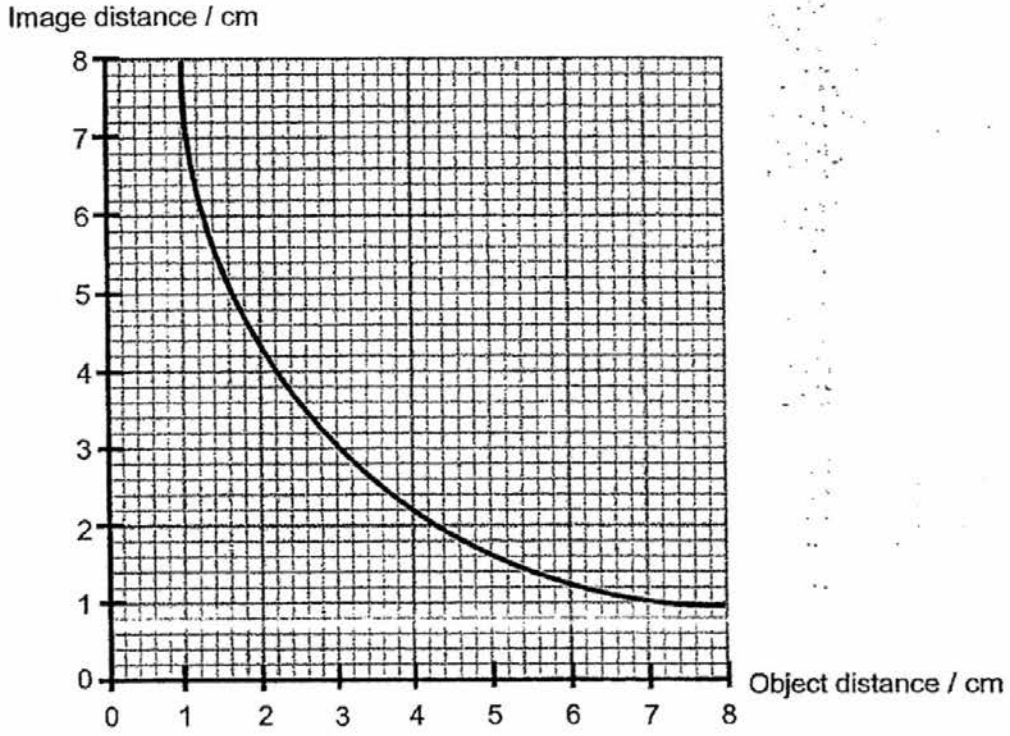


Fig. B6.1

Fig. B6.2 is an incomplete full-scale ray diagram. Using data from Fig. B6.1, complete Fig.B6.2 for the object when it is placed at a certain distance in front of the thin converging lens. Show clearly the image position and state the focal length of the lens.

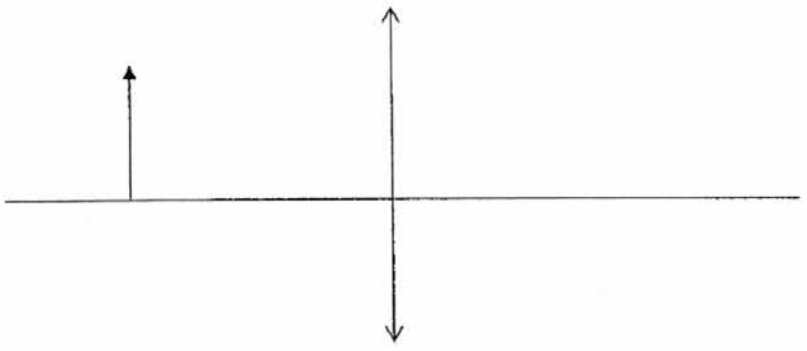


Fig. B6.2

Focal length = ... [4]

B7 Fig. B7.1 shows the positions of particles of a medium at a particular instant when a longitudinal sound wave, travelling from left to right, passes through the medium. Before the wave arrived, the particles were all spaced equally apart at their original undisturbed positions which are shown by the vertical lines.

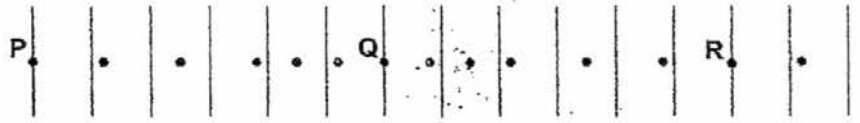


Fig. B7.1

(a) Explain what is meant by *longitudinal wave*.

.....

.....

..... [1]

(b) Given that the distance between P and Q is 10 cm and the frequency of the sound is 20 Hz.

(i) Calculate the speed of the wave

Speed = ... [2]

(ii) Calculate the time taken for the compression at Q to move to the position at R.

Time = ... [2]

(c) Describe how the movement of the particle at point P will change when

(i) A louder sound passes through it.

.....

..... [1]

(ii) A higher pitch sound passes through it.

.....

..... [1]

B8 Fig. B8.1 shows the cooling fins that are found behind a refrigerator. The black metal cooling fins help to transfer heat away from the hot fluid which flows through the metal pipe. As a result, a cooler fluid flows out of the metal pipe.

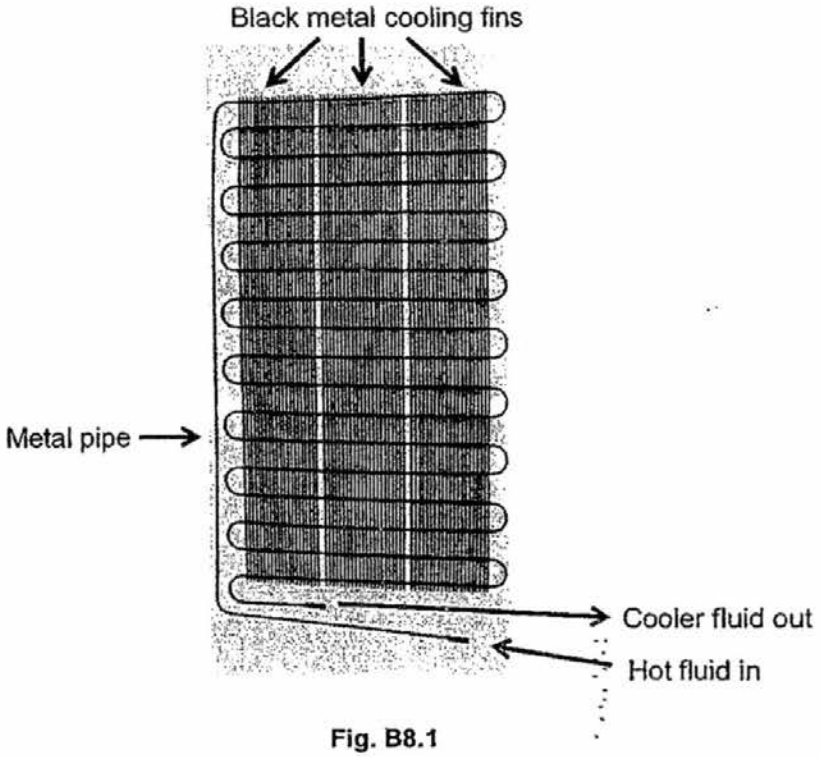


Fig. B8.1

(a) Describe how heat is transferred from the hot fluid to the cooling fins and then to the surrounding air. In your answer, state clearly the heat transfer processes involved.

.....

.....

.....

.....

..... [2]

(b) Explain how the features of the cooling fins allow heat to be transferred easily away from the hot fluid flowing in the metal pipe.

.....

.....

.....

.....

.....

..... [3]

(c) The refrigerator is able to transfer 36 MJ of heat energy in 4 hours. Calculate the power of the refrigerator.

power = ... [1]

- End of Section B -

Section C [30 marks]
Answer any **three** questions in the spaces provided.

C1 A student carries out an experiment to study the flow of heat. The student heats a 600 g metal block M in boiling water at 100 °C for 10 minutes until the block has the same temperature as the boiling water as shown in Fig. C1.1.

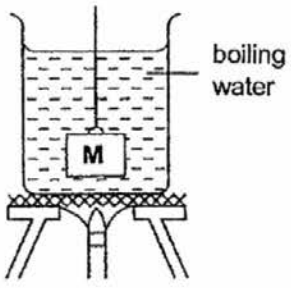


Fig. C1.1

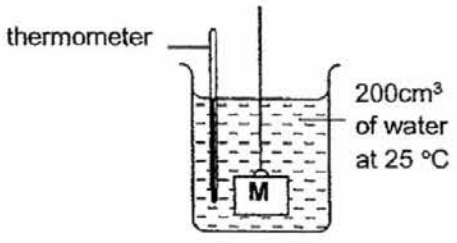


Fig. C1.2

The student then transfers the metal block into a beaker containing 200 cm³ of water at 25 °C as shown in Fig. C1.2.

The temperature of water in the beaker is recorded at 30-second intervals. The student then plots a graph of the temperature of the water against time as shown in Fig. C1.3.

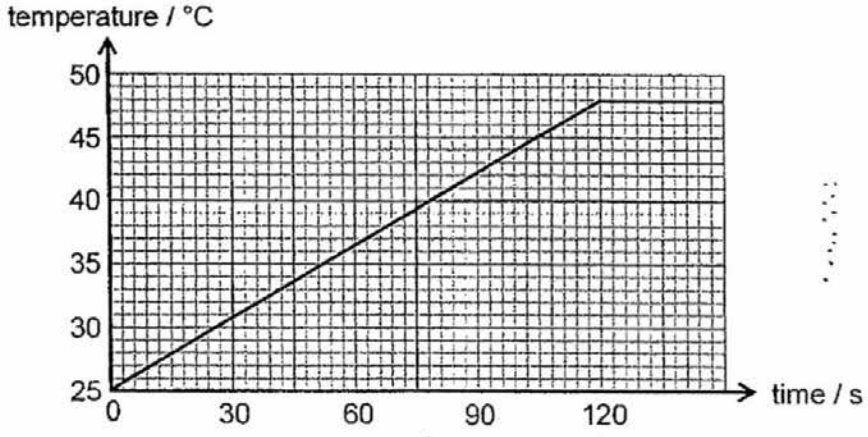


Fig. C1.3

(a) Explain why the temperature of the water remains constant at 50 °C after 120 seconds.

.....

..... [1]

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

.....

..... [1]

(c) The density of water is 1 g/cm^3. Calculate the heat gained by the water in the first 120 seconds.

Heat gained = ... [3]

(d) Calculate the specific heat capacity of the metal block M.

Specific heat capacity = ... [2]

(e) During 0 s to 120 s, some water may have evaporated from the beaker.

(i) Explain, using the concept of particles, how evaporation takes place.

.....

.....

.....

.....

..... [2]

(ii) Explain how evaporation can cause the value calculated in **(c)** to be inaccurate.

.....

..... [1]

C2 Fig. C2.1 shows a periscope which may be used to see what is behind a vehicle when towing a caravan. Two mirrors should be used, but only one mirror has been shown in Fig. C2.1.

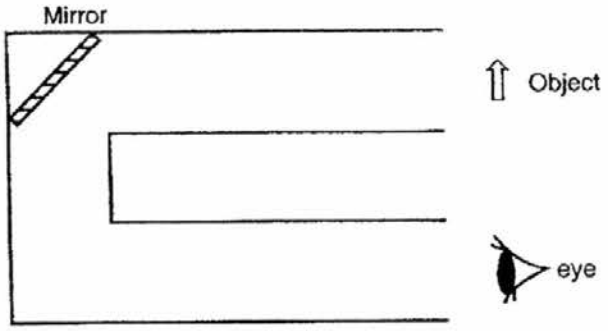


Fig. C2.1

(a) On Fig. C2.1, draw the second mirror in the correct position. [1]

(b) Draw accurately a ray of light from the

(i) top of the object to the eye. [1]

(ii) bottom of the object to the eye. [1]

(c) From your answers in part **(b)**, deduce whether the image is *upright* or *inverted*.

..... [1]

(d) Triangular glass prisms are usually used in place of the mirrors in the periscope by causing the light to undergo total internal reflection as shown in Fig. C2.2.

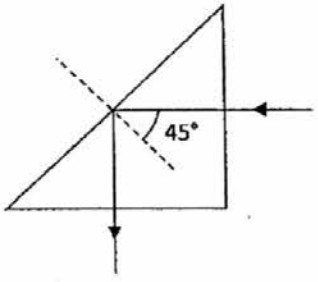


Fig. C2.2

(i) Explain why the light does not bend when it enters the glass prism from air.

..... [1]

(ii) Explain what is meant by the term *critical angle* of the glass prism.

.....

..... [1]

(iii) Given that the speed of light in air and glass is 2.99×10^8 m/s and 1.98×10^8 m/s respectively.

Calculate the critical angle of the glass prism.

Critical angle = ... [2]

(e) Glass mirrors usually have a layer of glass to protect the reflecting silvered surfaces from scratches as shown in Fig. C2.3.

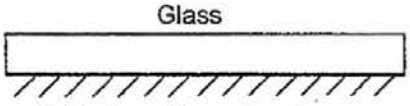


Fig. C2.3

Explain how the layer of glass would affect the image seen in the periscope.

.....

.....

.....

.....

.....

..... [2]

C3 **(a)** Brownian motion provides evidence that the molecules in a gas are moving.

(i) Draw a labelled diagram of an experiment that demonstrates Brownian motion.

[2]

(ii) Describe what is seen in the experiment.

..... [1]

(iii) State two reasons why the motion in **(aii)** is observed.

.....

.....

.....

.....

.....

..... [2]

(b) A filament lamp emits electromagnetic (E.M) waves with a range of wavelengths. Fig. C3.1 shows the energy emitted per second at each wavelength.

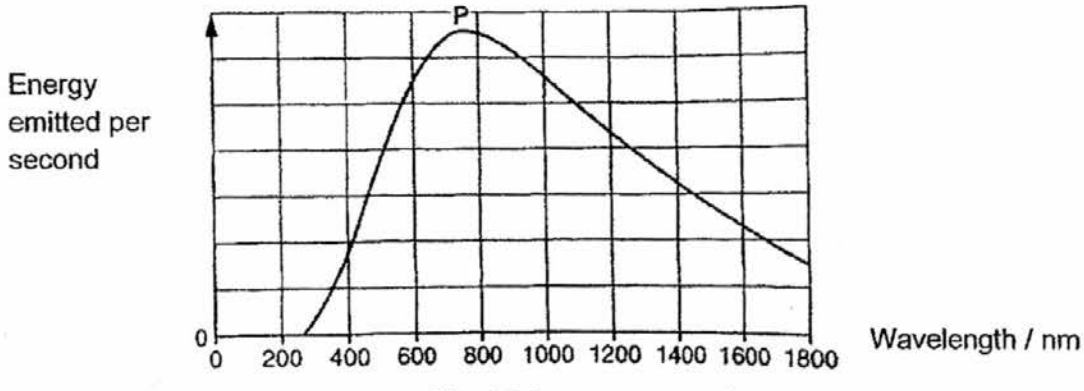


Fig. C3.1

The wavelength of visible light is between 400 nm and 700 nm.

(i) Suggest **two** other E.M waves that are emitted by the filament lamp other than light.

..... [2]

(ii) Given that the total amount of light energy emitted by the lamp was 1.8 MJ per second and the amount of electrical energy used by the lamp was 3 MJ per second.

Calculate the efficiency of the lamp.

efficiency = ... [1]

(iii) The glass casing of the filament lamp can be sprayed with a coating that will absorb E.M waves of a certain frequency.

By assuming a suitable value for the speed of the E.M waves, calculate the minimum frequency of E.M wave that should be absorbed so that the lamp is more efficient.

The glass should absorb EM waves with frequencies higher than ..... [2]

C4 A pedulum consisting of a metal sphere attached to a thin thread is shown in Fig. C4.1. When the thread is vertical, the metal sphere is at A. The metal sphere is moved to B by a horizontal force of 2.5 N.

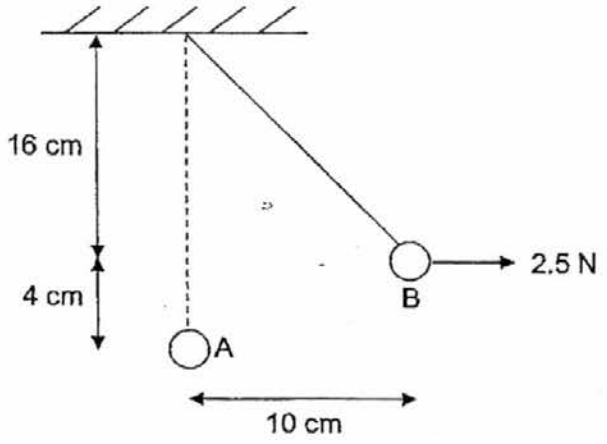


Fig. C4.1

(a) Draw a fully-labelled free-body diagram to showing all the forces acting on the metal sphere when it is at B. Name the forces clearly.

[1]

(b) The metal sphere is now released so that the pendulum is free to swing.

Explain why the metal sphere begins to move when released and why it continues to move past point A.

.....

.....

.....

.....

..... [2]

(c) The mass of the metal sphere is 400 g.

(i) Calculate the work done to raise the sphere.

Work done = ...[2]

(ii) Calculate the moment produced at point B due to its weight.

Moment = ...[2]

(d) Explain why the metal sphere eventually comes to a rest at point A after a while.

.....

..... [1]

(e) A student determines the time for one complete swing of the pendulum. She uses two methods.

In the first method, she measures the time for one complete swing.

In the second method, she measures the time for 20 complete swings and divides the total time by 20.

Explain why the second method gives a more accurate result than the first method.

.....

.....

.....

.....

..... [2]

30

- End of Section C -

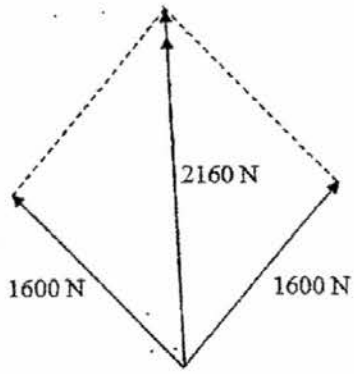
Answers

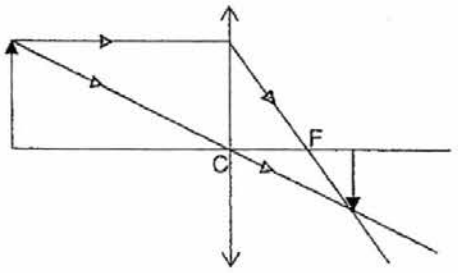
Qn	1	2	3	4	5	6	7	8	9	10
Ans	A	B	C	D	C	B	B	C	D	D

Qn	11	12	13	14	15	16	17	18	19	20
Ans	B	C	A	D	C	C	B	A	A	C

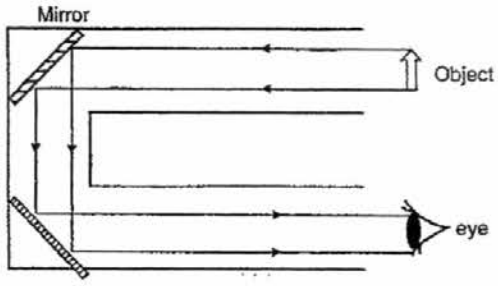
Qn	21	22	23	24	25
Ans	B	B	C	B	B

Qn	Answer	Mark
B1a(i)	a = (v-u) / t 0.4 = (v – 0) / 12 v = 4.8 m/s	 1 1
B1a(ii)	Distance = area under graph = ½ x 4.8 x 12 = 28.8 m	 1
B1a(iii)	F_r = m x a = 20 x 0.4 = 8 N F_r = F – friction 8 = 15 – friction Friction = 7 N	 1 1
B1b	As the object moves faster, the amount of air **resistance acting on it increases**. This will cause the **resultant force on the object to decrease**. Since F = m x a, the acceleration will decrease as well.	1 1
B2a	Mass is the **amount of substance inside a body** whereas weight is the **amount of gravitational force** acting on a body.	1
B2b	W = m x g = 100 x 10 = 1000 N	1
B2c	Weight is drawn in the middle and pointing downwards.	1
B2d	Sum of CW moments = Sum of ACW moment 1000 x 1.5 + 500 x 2.5= F_T x 3 F_T = 917 N	 1 1

B2e	Total upward force = Total downward force $F_T + F_R = W$ $917 + F_R = 1000 + 500$ $F_R = 583$ N	1
B2f	F_T will decrease whereas F_R will increase.	1
B3a	 Parallogram [1m] Magnitude = 2160 N (Accept 1944 N to 2376 N) [1m] Direction = 48° from 1600 N (Accept 46° to 50°) [1m]	3
B3b	Minimum Force = 2160 – 1500 = 660 N	1
B4a	At point A, the roller coaster would have **only gravitational potential energy**. As the roller coaster move from A to B would **lose gravitational potential energy** and **gain kinetic energy**. At **point B**, the roller coaster would have **both gravitational potential energy and kinetic energy**.	 1 1
B4b	GPE = m x g x h = 400 x 10 x 10 = 40,000 J	1
B4c	$E_A = E_D$ $GPE_A = GPE_D + KE_D$ $40{,}000 = 400 \times 10 \times 8 + \frac{1}{2} \times 400 \times v^2$ $v = 6.32$ m/s	1 1
B5a	It is the ratio of the sine of the angle of incidence to the sine of the angle of refraction. **OR** It is the ratio of the speed of light in vacuum to the speed of light in the optical medium	1

B5b	n = sin i / sin r 1.35 = sin 70 / sin r r = 44.1°	 1 1
B5c	Speed decreases. Wavelength decreases. Frequency remain the same.	1
B5d	The red light does not bend as much towards the normal than the violet light.	1
B6	 1 ray drawn passing through C [1m] Image distance = 2.2 cm [1m] 1 ray drawn passing through lens and then F [1m] Focal length = 1.4 cm [1m]	4
B7a	A longitudinal wave is a wave which **travels in a direction** that is **parallel** to the **direction of vibration of particles.**	1
B7bi	v = f x λ = 20 x 20 = 400 cm/s	 1 1
B7bii	T = 1 / f = 1 / 20 = 0.05 s. Time taken for compression to move = 0.05 / 2 = 0.025 s.	 1 1
B7ci	Particle P will away from its rest position with a **larger displacement.**	1
B7cii	Particle P will **oscillate more times in one second.**	1

B8a	Heat is transferred from the hot fluid to the metal pipe and then to the cooling fin by **conduction**. Heat is transferred from the cooling fin to the surrounding air by **radiation**.	2
B8b	The fins are painted black as **black is a good emitter of heat.** This **increases the heat lost** to the surroudings by **radiation**. The fins are made of metal as **metal is a good conductor of heat.** This **increases the heat lost** to the surroudings by **conduction**. There are **many fins placed behind to increase the surface area.** This **increases the heat lost** to the surroudings by **radiation**.	3
B8c	$P = E / t$ $= 36 * 10^6 / (4*3600)$ $= 2500$ W	1
C1a	The water and the metal block has **reached thermal equilibrium.** OR There is no net transfer of heat between the water and metal block.	1
C1b	It means 4200 J of heat energy is needed to raise the temperature of 1 kg of water by 1°C.	1
C1c	$m = D \times V$ $= 1 \times 200$ $= 200$ g $Q = mc\Delta\theta$ $= 0.2 \times 4200 \times (48-25)$ $= 19{,}320$ J	 1 1 1
C1d	Heat loss by metal block = Heat gained by water $mc\Delta\theta = 19320$ $0.6 \times c \times (100-48) = 19320$ $c = 619$ J/kg°C	 1 1
C1ei	The **particles at the water surface** which has **enough energy** to **overcome the downward attractive forces from the other particles** are able escape into the surroundings, leaving behind less energetic particles in the water.	1 1
C1eii	The **mass of the water would decrease due to evaporation,** hence the heat gained by the water will be lesser.	1

C2a **C2b**		3
C2c	Inverted	1
C2d(i)	The light is travelling along the normal	1
C2d(ii)	It is the angle of incidence in the optically denser medium such that the angle of refraction in the optically less dense medium is 90°	1
C2d(iii)	n = speed of light in air / speed of light in glass = $2.99 \times 10^8 / 1.98 \times 10^8$ = 1.51 c = $\sin^{-1}(1/n)$ = $\sin^{-1}(1/1.51)$ = 41.5°	1 1
C2e	As the light enters the glass mirror, **some light would be weakly reflected at the glass surface** and most of the light would refract through the glass, reflect at the reflecting surface and then refract out of the glass. The **weak reflected ray would cause the eye to see a faint image** which would interfere with the actual image.	1 1
C3ai	Apparatus drawn : light source, microscope, glass box, smoke	2
C3aii	The smoke moves in a constant and random motion.	1
C3aiii	The smoke particle is being **bombarded unevenly by the air particles at different speeds.** This is because the **air particles are in a constant and random motion.**	1 1
C3bi	Ultra violet and infra red	1
C3bii	Efficiency = $(1.8 \times 10^6 / 3 \times 10^6) \times 100$ = 60 %	1

C3biii	$f = v / \lambda$ $= 3 \times 10^8 / 700 \times 10^{-9}$ $= 4.29 \times 10^{14}$ Hz $f = v / \lambda$ $= 3 \times 10^8 / 400 \times 10^{-9}$ $= 7.5 \times 10^{14}$ Hz The glass should absorb frequency **higher than 7.5×10^{14} Hz**.	 1 1
C4a	Pulling force (acting to the right) Tension force (acting along string, away from sphere) Gravitational force (acting downwards)	1
C4b	The sphere begins to move due to the **resultant force** from the tension and gravitational force. The sphere continues to move past point A as it has **kinetic energy**.	1 1
C4ci	WD = increase GPE = m x g x h = 0.4 x 10 x 0.04 = 0.16 J	 1 1
C4cii	Moment = F x d = 0.4 x 10 x 0.1 = 0.4 Nm	 1 1
C4d	**All** the kinetic energy of the sphere has been converted to heat and sound energy as it swings.	1
C4e	The second method reduces the **human reaction error** as the error is **shared out among the 20 oscillations**.	2