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Take $g = 10\ m/s^2$ for all relevant questions.

1 A pair of vernier calipers is used to measure the thickness of a dictionary. Fig. 1.1 shows the reading when the outside jaws closed without the dictionary. Fig. 1.2 shows the reading when the dictionary is held between the outside jaws.

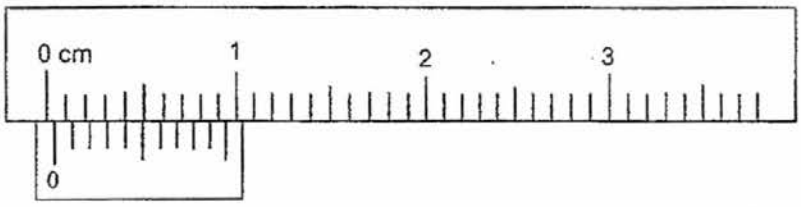

Fig. 1.1

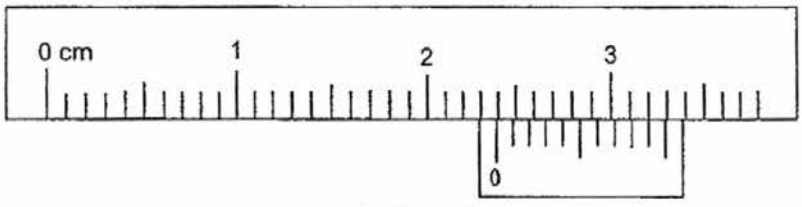

Fig. 1.2

What is the actual thickness of the dictionary?

A 2.18 cm
B 2.25 cm
C 2.28 cm
D 2.35 cm

2 Fig. 2.1 shows the reading on a micrometer screw gauge when the anvil and spindle are fully closed. Fig. 2.2 shows the reading when measuring the thickness of a coin.

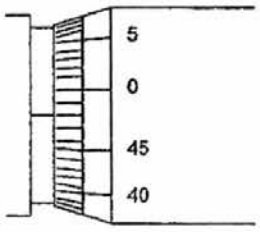

Fig. 2.1

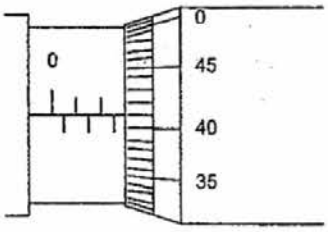

Fig. 2.2

What is the thickness of the coin?

A 2.89 mm
B 2.93 mm
C 5.41 mm
D 5.43 mm

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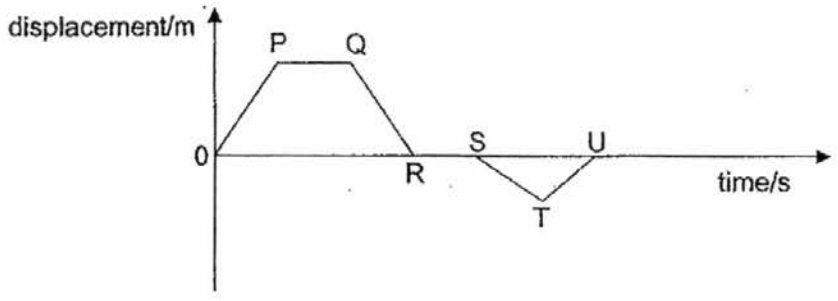
3 The graph below shows how the displacement of an object varies with time.



Which of the following statements about the motion of the object is **correct**?

A The object is travelling with constant velocity during the interval PQ.
B The object is moving away from its starting point during the interval QR.
C The object is travelling with constant velocity during the interval ST.
D The object has constant acceleration during the interval TU.

4 A gravitational field is

A a region is which a mass experiences a gravitational force.
B a gravitational force which is exerted on a mass.
C a force which acts against gravity.
D a region in which a mass experiences inertia which affects its state of rest or motion.

5 A parachutist falling vertically opens his parachute. Immediately after opening his parachute, he decelerates uniformly for a short interval of time. Which of the following statements correctly describes what happens during this short interval?

A His weight is lesser than the air resistance force opposing his motion.
B As he decelerates, the air resistance opposing his motion increases.
C His weight is greater than the air resistance force opposing his motion.
D As he decelerates, the air resistance opposing his motion remains equal in magnitude to his weight.

6 A rover sent to the planet Mars has a weight of 532 N on Mars where the gravitational field strength is 3.8 N/kg. What is the weight of the rover on earth if the gravitational field strength of the earth is 10 N/kg?

A 53 N
B 140 N
C 200 N
D 1400 N

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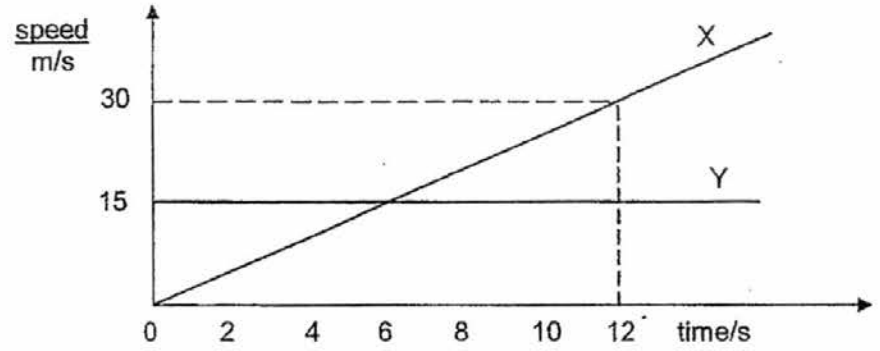
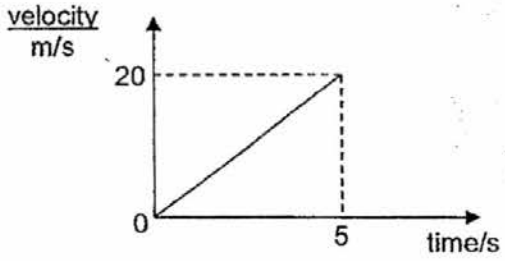
7 Two motorcycles X and Y start from the same point on a level road at different speeds, as shown in the graph below. The motorcycles travel in a straight line.



What is the time that the two motorcycles meet?

A 4 s
B 6 s
C 8 s
D 12 s

8 The diagram below shows the velocity-time graph of a 1500 kg car that moves off from rest from a traffic junction.



What is the total frictional force acting against the car in the first 2 s if the forward engine force of the car is 6500 N?

A 60 N
B 500 N
C 6000 N
D 12500 N

9 A brass ring is used to imitate a real gold ring. It has a composition of 12 g of copper and 4 g of zinc. If the density of copper is 9.0 g/cm^3 and the density of zinc is 7.1 g/cm^3, what is the density of the ring?

A 6.5 g/cm^3
B 8.1 g/cm^3
C 8.6 g/cm^3
D 17 g/cm^3

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10 The table shows the result of an experiment in which a solid object is placed in four different liquids. The solid object does not dissolve in the liquids.

liquid	density of liquid / kgm^{-3}	observation
mercury	13600	floats
water	1000	floats
kerosene	810	sinks
organic compound	450	sinks

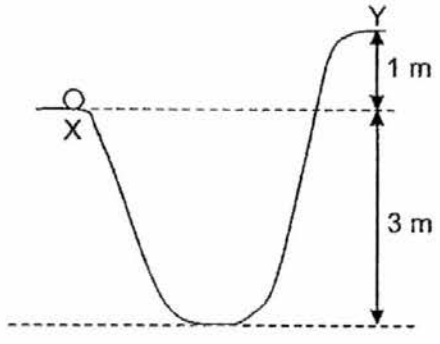
What is the density of the solid object?

A Between 1000 kg/m^3 and 13600 kg/m^3
B Between 810 kg/m^3 and 1000 kg/m^3
C Exactly 1000 kg/m^3
D Exactly 810 kg/m^3

11 Two constant forces of magnitude 3.0 N and 9.0 N act on a body at rest. Which of the following forces cannot be the resultant force of these two forces?

A 5.1 N **B** 7.5 N
C 9.9 N **D** 11 N

12 The diagram below shows a marble of mass 25 g at the top of a slope at point X. Assume that friction is negligible. Gravitational field strength is 10 N/kg.



What is the amount of kinetic energy that must be given to the marble such that it can reach point Y?

A 0.10 J **B** 0.25 J
C 0.75 J **D** 1.0 J

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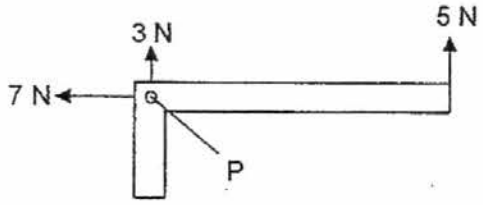
13 The diagram shows three forces acting on an L-shaped uniform metal bar pivoted at P.



Assuming the weight of the bar is negligible, the bar will

A turn anti-clockwise.
B remain in equilibrium.
C turn clockwise.
D turn clockwise followed by anti-clockwise.

14 The diagram below shows a tightrope walker carrying a long pole.

Why does he carry the long pole?

A To raise his centre of gravity to make him more stable.
B To allow him to keep his centre of gravity over the rope.
C So that his contact with the rope is greater, preventing him from toppling over.
D To increase the frictional force between him and the rope.

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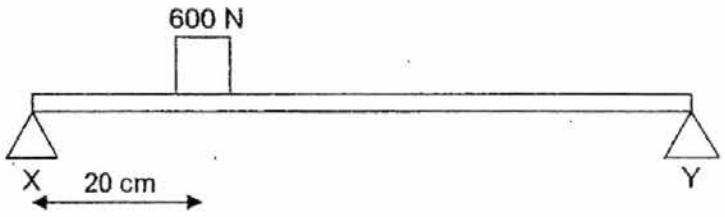
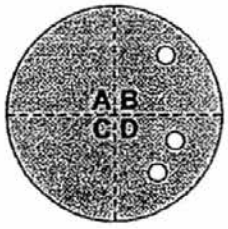
15 An object of weight 600 N is placed on a uniform, rigid, horizontal plank supported at points X and Y as shown below. The plank weighs 900 N and is 1.2 m long.



What is the force exerted on the plank by support X?

A 150 N
B 450 N
C 950 N
D 1100 N

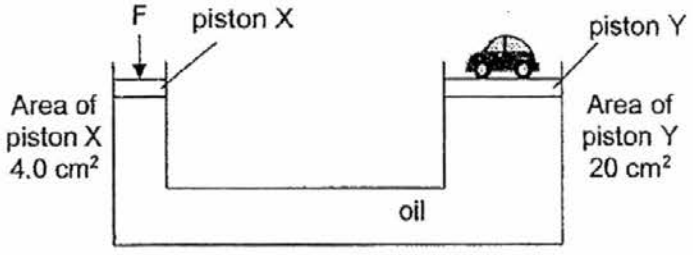
16 The diagram shows a plane circular lamina with three equal-sized holes drilled in it. In which quadrant is the center of gravity most likely to be?



17 A car moves at a constant speed of 18 m/s on a road. The frictional force opposing the car's motion is 150 N. What is the power developed by the engine of the car?

A 8.3 W
B 130 W
C 160 W
D 2700 W

18 The diagram shows a simple hydraulic jack used to lift a car of mass 2000 kg. Gravitational field strength is 10 N/kg.



What is the force F required to lift the car?

A 1000 N
B 2000 N
C 4000 N
D 8000 N

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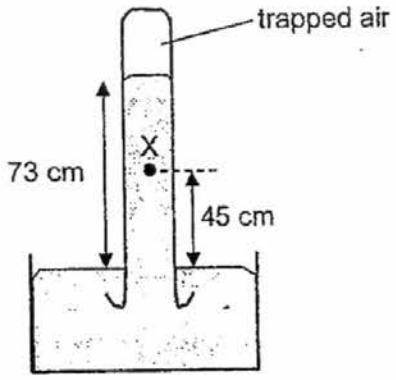
19 The diagram below shows a faulty mercury barometer that has some air trapped at the top. The atmospheric pressure is 76 cmHg. What is the pressure at point X?



A 28 cmHg
B 31 cmHg
C 73 cmHg
D 79 cmHg

20 The diagram shows a man lying flat across the thin ice and crawling to rescue his dog that has fallen into the icy water.

Why does the man lie down on the ice as he crawls across it?

A To lower his centre of gravity to make him more stable.
B To increase the rate of conduction of heat away from him.
C So that the line of action of his weight is within his base area.
D To reduce his pressure exerted on the ice.

21 Which of the following is **not** a suitable thermometric property?

A Weight of a fixed mass of solid at constant pressure
B Volume of a fixed mass of liquid
C Electrical resistance of a piece of metal
D Pressure of a fixed mass of gas at constant volume

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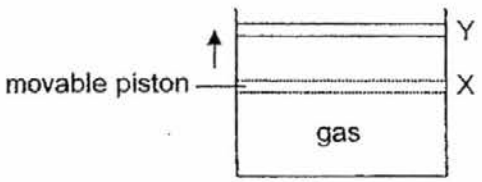
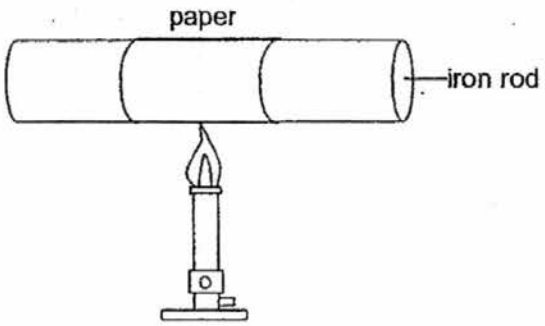
22 The diagram shows a gas enclosed in a container with a movable piston. The weight of the piston is negligible. Homer notices that when the gas is heated, the piston moves from X to Y.



Which of the following statements about Homer's observation is correct?

A The average distance between the gas molecules remains constant.
B The average kinetic energy of the gas molecules remains constant.
C The pressure of the gas remains constant.
D The average size of the gas molecules has increased.

23 The diagram shows a piece of paper wrapped around an iron rod and placed above a luminous Bunsen flame. Bart notices that the paper does not catch fire although it is placed above the flame for some time.



Which of the following statement best describes why the paper does not catch fire?

A The paper radiates thermal energy away.
B The iron rod conducts thermal energy away from the paper.
C Convection currents in the air carry thermal energy away from the paper.
D Air at high pressure near the paper moves towards the low pressure air around the rod, carrying thermal energy away.

24 A liquid is heated and its temperature rises. Which of the following statements about the particles of the liquid is correct?

A The kinetic energy and internal energy of the liquid particles remain constant.
B The kinetic energy of the liquid particles remains constant but the internal energy of the liquid particles increases.
C The kinetic energy of the liquid particles increases but the internal energy of the liquid particles remains constant.
D The kinetic energy and internal energy of the liquid particles increase.

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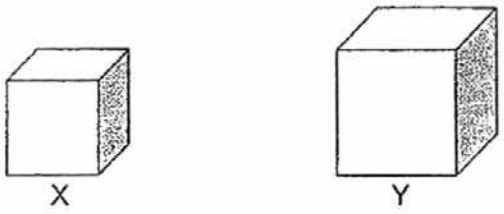
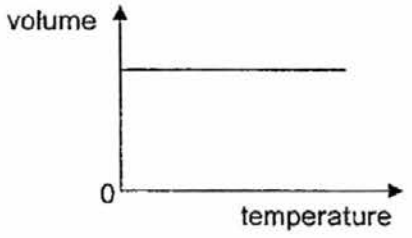
25 The diagram shows two cubes made of the same material but of different masses. Cube Y has twice the mass of cube X.



Which of the following statements is correct?

A Both cubes have the same heat capacities.
B Cube X has a larger heat capacity than cube Y.
C Cube Y has a larger specific heat capacity than cube X.
D Both cubes have the same specific heat capacities.

26 The graph below shows how the volume of gas in a container varies with temperature.



Which of the following statements correctly describes the gas?

A The pressure of the gas is decreasing.
B The pressure of the gas remains constant.
C The pressure of the gas is increasing.
D The pressure of the gas remains constant for a while and then decreases.

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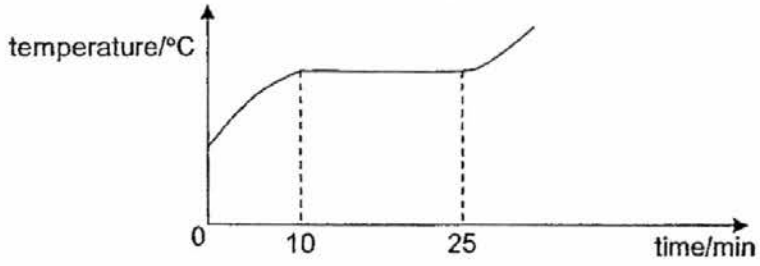
27 A man stands beside a small fire to warm his legs and hands.

How does **most** of the thermal energy reach his legs and hands?

	Legs	Hands
A	radiation	convection
B	convection	radiation
C	conduction	radiation
D	radiation	radiation

28 The graph shows how the temperature of a solid X of mass 400 g varies as it is heated by a heater of power 200 W.



What is the specific latent heat of fusion of X?

A 5000 J/kg
B 12500 J/kg
C 300000 J/kg
D 450000 J/kg

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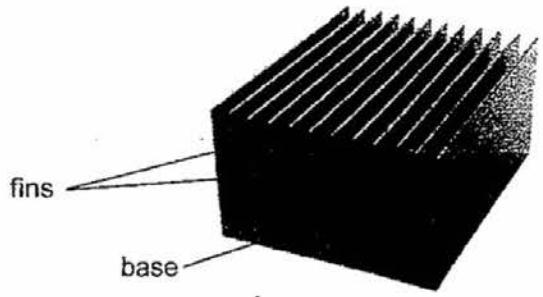
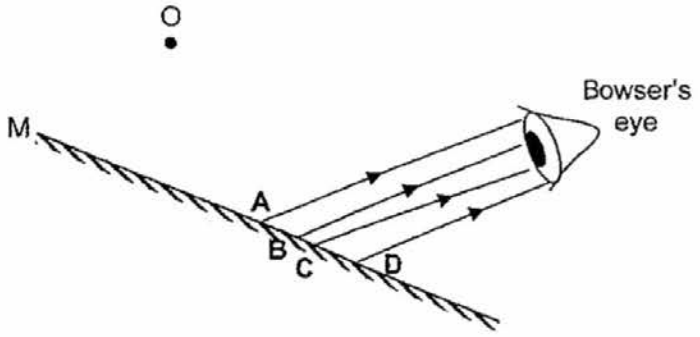
29 The diagram shows a heat sink that is used to cool hot components in a computer. The sink is attached by its base to the components and consists of protruding fins.



What is the purpose of the fins?

A To allow more thermal energy to be conducted from the base.
B To increase the surface area and rate of radiation of thermal energy.
C To increase the surface area so that more thermal energy can be absorbed from the surrounding air.
D To allow more thermal energy to be conducted from the surrounding air to the surface of the fins.

30 The diagram shows an object O placed in front of a plane mirror M. Bowser sees the image of O in the mirror M. Which of the reflected rays drawn is correct?



End of Paper

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SECTION A

For Examiner's Use

Answer **ALL** the questions in this section.

1 A remote-controlled car starts from rest at t = 0 s and travels in a straight line. Fig. 1 shows the velocity-time graph for the car for the starting part of its journey.

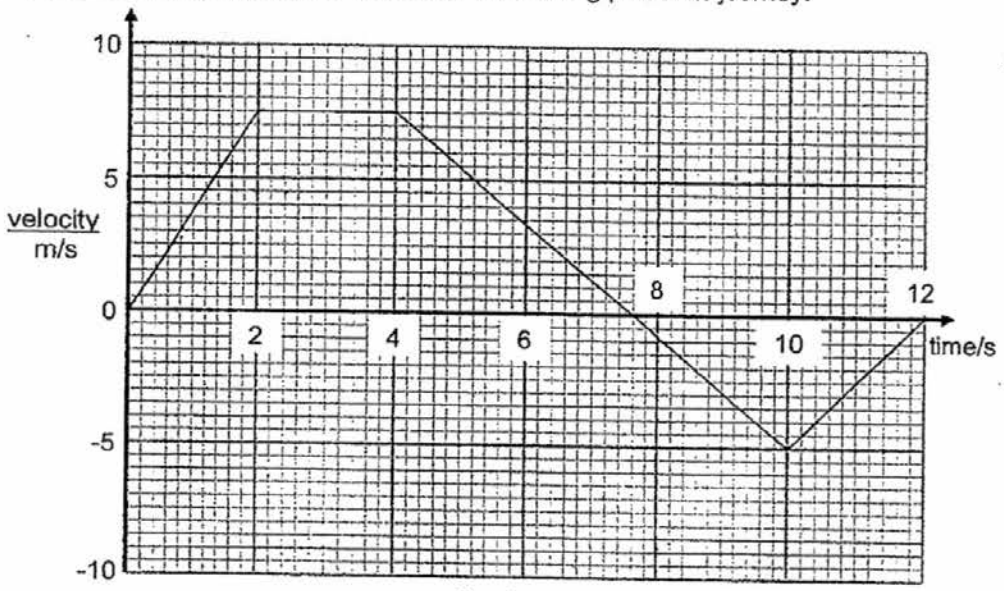

Fig. 1

(a) Define acceleration.

.....

[1]

(b) Calculate the acceleration of the car from t = 0 s to t = 2 s.

acceleration = ...

[2]

(c) Describe the motion of car from t = 4 s to t = 10 s, **stating all relevant values of velocity and time.**

.....

.....

.....

.....

.....

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[2]

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(d) Calculate the total displacement of the car from t = 0 s to t = 12 s.

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total displacement = ... [2]

2 Fig. 2 shows a man pushing two boxes X and Y across a rough floor by exerting an 8.0 N constant horizontal force on box X.

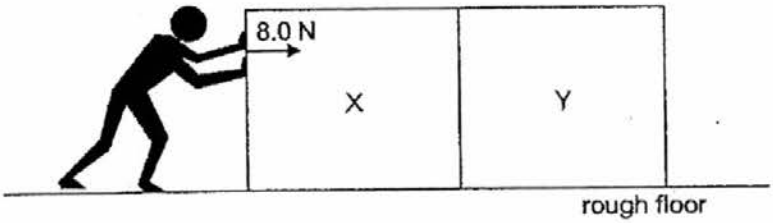

Fig. 2

Box X has a mass of 1.8 kg and box Y has a mass of 0.60 kg. The boxes accelerate uniformly along the rough floor. The frictional force acting on box X is 2.0 N and the frictional force acting on box Y is 1.2 N.

(a) In the space below, draw the free body diagrams for both box X and box Y, showing only the **horizontal** forces. [2]

(b) Calculate the acceleration of the boxes.

acceleration = ... [2]

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(c) Determine the force that box Y exerts box X.

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force = ... [2]

3 Fig. 3 shows a 5.0 kg block at rest on an incline at X. A constant force of 50 N is used to push the block 6.0 m up the incline and it reaches the top at Y with a speed of 2.5 m/s. Point Y is 4.0 m vertically above point X. Gravitational field strength is 10 N/kg.

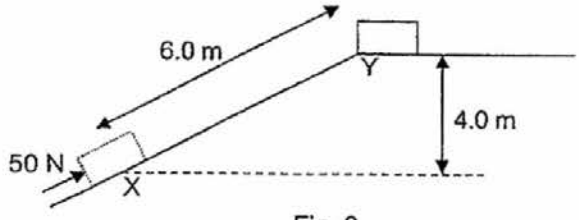

Fig. 3

(a) Calculate the total work done by the 50 N force.

work done = ... [1]

(b) Calculate the gain in kinetic energy of the block from X to Y.

gain in kinetic energy = ... [2]

(c) Calculate the gain in gravitational potential energy of the block from X to Y.

gain in gravitational potential energy = ... [2]

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(d) Calculate the frictional force opposing the motion of the block, assuming it is constant.

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frictional force = ... [2]

4 Fig. 4 shows a mercury manometer used to measure the gas pressure of a gas container. The density of mercury is 13600 kg/m^3, gravitational field strength is 10 N/kg and atmospheric pressure is 1 x 10^5 Pa.

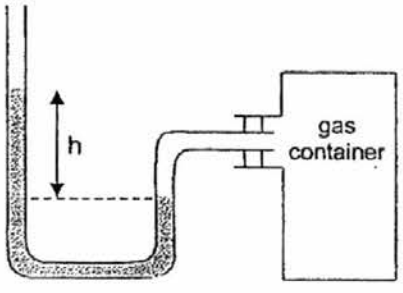

Fig. 4

(a) The pressure of the gas container is 140000 Pa.
Determine h.

h = ... [2]

(b) Describe and explain, using the Kinetic Model of Matter, the change to h, if any, when the gas in the container is heated.

.....

.....

.....

.....

..... [3]

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5 Fig. 5 shows a retort stand with a mass holder held at the clamp. The centre of gravity of the stand is at X.

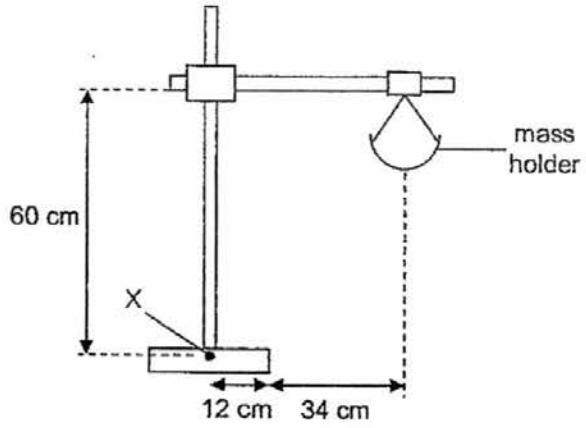

Fig. 5

(a) State the Principle of Moments.

.....

.....

..... [1]

(b) Mario notices that the retort stand is about to topple when the mass added is 600 g. Calculate the mass of the retort stand.

mass = ... [2]

(c) State one assumption that was made when answering part (b).

..... [1]

(d) Luigi suggests lowering the mass holder so that the retort stand is able to hold more than 600 g in the holder. Explain why this will not work.

.....

.....

..... [1]

(e) State two methods that the student can use to allow the retort stand to hold more mass in the holder without toppling over.

.....

.....

[2]

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6 Rosalina observed the motion of pollen particles suspended in water through a microscope. Fig. 6 shows her observation of one pollen particle.

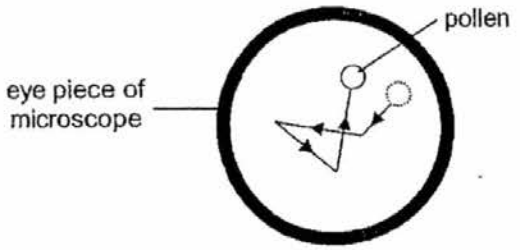

Fig. 6

(a) Rosalina observed one pollen particle and noticed that it moved continuously and randomly. Explain why the particles move about in such a manner.

.....

.....

..... [2]

(b) State what Rosalina would observe if the pollen particles were larger.

..... [1]

7 When one junction of a thermocouple is removed from melting ice and placed in steam above boiling water, the voltage reading of the thermocouple changes from 0.24 mV to 3.33 mV.

(a) Explain why the thermocouple must be placed **above** the boiling water, and not **in** the boiling water.

..... [1]

(b) Determine the voltage reading of the thermocouple when it is placed in a liquid of temperature 58°C.

voltage = ... [2]

(c) Thermocouples are known to have low heat capacities.

(i) Define *heat capacity* of a substance.

.....

..... [1]

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(ii) Explain how this is an advantage in the use of thermocouples as thermometers.

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.....

.....

..... [1]

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For Examiner's Use

SECTION B

Answer **ALL** the questions in this section.

8 A 550 g copper block is heated to a temperature of 100 °C. The copper block is then immediately transferred to a polystyrene cup containing water at a room temperature of 26°C as shown in Fig. 8.1 below.

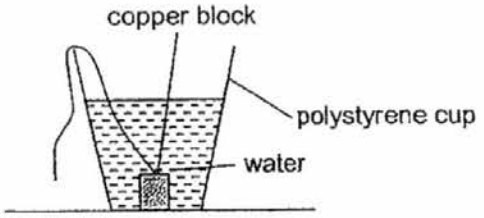

Fig. 8.1

Readings of the water temperature are taken at intervals of 10 s immediately after the copper block is lowered into the water. The mass of water in the cup is 130 g. Fig. 8.2 shows the graph of the variation of the temperature of water in the cup against time. The specific heat capacity of water is 4200 J/(kg°C).

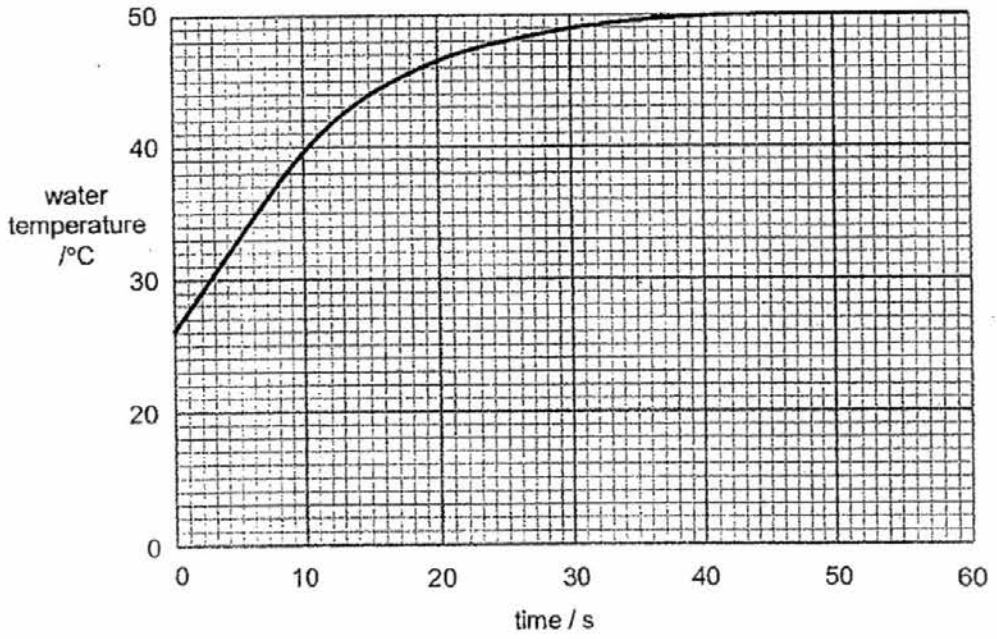

Fig. 8.2

(a) Explain, in terms of heat transfer, why the water temperature remains constant after 50 s.

.....

..... [1]

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(b) Explain why polystyrene is chosen as the material for the cup.

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..... [2]

(c) Describe how heat is transferred in the water as the water is heated up by the copper block.

.....

.....

.....

.....

..... [2]

(d) Calculate the heat gained by the water in the cup.

heat gained by water = ... [2]

(e) Hence, calculate the specific heat capacity of the copper block, assuming that the initial temperature of the copper block was 100 °C.

heat capacity of copper = ... [2]

(f) State one assumption in your calculations in part (e).

.....

..... [1]

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9 Fig. 9 shows a ray of light entering a transparent prism ABCD at X, totally internally reflected at Y and then travelling along side CD after being incident at Z.

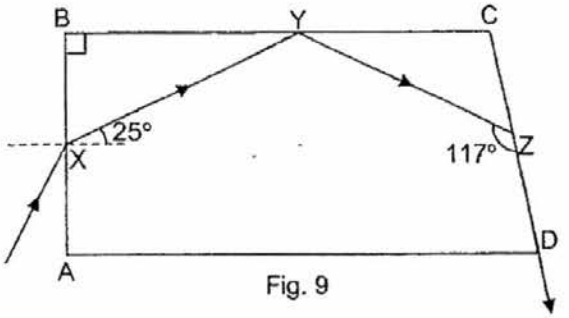

Fig. 9

(a) Define *critical angle*. [1]

.....

.....

(b) Determine the critical angle of the prism.

critical angle = ... [1]

(c) Hence, calculate the refractive index of the prism.

refractive index = ... [2]

(d) Calculate the angle of incidence of the light ray at X.

angle of incidence = ... [2]

(e) Determine the speed of the light ray through the prism.

speed = ... [2]

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(f) State the two conditions for the light ray to be totally internally reflected at Y.

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..... [2]

10 Fig. 10 shows an air bubble 55 m below the surface of a lake.

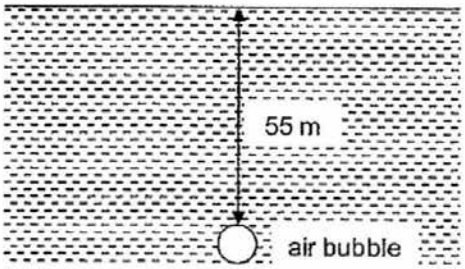

Fig. 10

The atmospheric pressure is 74 cmHg, density of the lake water is 1050 kg/m^3, the density of mercury is 13500 kg/m^3 and the gravitational field strength is 10 N/kg.

(a) Calculate the atmospheric pressure in Pa.

atmospheric pressure = ... [2]

(b) Calculate the pressure exerted on the air bubble when it is 55 m below the surface of the lake.

pressure = ... [2]

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(c) The bubble then rises to the surface of the lake and remains there. Describe and explain the change, if any, to the **pressure exerted by the water** on the air bubble as it rises.

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.....

.....

.....

..... [2]

(d) The volume of the air bubble increases and the **air pressure inside** the bubble decreases as it rises up the lake.
Explain, in terms of the kinetic model of matter, why the air pressure inside the bubble decreases as the volume of the bubble increases. Assume the temperature of the lake water is constant throughout.

.....

.....

.....

..... [2]

(e) The volume of the air bubble 55 m below the surface of the lake is 0.50 cm^3. Calculate the volume of the air bubble at the surface of the lake.

volume = ... [2]

End of Paper

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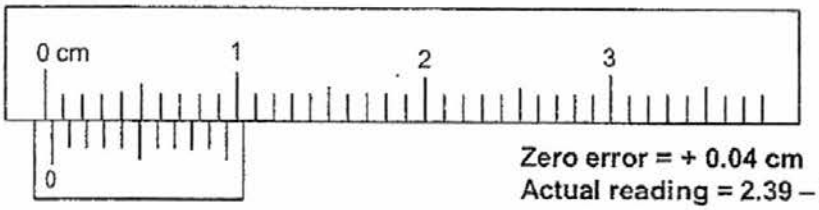
Take $g = 10\ m/s^2$ for all relevant questions.

1 A pair of vernier calipers is used to measure the thickness of a dictionary. Fig. 1.1 shows the reading when the outside jaws closed without the dictionary. Fig. 1.2 shows the reading when the dictionary is held between the outside jaws.



Zero error = + 0.04 cm
Actual reading = 2.39 – (+0.04) = 2.35 cm

Fig. 1.1

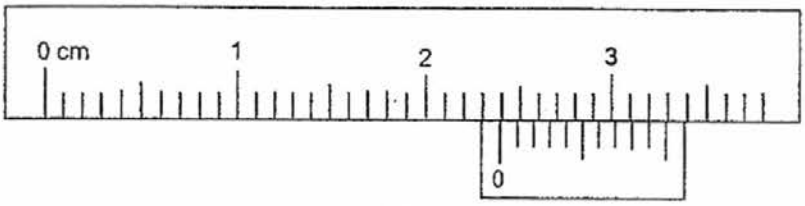


Fig. 1.2

What is the actual thickness of the dictionary?

A 2.18 cm
B 2.25 cm
C 2.28 cm
D 2.35 cm

2 Fig. 2.1 shows the reading on a micrometer screw gauge when the anvil and spindle are fully closed. Fig. 2.2 shows the reading when measuring the thickness of a coin.

Thickness = 2.91 – (-0.02) = 2.93 mm

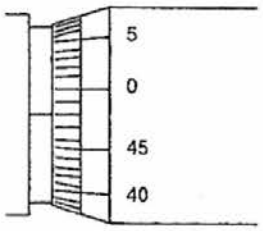


Fig. 2.1

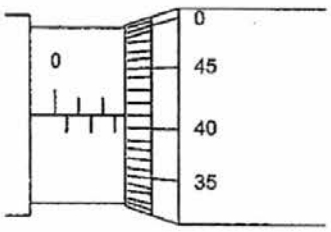


Fig. 2.2

What is the thickness of the coin?

A 2.89 mm
B 2.93 mm
C 5.41 mm
D 5.43 mm

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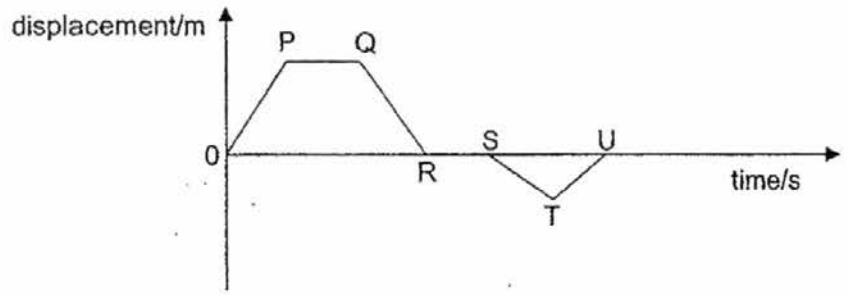
3 The graph below shows how the displacement of an object varies with time.



Which of the following statements about the motion of the object is **correct**?

A The object is travelling with constant velocity during the interval PQ.
B The object is moving away from its starting point during the interval QR.
C The object is travelling with constant velocity during the interval ST.
D The object has constant acceleration during the interval TU.

4 A gravitational field is

A a region in which a mass experiences a gravitational force.
B a gravitational force which is exerted on a mass.
C a force which acts against gravity.
D a region in which a mass experiences inertia which affects its state of rest or motion.

5 A parachutist falling vertically opens his parachute. Immediately after opening his parachute, he decelerates uniformly for a short interval of time. Which of the following statements correctly describes what happens during this short interval?

A His weight is lesser than the air resistance force opposing his motion.
B As he decelerates, the air resistance opposing his motion increases.
C His weight is greater than the air resistance force opposing his motion.
D As he decelerates, the air resistance opposing his motion remains equal in magnitude to his weight.

6 A rover sent to the planet Mars has a weight of 532 N on Mars where the gravitational field strength is 3.8 N/kg. What is the weight of the rover on earth if the gravitational field strength of the earth is 10 N/kg?

A 53 N
B 140 N
C 200 N
D 1400 N

W = mg
532 = m x 3.8
m = 140 kg
W = mg
W = 140 x 10 = 1400 N

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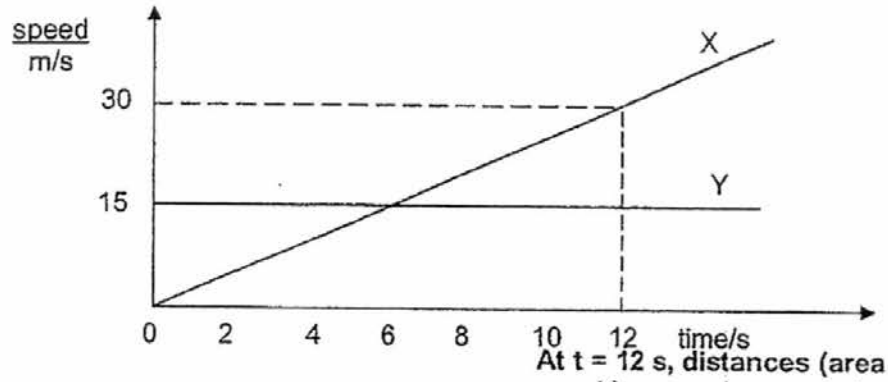
7 Two motorcycles X and Y start from the same point on a level road at different speeds, as shown in the graph below. The motorcycles travel in a straight line.



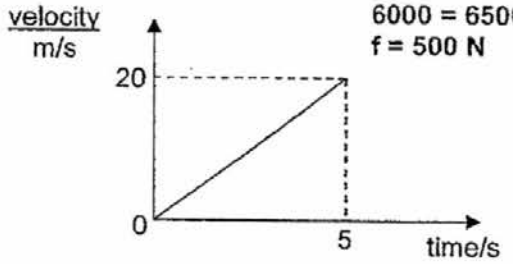
At t = 12 s, distances (area under graph) covered are equal.

What is the time that the two motorcycles meet?

A 4 s
B 6 s
C 8 s
D 12 s

8 The diagram below shows the velocity-time graph of a 1500 kg car that moves off from rest from a traffic junction.

F = ma = 1500 x 20/5 = 6000 N
6000 = 6500 – f
f = 500 N



What is the total frictional force acting against the car in the first 2 s if the forward engine force of the car is 6500 N?

A 60 N
B 500 N
C 6000 N
D 12500 N

9 A brass ring is used to imitate a real gold ring. It has a composition of 12 g of copper and 4 g of zinc. If the density of copper is 9.0 g/cm^3 and the density of zinc is 7.1 g/cm^3, what is the density of the ring?

volume of copper = 12/9 = 1.3 cm^3
volume of zinc = 4/7.1 = 0.56
density = 16/(1.3 + 0.56) = 8.6 g/cm^3

A 6.5 g/cm^3
B 8.1 g/cm^3
C 8.6 g/cm^3
D 17 g/cm^3

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10 The table shows the result of an experiment in which a solid object is placed in four different liquids. The solid object does not dissolve in the liquids.

liquid	density of liquid / kgm^{-3}	observation
mercury	13600	floats
water	1000	floats
kerosene	810	sinks
organic compound	450	sinks

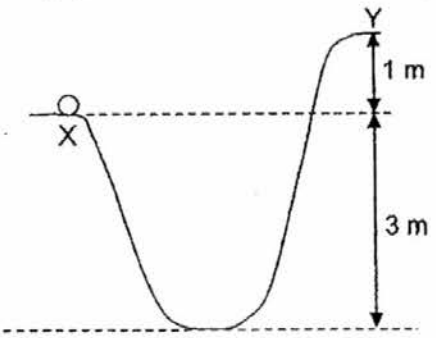
What is the density of the solid object?

A Between 1000 kg/m^3 and 13600 kg/m^3
B Between 810 kg/m^3 and 1000 kg/m^3
C Exactly 1000 kg/m^3
D Exactly 810 kg/m^3

11 Two constant forces of magnitude 3.0 N and 9.0 N act on a body at rest. Which of the following forces cannot be the resultant force of these two forces?

A 5.1 N
B 7.5 N
C 9.9 N
D 11 N

12 The diagram below shows a marble of mass 25 g at the top of a slope at point X. Assume that friction is negligible. Gravitational field strength is 10 N/kg.



KE given = gain in GPE = 0.025 x 10 x 1 = 0.25 J

What is the amount of kinetic energy that must be given to the marble such that it can reach point Y?

A 0.10 J
B 0.25 J
C 0.75 J
D 1.0 J

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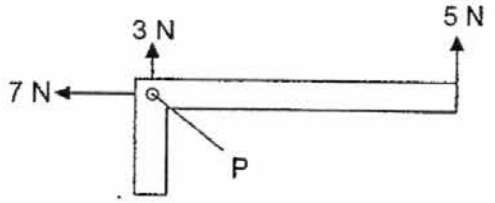
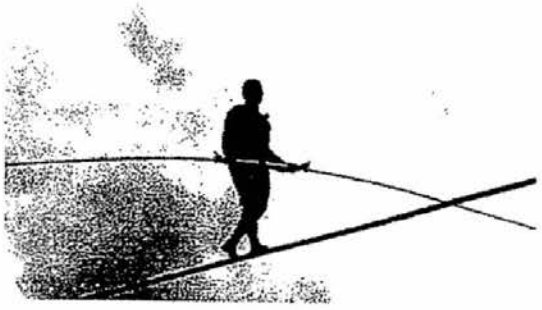
13 The diagram shows three forces acting on an L-shaped uniform metal bar pivotec at P.



Assuming the weight of the bar is negligible, the bar will

A turn anti-clockwise.
B remain in equilibrium.
C turn clockwise.
D turn clockwise followed by anti-clockwise.

14 The diagram below shows a tightrope walker carrying a long pole.



Why does he carry the long pole?

A To raise his centre of gravity to make him more stable.
B To allow him to keep his centre of gravity over the rope.
C So that his contact with the rope is greater, preventing him from toppling over.
D To increase the frictional force between him and the rope.

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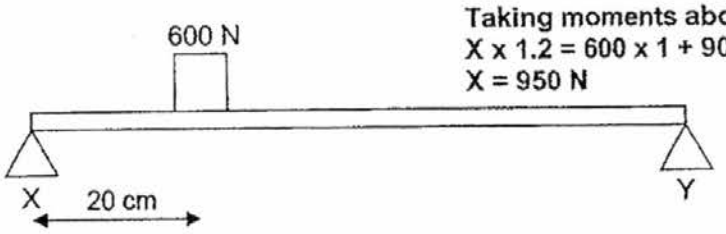
15 An object of weight 600 N is placed on a uniform, rigid, horizontal plank supported at points X and Y as shown below. The plank weighs 900 N and is 1.2 m long.

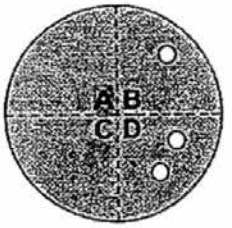


Taking moments about X,
X x 1.2 = 600 x 1 + 900 x 0.6
X = 950 N

What is the force exerted on the plank by support X?

A 150 N
B 450 N
C 950 N
D 1100 N

16 The diagram shows a plane circular lamina with three equal-sized holes drilled in it. In which quadrant is the center of gravity most likely to be?

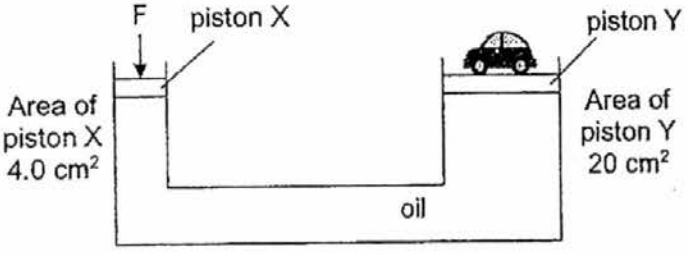


17 A car moves at a constant speed of 18 m/s on a road. The frictional force opposing the car's motion is 150 N. What is the power developed by the engine of the car?

A 8.3 W
B 130 W
C 160 W
D 2700 W

P = Wd/t
P = (f x d)/t = f x d/t = f x v
P = 150 x 18 = 2700 N

18 The diagram shows a simple hydraulic jack used to lift a car of mass 2000 kg. Gravitational field strength is 10 N/kg.



F/4 = 20000/20
F = 4000 N

What is the force F required to lift the car?

A 1000 N
B 2000 N
C 4000 N
D 8000 N

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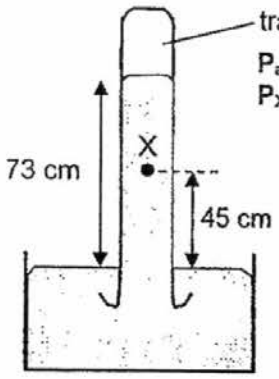
19 The diagram below shows a faulty mercury barometer that has some air trapped at the top. The atmospheric pressure is 76 cmHg. What is the pressure at point X?



A 28 cmHg
B 31 cmHg
C 73 cmHg
D 79 cmHg

20 The diagram shows a man lying flat across the thin ice and crawling to rescue his dog that has fallen into the icy water.

Why does the man lie down on the ice as he crawls across it?

A To lower his centre of gravity to make him more stable.
B To increase the rate of conduction of heat away from him.
C So that the line of action of his weight is within his base area.
D To reduce his pressure exerted on the ice.

21 Which of the following is **not** a suitable thermometric property?

A Weight of a fixed mass of solid at constant pressure
B Volume of a fixed mass of liquid
C Electrical resistance of a piece of metal
D Pressure of a fixed mass of gas at constant volume

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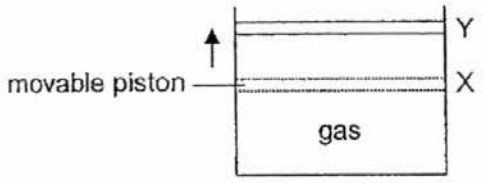
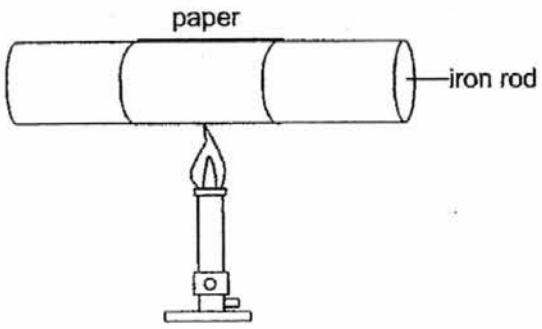
22 The diagram shows a gas enclosed in a container with a movable piston. The weight of the piston is negligible. Homer notices that when the gas is heated, the piston moves from X to Y.



Which of the following statements about Homer's observation is correct?

A The average distance between the gas molecules remains constant.
B The average kinetic energy of the gas molecules remains constant.
C The pressure of the gas remains constant.
D The average size of the gas molecules has increased.

23 The diagram shows a piece of paper wrapped around an iron rod and placed above a luminous Bunsen flame. Bart notices that the paper does not catch fire although it is placed above the flame for some time.



Which of the following statement best describes why the paper does not catch fire?

A The paper radiates thermal energy away.
B The iron rod conducts thermal energy away from the paper.
C Convection currents in the air carry thermal energy away from the paper.
D Air at high pressure near the paper moves towards the low pressure air around the rod, carrying thermal energy away.

24 A liquid is heated and its temperature rises. Which of the following statements about the particles of the liquid is correct?

A The kinetic energy and internal energy of the liquid particles remain constant.
B The kinetic energy of the liquid particles remains constant but the internal energy of the liquid particles increases.
C The kinetic energy of the liquid particles increases but the internal energy of the liquid particles remains constant.
D The kinetic energy and internal energy of the liquid particles increase.

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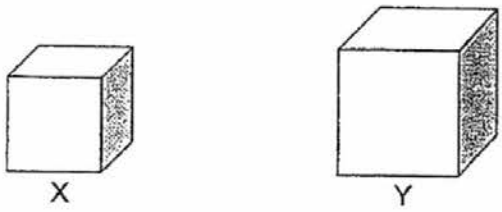
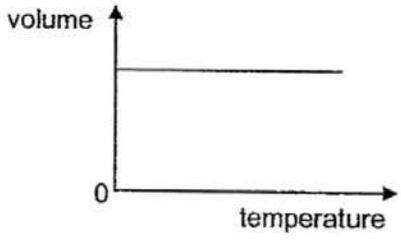
25 The diagram shows two cubes made of the same material but of different masses. Cube Y has twice the mass of cube X.



Which of the following statements is correct?

A Both cubes have the same heat capacities.
B Cube X has a larger heat capacity than cube Y.
C Cube Y has a larger specific heat capacity than cube X.
D Both cubes have the same specific heat capacities.

26 The graph below shows how the volume of gas in a container varies with temperature.



Which of the following statements correctly describes the gas?

A The pressure of the gas is decreasing.
B The pressure of the gas remains constant.
C The pressure of the gas is increasing.
D The pressure of the gas remains constant for a while and then decreases.

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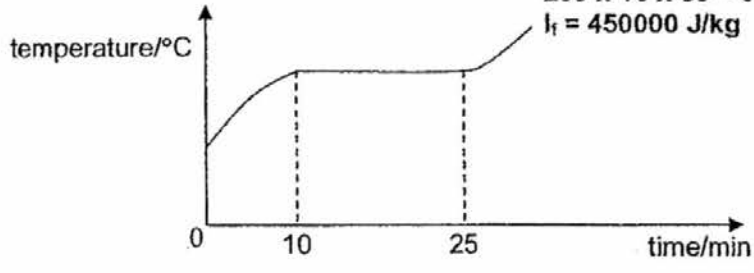
27 A man stands beside a small fire to warm his legs and hands.

How does **most** of the thermal energy reach his legs and hands?

	Legs	Hands
A	radiation	convection
B	convection	radiation
C	conduction	radiation
D	radiation	radiation

28 The graph shows how the temperature of a solid X of mass 400 g varies as it is heated by a heater of power 200 W.

$Q = Pt = ml_f$
$200 \times 15 \times 60 = 0.4 \times l_f$
$l_f = 450000$ J/kg



What is the specific latent heat of fusion of X?

A 5000 J/kg
B 12500 J/kg
C 300000 J/kg
D 450000 J/kg

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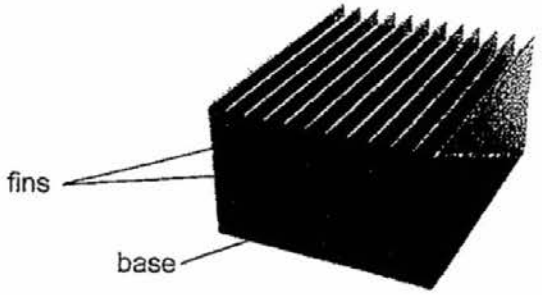
29 The diagram shows a heat sink that is used to cool hot components in a computer. The sink is attached by its base to the components and consists of protruding fins.



What is the purpose of the fins?

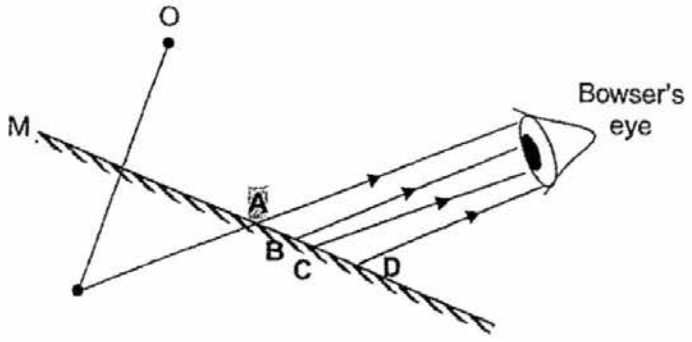
A To allow more thermal energy to be conducted from the base.

B To increase the surface area and rate of radiation of thermal energy.

C To increase the surface area so that more thermal energy can be absorbed from the surrounding air.

D To allow more thermal energy to be conducted from the surrounding air to the surface of the fins.

30 The diagram shows an object O placed in front of a plane mirror M. Bowser sees the image of O in the mirror M. Which of the reflected rays drawn is correct?



End of Paper

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SECTION A

For Examiner's Use

Answer **ALL** the questions in this section.

1 A remote-controlled car starts from rest at t = 0 s and travels in a straight line. Fig. 1 shows the velocity-time graph for the car for the starting part of its journey.

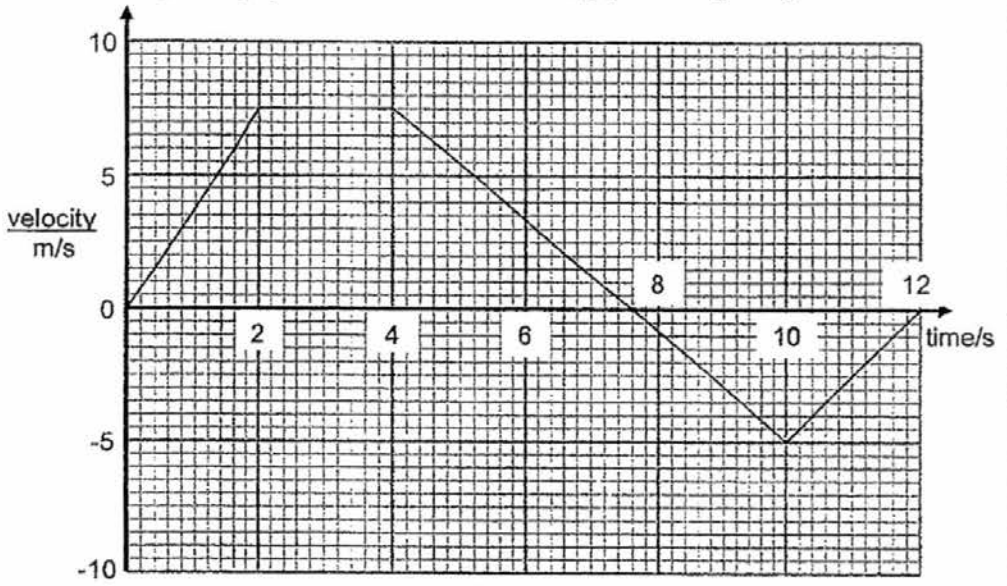

Fig. 1

(a) Define acceleration.

Rate of change of velocity/change of velocity per unit time. ..... [1]

(b) Calculate the acceleration of the car from t = 0 s to t = 2 s.

a = (v - u)/t
a = 7.5 / 2 [1]
a = 3.8 m/s² [1]

acceleration = ... [2]

(c) Describe the motion of car from t = 4 s to t = 10 s, **stating all relevant values of velocity and time.**

From t = 4 s to t = 5.6 s, the car decelerates uniformly from 7.5 m/s to rest. [1]
It then reverses direction and accelerates uniformly from rest to a velocity of 5 m/s [1].

.....

.....

.....

.....

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..... [2]

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(d) Calculate the total displacement of the car from t = 0 s to t = 12 s.

displacement 1 = 1/2 x 7.5 x (2 + 7.6) = 36 m } [1]
displacement 2 = - 1/2 x 5 x 4.4 = -11 m
Total displacement = 36 - 11 = 25 m [1]

total displacement = ... [2]

2 Fig. 2 shows a man pushing two boxes X and Y across a rough floor by exerting an 8.0 N constant horizontal force on box X.

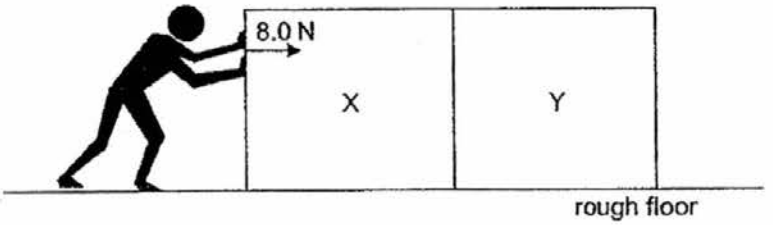
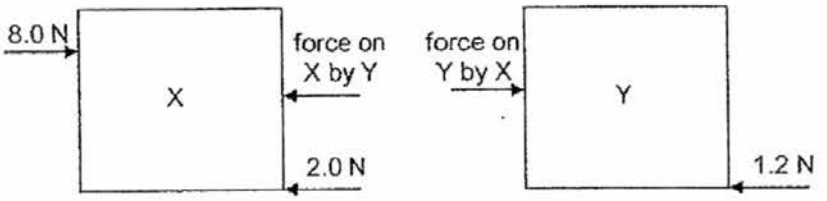


Fig. 2

Box X has a mass of 1.8 kg and box Y has a mass of 0.60 kg. The boxes accelerate uniformly along the rough floor. The frictional force acting on box X is 2.0 N and the frictional force acting on box Y is 1.2 N.

(a) In the space below, draw the free body diagrams for both box X and box Y, showing only the **horizontal** forces. [2]



(b) Calculate the acceleration of the boxes.

F = 8 – 2 – 1.2 = 4.8 N [1]
F = ma
4.8 = (1.8 + 0.6) x a
a = 2.0 m/s² [1]

acceleration = ... [2]

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(c) Determine the force that box Y exerts box X.

F = ma
F = 0.6 x 2 = 1.2 [1]
f – 1.2 = 1.2
f = 2.4 N

force = ... [2]

3 Fig. 3 shows a 5.0 kg block at rest on an incline at X. A constant force of 50 N is used to push the block 6.0 m up the incline and it reaches the top at Y with a speed of 2.5 m/s. Point Y is 4.0 m vertically above point X. Gravitational field strength is 10 N/kg.

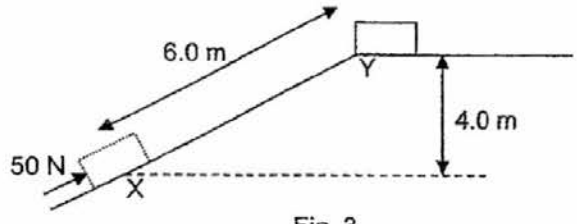

Fig. 3

(a) Calculate the total work done by the 50 N force.

Wd = f x d
Wd = 50 x 6 = 300 J

work done = ... [1]

(b) Calculate the gain in kinetic energy of the block from X to Y.

Gain in KE = ½ x m x v^2
= ½ x 5 x 2.5^2 [1]
= 16 J [1]

gain in kinetic energy = ... [2]

(c) Calculate the gain in gravitational potential energy of the block from X to Y.

Gain in GPE = mgh
= 5 x 10 x 4 [1]
= 200 J [1]

gain in gravitational potential energy = ... [2]

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(d) Calculate the frictional force opposing the motion of the block, assuming it is constant.

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Wd against friction = 300 – 200 – 16 = 84 J [1]
84 = f x 6
f = 14 N [1]

frictional force = ... [2]

4 Fig. 4 shows a mercury manometer used to measure the gas pressure of a gas container. The density of mercury is 13600 kg/m^3, gravitational field strength is 10 N/kg and atmospheric pressure is 1 x 10^5 Pa.

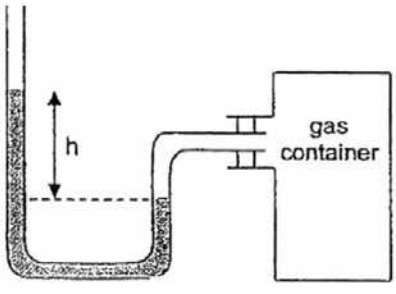

Fig. 4

(a) The pressure of the gas container is 140000 Pa.
Determine h.

100000 + P_L = 140000
P_L = 40000 Pa [1]
40000 = ρhg
40000 = 13600 x h x 10
h = 0.29 m [1]

h = ... [2]

(b) Describe and explain, using the Kinetic Model of Matter, the change to h, if any, when the gas in the container is heated.

h will increase [1]. The gas molecules will gain KE and move at greater speeds [1], colliding against the walls of the container more frequently and vigorously, exerting a greater force per unit area and pressure [1].

..... [3]

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5 Fig. 5 shows a retort stand with a mass holder held at the clamp. The centre of gravity of the stand is at X.

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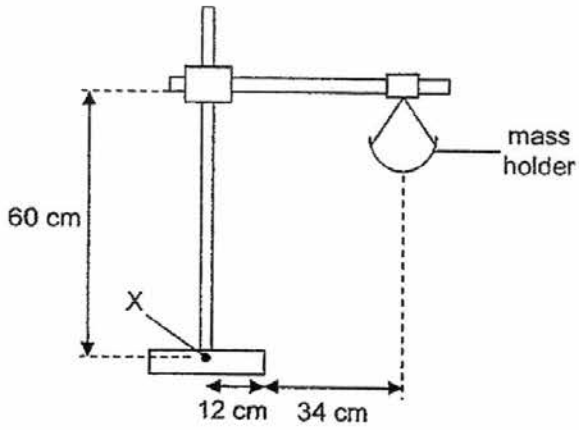

Fig. 5

(a) State the Principle of Moments.

For a body in equilibrium, the sum of the clockwise moments about a pivot is equal to the sum of the anticlockwise moments about the same pivot.

..... [1]

(b) Mario notices that the retort stand is about to topple when the mass added is 600 g. Calculate the mass of the retort stand.

acw = cw
m x g x 12 = 0.6 x g x 34 [1]
m = 1.7 kg [1]

mass = ... [2]

(c) State one assumption that was made when answering part **(b)**.

The mass of the mass holder is negligible/the weight of the mass is at the centre of the holder [1]

(d) Luigi suggests lowering the mass holder so that the retort stand is able to hold more than 600 g in the holder. Explain why this will not work.

The perpendicular distance from the line of action of the weight of the mass remains the same. Hence the clockwise moments is still the same.

..... [1]

(e) State two methods that the student can use to allow the retort stand to hold more mass in the holder without toppling over.

Adjust the mass holder nearer to X / increase the base area of the stand / add more weight to the base of the stand

..... [2]

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6 Rosalina observed the motion of pollen particles suspended in water through a microscope. Fig. 6 shows her observation of one pollen particle.

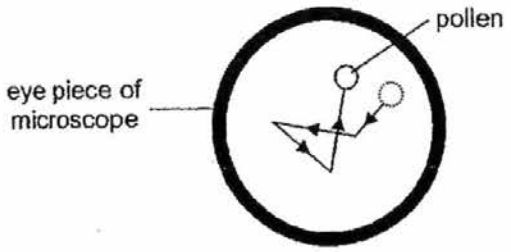

Fig. 6

(a) Rosalina observed one pollen particle and noticed that it moved continuously and randomly. Explain why the particles move about in such a manner.

The water molecules are moving continuously and randomly [1], and they are bombarding/colliding against the bigger pollen particles continuously and randomly [1].

..... [2]

(b) State what Rosalina would observe if the pollen particles were larger.

The pollen particles would move slower/appear to be less agitated. [1]

7 When one junction of a thermocouple is removed from melting ice and placed in steam above boiling water, the voltage reading of the thermocouple changes from 0.24 mV to 3.33 mV.

(a) Explain why the thermocouple must be placed **above** the boiling water, and not **in** the boiling water.

The temperature of the boiling water may not be 100°C at every point. [1]

(b) Determine the voltage reading of the thermocouple when it is placed in a liquid of temperature 58°C.

$\theta = (V_\theta - V_0)/(V_{100} - V_0)$
$58 = (V_\theta - 0.24)/(3.33 - 0.24) \times 100$ [1]
$V_\theta = 2.0$ mV [1]

voltage = ... [2]

(c) Thermocouples are known to have low heat capacities.

(i) Define *heat capacity* of a substance.

The amount of thermal energy required to change the temperature of the substance by 1 K.

..... [1]

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(ii) Explain how this is an advantage in the use of thermocouples as thermometers.

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A small change in thermal energy supplied to or removed from the thermocouple will cause a large change in temperature shown by the thermocouple, making it responsive OR it can detect small changes in temperature quickly.

[1]

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SECTION B

Answer **ALL** the questions in this section.

8 A 550 g copper block is heated to a temperature of 100 °C. The copper block is then immediately transferred to a polystyrene cup containing water at a room temperature of 26°C as shown in Fig. 8.1 below.

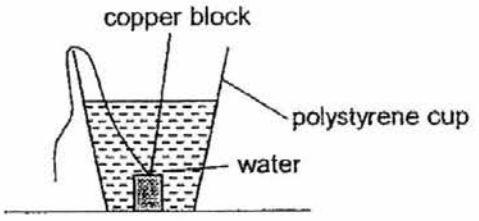

Fig. 8.1

Readings of the water temperature are taken at intervals of 10 s immediately after the copper block is lowered into the water. The mass of water in the cup is 130 g. Fig. 8.2 shows the graph of the variation of the temperature of water in the cup against time. The specific heat capacity of water is 4200 J/(kg°C).

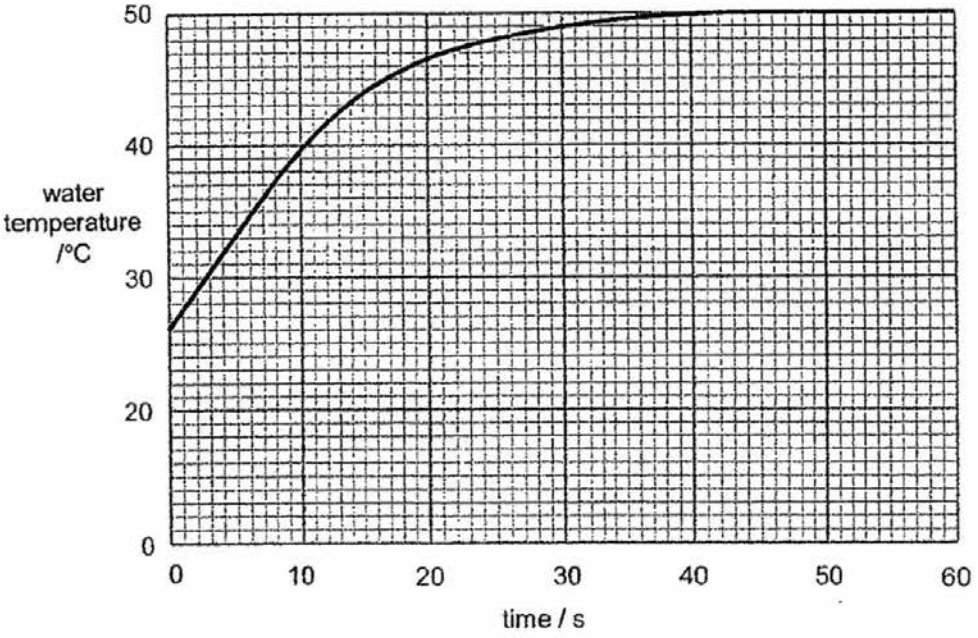

Fig. 8.2

(a) Explain, in terms of heat transfer, why the water temperature remains constant after 50 s.

There is no net gain or loss of heat energy by the water.

..... [1]

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(b) Explain why polystyrene is chosen as the material for the cup.

Polystyrene is a poor conductor of heat [1] and reduces the conduction of heat from the water to the surroundings [1].

[2]

(c) Describe how heat is transferred in the water as the water is heated up by the copper block.

The heated water at the bottom expands, becomes less dense and rises [1], while the cooler water at the top, being denser, sinks to replace it, forming convection currents [1].

[2]

(d) Calculate the heat gained by the water in the cup.

$Q = mc\Delta\theta$
$Q = 0.13 \times 4200 \times (50 - 26)$ [1]
$Q = 13000$ J [1]

heat gained by water = ... [2]

(e) Hence, calculate the specific heat capacity of the copper block, assuming that the initial temperature of the copper block was 100 °C.

$Q = mc\Delta\theta$
$13000 = 0.55 \times c \times (100 - 50)$ [1]
$c = 470$ J/(kg °C) [1]

heat capacity of copper = ... [2]

(f) State one assumption in your calculations in part (e).

There is no heat transfer from the water to the surroundings/no heat is gained by the polystyrene cup.

[1]

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9 Fig. 9 shows a ray of light entering a transparent prism ABCD at X, totally internally reflected at Y and then travelling along side CD after being incident at Z.

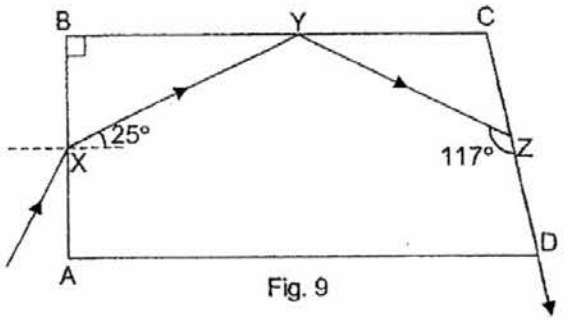

Fig. 9

(a) Define *critical angle*. [1]

The angle of incidence of the light ray in the optically denser medium which gives an angle of refraction of 90° in the optically less dense medium.

(b) Determine the critical angle of the prism.

c = 117° - 90° = 27°

critical angle = ... [1]

(c) Hence, calculate the refractive index of the prism.

n = 1/sin c
n = 1/sin 27° [1]
n = 2.2 [1]

refractive index = ... [2]

(d) Calculate the angle of incidence of the light ray at X.

n = sin i / sin r
2.2 = sin i / sin 25° [1]
i = 68° [1]

angle of incidence = ... [2]

(e) Determine the speed of the light ray through the prism.

n = c / v
2.2 = 3 x 10^8 / v [1]
v = 1.4 x 10^8 m/s [1]

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speed = ... [2]

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(f) State the two conditions for the light ray to be totally internally reflected at Y.

The light ray must be travelling from an optically denser medium towards an optically less dense medium [1].

The angle of incidence at Y must be greater than the critical angle of the material of the prism [1].

..... [2]

10 Fig. 10 shows an air bubble 55 m below the surface of a lake.

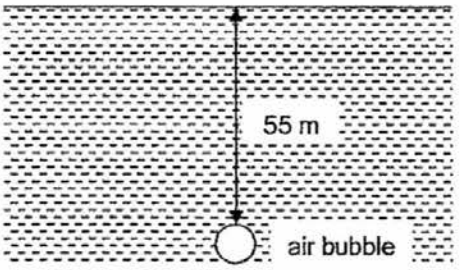

Fig. 10

The atmospheric pressure is 74 cmHg, density of the lake water is 1050 kg/m^3, the density of mercury is 13500 kg/m^3 and the gravitational field strength is 10 N/kg.

(a) Calculate the atmospheric pressure in Pa.

$P = \rho hg$
$P = 13500 \times 10 \times 0.74$ [1]
$P = 100000$ Pa [1]

[2]

atmospheric pressure = ...

(b) Calculate the pressure exerted on the air bubble when it is 55 m below the surface of the lake.

$P = 100000 + (1050 \times 55 \times 10)$ [1]
$P = 680000$ Pa [1]

pressure = ... [2]

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(c) The bubble then rises to the surface of the lake and remains there. Describe and explain the change, if any, to the **pressure exerted by the water** on the air bubble as it rises.

The pressure exerted by the water on the bubble decreases.[1]
As the bubble rises, the height of the water above the bubble decreases [1], causing the water pressure on the bubble to decreases too.

[2]

(d) The volume of the air bubble increases and the **air pressure inside** the bubble decreases as it rises up the lake.
Explain, in terms of the kinetic model of matter, why the air pressure inside the bubble decreases as the volume of the bubble increases. Assume the temperature of the lake water is constant throughout.

As the volume increases the number of air molecules per unit volume decreases, and the air molecules collide against the wall of the bubble less frequently [1], exerting lesser force per unit area.[1]

[2]

(e) The volume of the air bubble 55 m below the surface of the lake is 0.50 cm^3. Calculate the volume of the air bubble at the surface of the lake.

$P_1V_1 = P_2V_2$
$100000 \times V_1 = 680000 \times 0.50$ [1]
$V_1 = 3.4\ cm^3$ [1]

volume = ... [2]

End of Paper

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