$v = u + at$ $\quad s = vt - \frac{1}{2}at^2$

$v^2 = u^2 + 2as$ $\quad s = ut + \frac{1}{2}at^2$

$s = \frac{1}{2}(v+u)t$

Section A

Answer **all** questions.

1 A cruise ship departs from a jetty and sails 12.0 km due north in 8.0 minutes. It then changes direction and sails due east at a constant speed of 40.0 m s^{-1} for 10.0 minutes.

(a) Show that the average speed of the ship for the entire journey is 33 m s^{-1}.

~~12 km = 12 000 m~~

~~$\frac{12000}{60 \times 8} = 25 \text{ m s}^{-1}$~~

12 km = 12 000 m

$40 \times (10 \times 60) = 24\,000 \text{ m}$

$\frac{\text{total distance travelled}}{\text{total time taken}} = \frac{12\,000 + 24\,000}{8 \times 60 + 10 \times 60}$

$= 33.3 \text{ ms}^{-1}$ (3s.f.)

$= 33 \text{ ms}^{-1}$ (2s.f.) [3] 3

(b) **(i)** Fig. 1.1 shows the displacement of the ship in the northerly direction drawn to scale.

Scale: 1.0 cm represents 4000 m

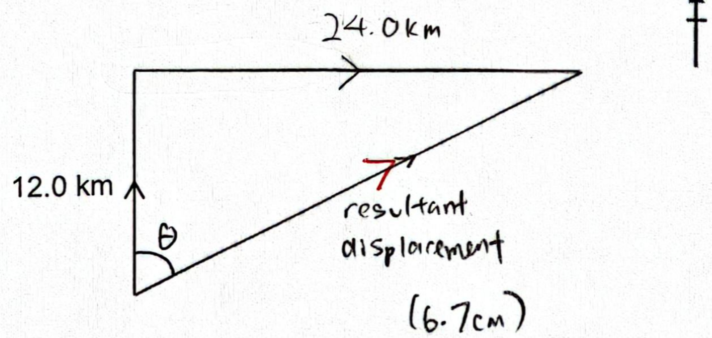

Fig. 1.1

On Fig. 1.1, complete the scale drawing to show the displacement in the easterly direction and the resultant displacement of the ship.

Use your drawing or otherwise, determine the magnitude of the resultant displacement and the angle between the resultant displacement and north.

resultant displacement $= 6.7 \times 4000$

$= 26800 \text{ m}$

$= 26.8 \text{ km}$

$\approx 27 \text{ km}$ (2s.f.)

$\tan\theta = \frac{24}{12}$

$\theta = \tan^{-1}(2)$

$= 63.4°$ (3s.f.)

$= 63°$ (2s.f.)

resultant displacement = 27 km (2s.f.)

angle = 63° [3] 2

(ii) Calculate the magnitude of the average velocity of the ship for the entire journey.

$$\text{average velocity} = \frac{\cancel{\text{average}}\ \text{displacement}}{\text{time}}$$

$$= \frac{26.8 \times 1000}{8\times 60 + 10\times 60} = 24.8 \text{ m/s } (3\text{s.f.}) = 25 \text{ m/s } (2\text{s.f.})$$

average velocity = 25 m/s (2s.f.) [1]

1

[Total: 7]

6

2 Fig. 2.1 is the displacement–time graph for a skydiver who jumps from a balloon at time $t = 0$.

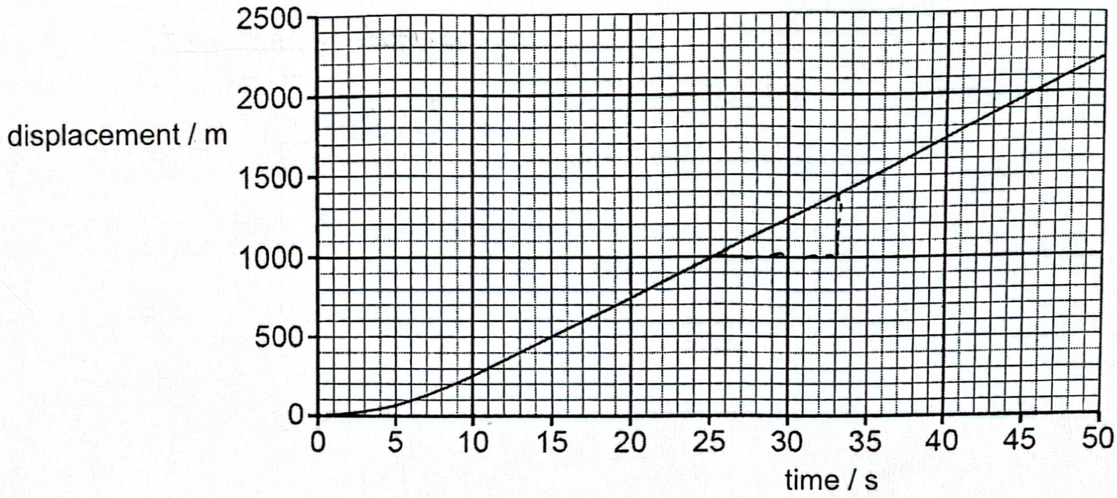

Fig. 2.1

(a) The first part of the graph shows the motion of the skydiver from when he jumps until he reaches terminal velocity.

(i) Describe the motion of the skydiver between $t = 0$ and $t = 15$ s.

The skydiver is displacing in the positive direction, with his velocity increasing at an increasing rate, meaning he is accelerating.

[1] 0

(ii) Explain the motion of the skydiver between $t = 0$ and $t = 15$ s in terms of the forces acting on him.

From 0 - 10 s, the skydiver is falling due to his weight. The air resistance opposing his motion, as his velocity is increasing due to gravity increases as well. From 10 - 15 s, the skydiver reaches terminal velocity, where the air resistance is equals to his weight, resulting in the skydiver being in ~~equil~~ equilibrium and stop accelerating.

[3] 2-1

(b) Using Fig. 2.1, determine the terminal speed of the skydiver.

$$\frac{1400 - 1000}{33 - 25} = 50 \text{ m/s}$$

terminal speed = 50 m/s [2] 2

[Total: 6]

4-1

at time $t = 0$.

(a) Ketchup does not flow easily. Shaking the glass bottle when tilted helps to get ketchup out, as shown in Fig. 3.1.

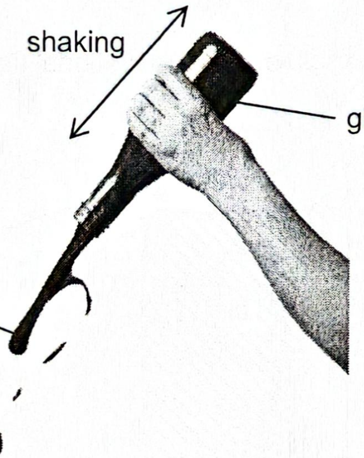

Fig. 3.1

Explain, using Newton's first law, how shaking the bottle helps to get ketchup out.

According to Newton's first law, a substance will remain at rest or remain at constant velocity unless an external force acts on it. The shaking of the bottle acts as an external force, changing to motion of the ketchup from rest to getting out of the bottle. [2]

(b) Evaporated milk in a tin can flows out slowly through a small hole in the lid, as shown in Fig. 3.2. When a second hole is punched, air can enter the can more easily, causing the milk to flow out more quickly.

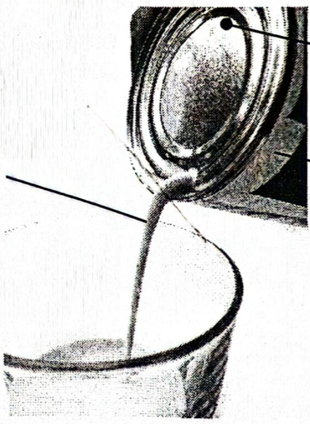

Fig 3.2

Using ideas of pressure, explain why evaporated milk flows out of a tin can more easily when there are two holes in the lid.

The atmospheric pressure is pushing the evaporated milk through the first hole. This is because the second hole allows air to enter the tin can. [1]

[Total: 3]

2

(iii)

4 A stone of mass 0.30 kg is thrown horizontally at a speed of 8.0 m s^{-1} from the top of a cliff height 45 m. The stone follows along a parabolic path and reaches point P, which is 32 m above the ground, as shown in Fig. 4.1.

Air resistance is negligible. The gravitational field strength *g* is 10 N kg^{-1}.

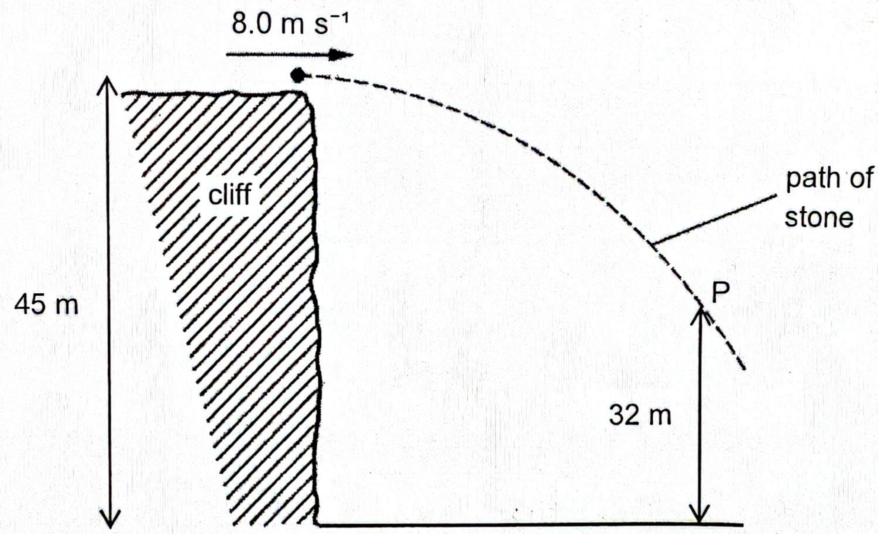

Fig. 4.1 (not to scale)

(a) State the *principle of conservation of energy*.

The principle of conservation of energy states that energy cannot be created nor destroyed, only transferred from one store to another or one system to another. The total energy in a isolated system is constant.

[2] 2

(b) (i) Calculate the kinetic energy of the stone at the top of the cliff.

$KE = \frac{1}{2} mv^2$

$= \frac{1}{2}(0.30)(8.0)^2$

$= 9.6\ J$

kinetic energy = 9.6 J [2] 2

(ii) Calculate the loss in gravitational potential energy of the stone as it moves from the top of the cliff to point P.

$GPE = mgh$

$= (0.30)(10)(45-32)$

$= 39\ J$

loss in potential energy = 39 J [1] 1

7

top of a cliff
is 32 m above

(iii) Determine the speed of the stone at point P.

$KE = \frac{1}{2} mv^2$

$9.6 + 39 = \frac{1}{2}(0.30)v^2$

$0.3v^2 = 97.2$

$v^2 = 324$

$v = 18$ m/s

speed = 18 m/s .... [2] 2

[Total: 7]

5 Fig. 5.1 shows a laboratory freezer.

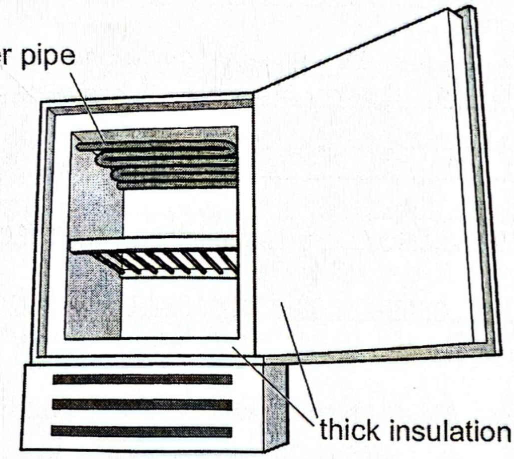

Fig. 5.1

The door is closed and the freezer is switched on.

A cold liquid is pumped through the copper pipe at the top of the freezer.

The temperature of the air next to the copper pipe decreases quickly.

(a) Explain how the temperature of the rest of the air in the freezer decreases.

This is done through ~~cond~~ ~~conv~~ convection. The air at the top of the freezer next to the copper pipe cools down, resulting in ~~the space~~ the air becoming denser, which then sinks down and displaces the warm, less dense air at the bottom. This air now cools down and repeats the process, ~~creat~~ creating a convection current. [3] 3

Fig. 6.1 sh

(b) The thick insulation shown in Fig. 5.1 is made from a plastic material.

(i) The plastic material in the insulation is a poor thermal conductor.

Using ideas about particles, describe how energy is transferred through the plastic material.

The plastic material is a solid, meaning it's particles are fixed in place in a orderly manner, vibrating at its fixed position. To transfer energy, particles with more kinetic energy vibrates more vigourosly, bumping into the neighboring particles, trasfering some ~~to~~ kinetic energy to those particles, which in turn vibrates more vigourosly and bumps into its neighboring particles. Eventually, the energy will be trasferred througout the plastic material. [2]

(ii) The plastic material also contains a large number of small air bubbles.

Explain how the air bubbles reduce the transfer of thermal energy through the insulation.

Air is a poor thermal conductor ~~absorber of thermal energy~~. Hence, the air bubbles in the plastic would slow ~~down~~ down the transfer of thermal energy through the insulation.

[1]

[Total: 6]

6

Fig. 6.1 shows a sealed cylinder with a piston of area 2.0 cm² that contains air.

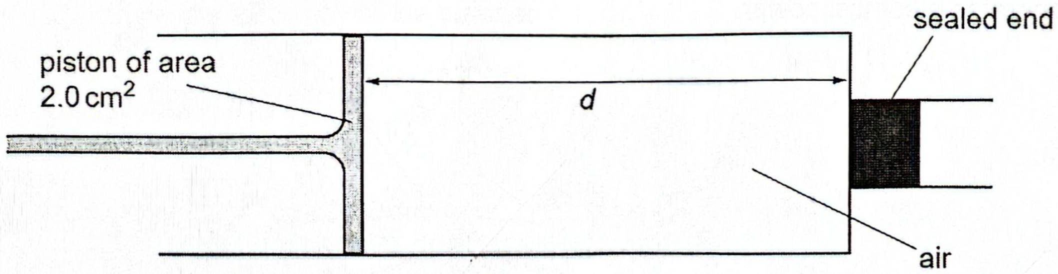

Fig. 6.1

When a force is applied to the piston, the length d changes from 6.0 cm to 4.0 cm. The pressure of the air increases but the temperature stays constant.

(a) Describe how the molecules of the air exert a pressure.

The air molecules are in continuous random motion, colliding with the inner walls of the ~~cy~~ cylinder, generating a force. The average force of all the air ~~molecules~~ molecules divided by the area of the inner walls of the cylinder gives us pressure. [2] 2

(b) Using ideas about molecules, explain why the pressure increases even though the temperature remains constant.

molecules closer

This is because the area of the inner walls of the cylinder decreases while the number of air molecules in the cylinder remains the same. Hence, the air molecules would collide with the inner walls of the cylinder a higher number of times, generating [2] a bigger force. Combined with the smaller area, this ~~cre~~ creates an increase in pressure. H1

(c) The initial pressure of the air is 1.0×10^5 Pa.

Calculate the final pressure of the air.

$$1.0 \times 10^5 = \frac{F}{\frac{2}{100} \times \frac{6}{100}}$$

$$F = 120$$

$$\text{final pressure} = \frac{120}{\frac{2}{100} \times \frac{4}{100}}$$

$$= 150000 \text{ Pa}$$

$$= 1.5 \times 10^5 \text{ Pa}$$

final pressure = 1.5×10^5 Pa [2] 2

[Total: 6]

5+1

7 Fig. 7.1 shows a wind turbine with a blade radius of 50.0 m. When the wind blows directly towards the turbine at a speed of 15.0 m s^{-1}, the blades spin and the generator connected to the blades generates electrical power.

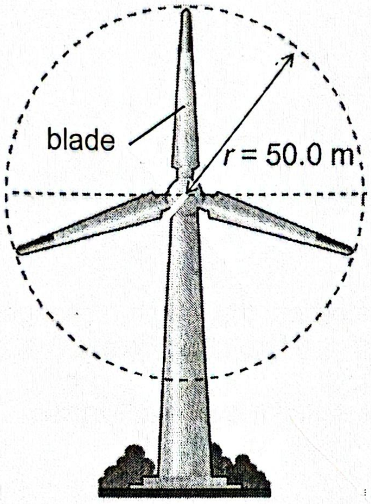

Fig. 7.1

(a) Wind energy is a renewable energy resource.

Name one other renewable energy resource.

Solar energy .... [1]

1

(b) The kinetic energy E of the wind blowing at a wind turbine for time t is given by the equation

$$E = \frac{1}{2}\pi r^2 v^3 \rho t$$

where r is the blade radius, v is the wind speed and ρ is the density of air. Take π = 3.142.

(i) The density of air is 1.25 kg m^{-3}.

Calculate the kinetic power P of the wind.

$E = \frac{1}{2}(3.142)(50)^2(15)^3(1.25)t$

$E = 17\,000\,000\,t$ (2s.f.)

$\frac{E}{t} = 1.7 \times 10^7$

$P = \frac{E}{t}$

$P = 1.7 \times 10^7$ W

P = 1.7×10^7 W .... [2]

2

3sf

irectly towards
the blades

10^6

(ii) The average electrical power generated by the turbine is 3.03 MW.

Calculate the efficiency of the turbine.

$3.03 \text{ MW} = 3.03 \times 10^6 \text{ W}$

$\text{Efficiency} = \dfrac{3.03 \times 10^6}{1.7 \times 10^7} \times 100\%$

$= 18\% \text{ (2s.f.)}$

efficiency = 18% (2s.f.) [2] 2

[Total: 5]

5

8 A student investigates the specific heat capacity of water using the apparatus shown in Fig. 8.1.

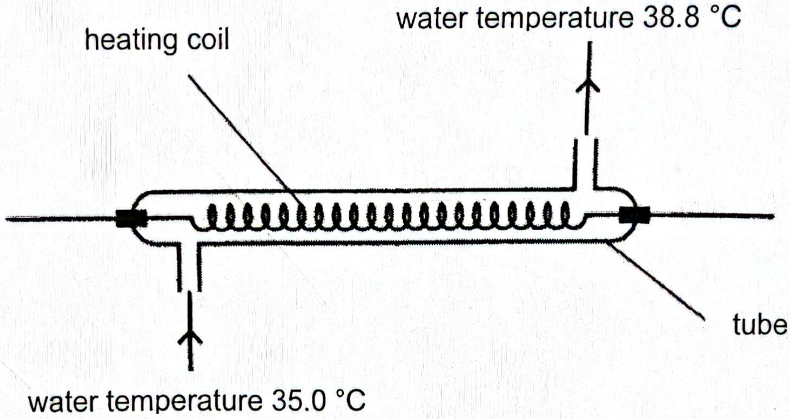

Fig. 8.1

Water enters the thin glass tube at a constant temperature of 35.0 °C. The power of a heating coil and the mass flow rate, which is the mass of water flowing through the tube per unit time, are varied such that the output temperature is always 38.8 °C.

Fig. 8.2 shows how the mass flow rate $\frac{\Delta m}{\Delta t}$ of water varies with the power P of the heating coil.

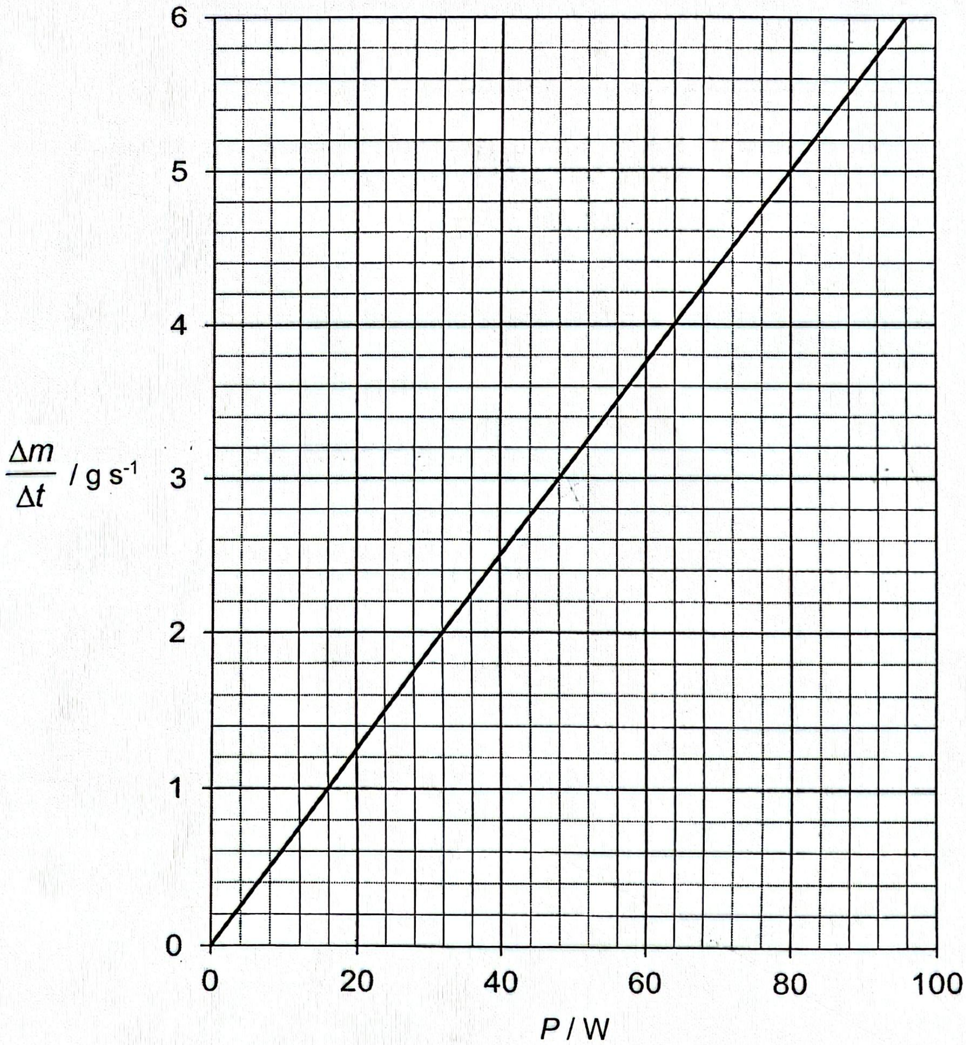

Fig. 8.2

wn in Fig. 8.1.

(a) (i) Define *specific heat capacity*.

Specific heat capacity is the amount of energy required to raise a substance's temperature by 1K or 1°C per unit mass. [2] 2

(ii) Using Fig. 8.2, determine the power of the heating coil when the mass flow rate of water is 4.0 g s^{-1}.

$P =$ 64W [1] 1

(iii) Assuming no energy is lost to the surroundings, use your answer to **(a)(ii)** to determine the specific heat capacity of water. Give your answer in $\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$.

gradient $= \frac{6-0}{96-0}$

$= 0.0625$

$\frac{\Delta m}{\Delta t} = 0.625P$

$4 = 0.625(64)$

$4g = 4J$

$1g = 1J$

∴ specific heat capacity $= \frac{1}{1(38.8-35)}$

$= 0.26$ (2s.f.)

specific heat capacity = 0.26 $\text{J}\,\text{g}^{-1}\,\text{K}^{-1}$ [2] 0

(iv) The tube is surrounded by insulation (not shown on Fig. 8.1) to reduce energy loss to the surroundings.

On Fig. 8.2, sketch a graph to show the variation of mass flow rate $\frac{\Delta m}{\Delta t}$ with power P when the insulation is removed. [2] 0

(b) Now, water at 100 °C enters the tube and begins to boil.

(i) Describe the change in the spacing between the water molecules during boiling.

The ~~spacing increases~~ spacing increases [1] 1

(ii) The volume flow rate is the volume of water flowing through the tube per unit time.

Explain why the volume flow rate of water is much smaller than the volume flow rate of steam if both water and steam have the same mass flow rate.

water has a fixed volume while steam does not.

[1] 0

(iii) Explain why the apparatus shown in Fig. 8.1 is not suitable for boiling water.

The gap for steam to escape is very small

[1] 0

[Total: 10] 4

9 Fig. 9.1 shows a stationary lift of 2000 kg supported by a cable that is connected to a motor.

Fig. 9.2 shows a man of mass 72.8 kg standing inside the lift.

The gravitational field strength g is 10 N kg^{-1}.

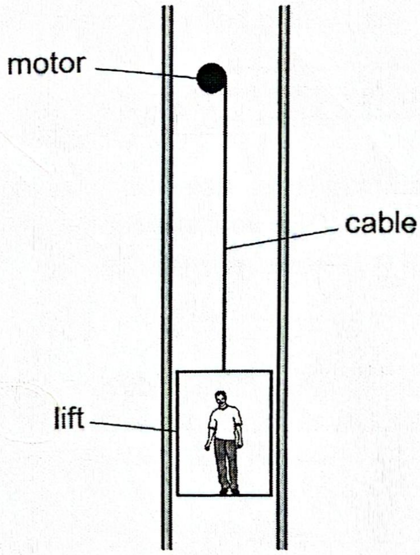

Fig. 9.1 (not to scale)

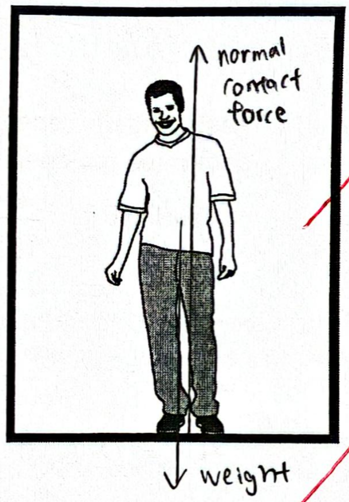

Fig. 9.2

(a) On Fig. 9.2, draw and label the forces acting on the man inside the lift. [2] 2

(b) When the motor is switched on, both the lift and the man accelerate upwards uniformly at 1.20 m s^{-2}.

(i) Calculate the resultant force acting on the man.

~~weight = 72.8 x 10 = 728 N~~

$F = ma$

$= (72.8)(10 - 1.20)$

$= 640$ N (2s.f.)

resultant force = 640N [2] 0

(ii) Calculate the magnitude of the force exerted by the lift on the man.

force = ... [3] 0

(iii) Calculate the distance travelled by the lift in the first 5.0 s.

distance = ... [2] 0

(c) After the man exits the lift, the lift accelerates downwards at 10 m s^{-2}.

State the tension in the cable.

tension = ... [1] 0

[Total: 10]

2

Section B

Answer **one** question from this section.

10 Fig. 10.1 shows a student of weight 584 N at rest in a push-up position on the ground. The centre of gravity (CG) of the student is 0.840 m from his feet and 0.410 m from his hands.

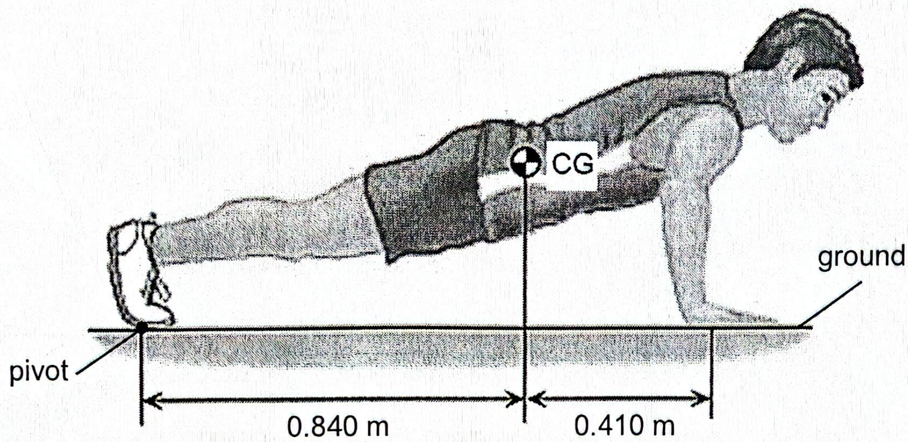

Fig. 10.1 (not to scale)

(a) State what is meant by the *centre of gravity*.

The centre of gravity is an imaginary point ~~where~~ where the whole weight of an object acts on. [1] 1

(b) (i) State two conditions required for the person to be in equilibrium.

1. the net force acting on the person is zero.

2. The person is either at rest or moving at a constant velocity. [2] 1

(ii) By taking moment about the pivot, determine the total normal force F_h exerted by the ground on the student's hands.

~~momen~~ moment $= Fd$

$= 584 \times 0.840$

~~= 490 N (2s.f.)~~

$584 \times 0.840 = F_h \times (0.840 + 0.410)$

$584 \times 0.840 = F_h \times 1.25$

$F_h = 390$ N (2s.f.)

F_h = ~~490 N~~ 390 N [2] 2

(iii) Determine the total normal force F_f exerted by the ground on the student's feet.

$F_p = Fd$
$= F(0)$
$= 0$

$F_f =$ 0N [1] 0

(iv) The student shifts his CG slightly forward and closer to his hands without moving his hands and feet on the ground. He remains at rest in the new push-up position.

State and explain what happens to F_h and F_f.

F_f?

F_h will increase as the ~~mom~~ clockwise moment ~~of~~ by CG increases while there is no change in the dis

[2] 1

(c) The student does 20 push-ups. For each push-up, the student applies an average force of 600 N as he pushes up a distance of 0.50 m.

Calculate the total work done by the force.

Work done = ~~for~~ force x displacement

$= 600 \times 0.5$
$= 300J$

$300 \times 20 = 6000 J$

total work done = 6000 J [2] 2

[Total: 10]

7

11 A small glass measuring cylinder of oil is placed inside a freezer where the temperature is –18 °C.

Fig. 11.1 shows how the temperature of the oil varies with time *t*.

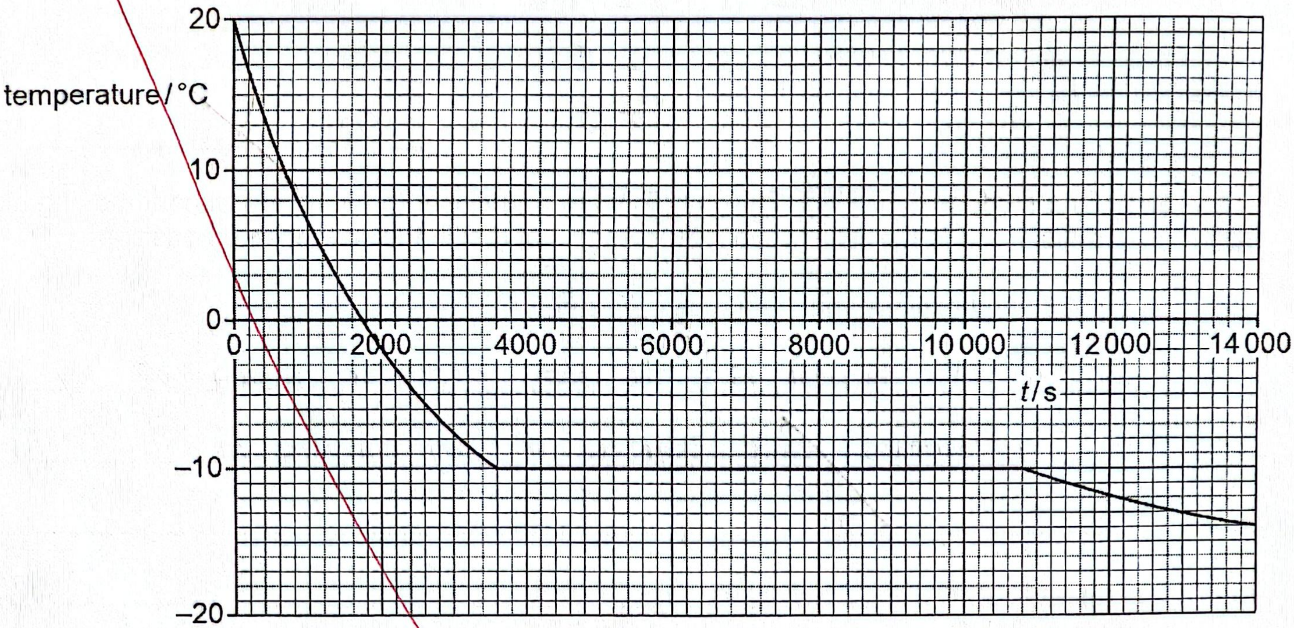

Fig. 11.1

Fig. 11.1 shows that it takes 700 s for the temperature to decrease from 20 °C to 10 °C but that it takes 1900 s to decrease from 0 °C to –10 °C.

(a) Explain why these times are different.

....

....

....

.... [2]

(b) Explain what happens to the molecules of the oil and what happens to the level of the oil in the glass measuring cylinder as the temperature decreases from 20 °C to 0 °C.

....

....

....

....

....

.... [3]

(c) Using ideas about molecules, explain why the temperature does not change between $t = 3600$ s and $t = 10\,800$ s, even though energy is lost by the oil.

....

....

....

.... [2]

(d) There is 45 g of oil in the glass measuring cylinder and the specific latent heat of fusion of the oil is $5.7 \times 10^4\ \mathrm{J\,kg^{-1}}$.

Calculate the energy transferred from the oil between $t = 3600$ s and $t = 10\,800$ s.

energy = ... [2]

(e) After $t = 20\,000$ s, the temperature of the oil remains constant.

Explain why.

.... [1]

[Total: 10]

--- End of Paper ---