1. Motion, forces and energy

1.5 Forces

Paper 3 and 4

Question Paper

Paper 3

Questions are applicable for both core and extended candidates

1 A person pushes a pushchair. A young child rides in the pushchair. Fig. 2.1 shows horizontal forces acting on the front wheel of the pushchair.

Fig. 2.1 (not to scale)

(a) Calculate the resultant of the horizontal forces shown in Fig. 2.1.

resultant force = ... N

direction = ...
[2]

(b) **(i)** Another person pushes a shopping trolley with a force of 40 N. The shopping trolley moves at a constant speed along a horizontal path.

Calculate the work done by the 40 N force to move the shopping trolley a distance of 50 m.

work done = ... J [3]

(ii) The work done on the shopping trolley as it starts moving is transferred into other energy stores.
State **two** such energy stores.

1 ....

2 ....
[2]

2 A car has a fault. A mechanic uses a machine to pull the car onto a recovery vehicle as shown in Fig. 3.1.

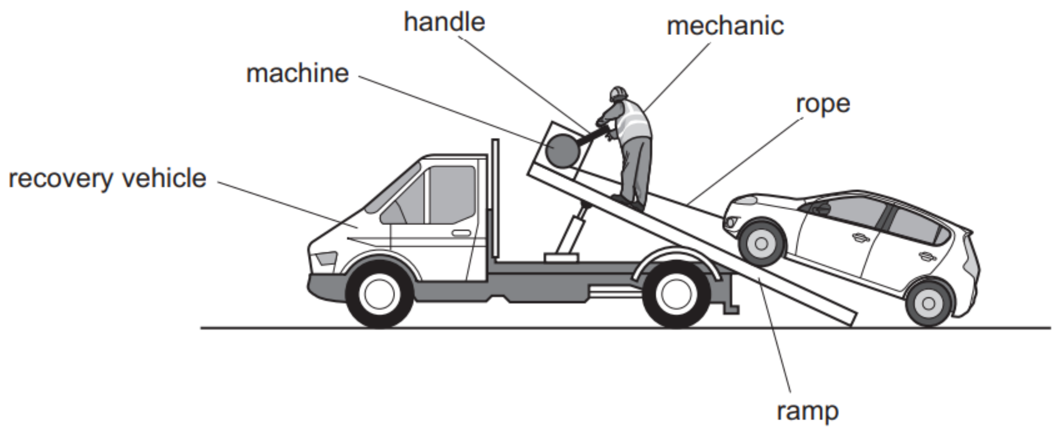


Fig. 3.1

(a) Fig. 3.2 shows how the mechanic applies a force to the handle of the machine.

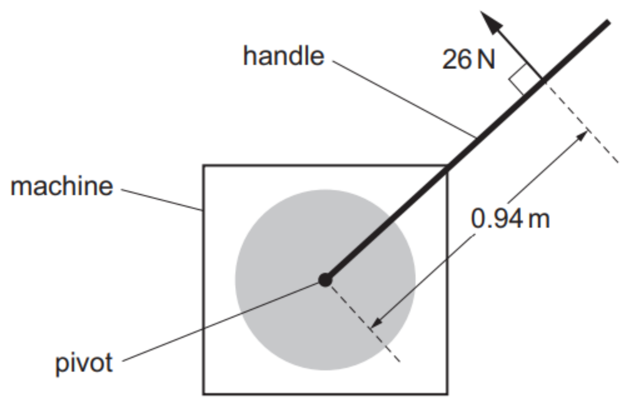


Fig. 3.2

(i) Calculate the moment of the 26 N force about the pivot. Use the information in Fig. 3.2.

moment = ... N m [3]

(ii) Describe **one** way the mechanic can increase the moment of the 26 N force about the pivot.

.... [1]

3 Fig. 3.1 shows the horizontal forces acting on a boat.

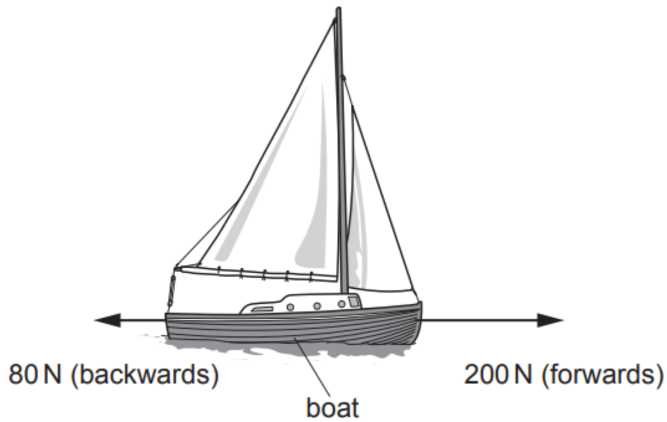


Fig. 3.1

(a) (i) Calculate the resultant horizontal force on the boat in Fig. 3.1.

size of resultant force = ... N

direction of resultant force ....
[2]

(ii) Suggest what causes the 80 N force on the boat in Fig. 3.1.

....

.... [1]

(iii) Another boat is travelling and the horizontal forces on this boat are balanced.

Describe the horizontal motion of this boat.

.... [1]

(b) Fig. 3.2 shows the wheel used to steer a boat.

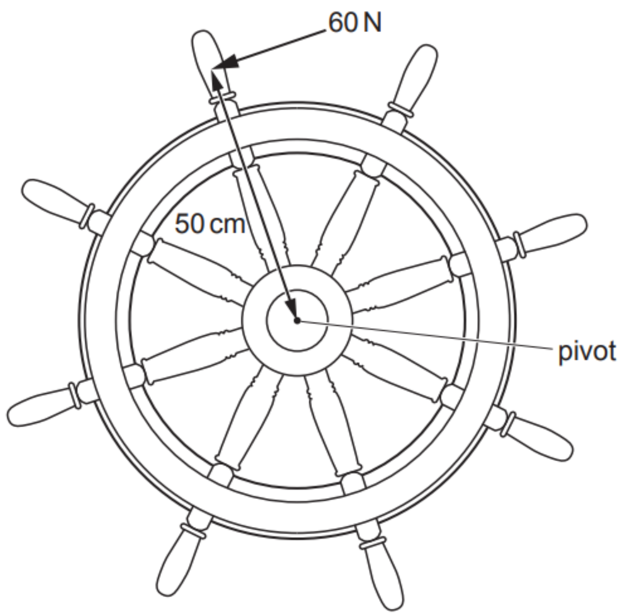


Fig. 3.2

A force of 60 N acts at a perpendicular distance of 50 cm from the wheel's pivot.

Calculate the moment of the 60 N force about the pivot. Include the unit.

moment = ...

unit ....

[4]

[Total: 8]

4 Fig. 3.1 shows two solid shapes, a cylinder and a cone, which are made from the same material.

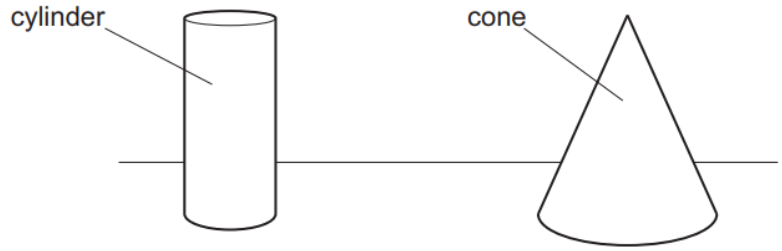


Fig. 3.1

(a) State and explain which shape is the more stable.

the more stable shape is ....

explanation ....

....
[1]

(b) The mass of the cylinder is 0.25 kg.

Calculate the weight of the cylinder.

weight = ... N [2]

(c) A horizontal force of 3.0 N tilts the cone. The cone balances on one edge, as shown in Fig. 3.2.

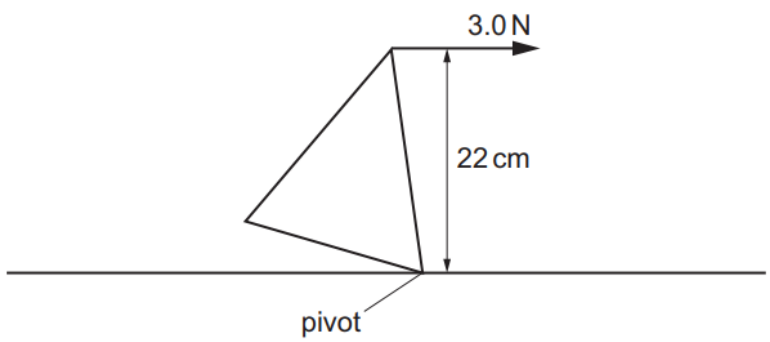


Fig. 3.2

(i) Calculate the moment of the 3.0 N force about the pivot in Fig. 3.2.

moment = ... N cm [3]

(ii) Determine the moment of the weight of the cone about the pivot.
Use ideas about the principle of moments.

moment of weight about pivot = ... N cm [1]

[Total: 7]

5 **(b)** The cylinder is falling at constant speed through the air. Fig. 2.1 shows the vertical forces acting on the cylinder.

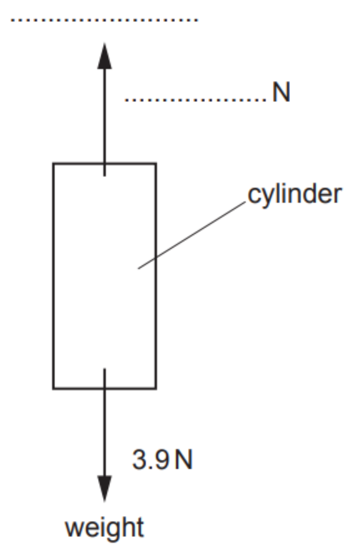


Fig. 2.1 (not to scale)

On Fig. 2.1, write the name and the size of the upward force on the cylinder. [2]

(c) The student balances a beam on a pivot. On the beam, he positions the cylinder and a block so that the beam remains balanced. The arrangement is shown in Fig. 2.2.

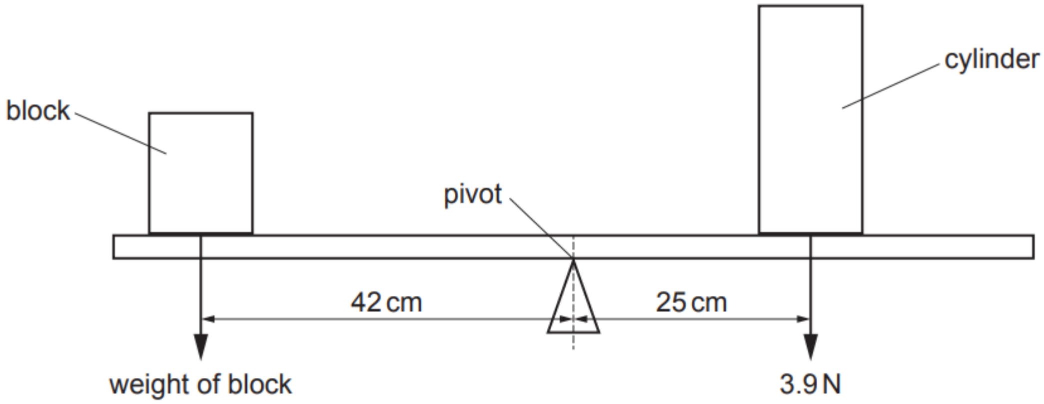


Fig. 2.2 (not to scale)

Calculate the weight of the block.

weight of block = ... N [4]

[Total: 10]

6 A platform rests on a pivot as shown in Fig. 3.1.

A diver sits at a distance of 1.8 m from the pivot. The weight of the diver is 1100 N.

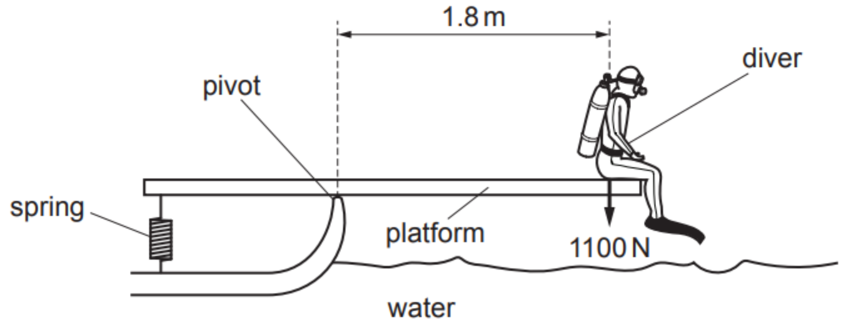


Fig. 3.1 (not to scale)

(a) Using the information in Fig. 3.1, calculate the moment of the diver about the pivot.

moment of diver = ... N m [3]

(b) (i) Fig. 3.2 represents the platform without the diver.

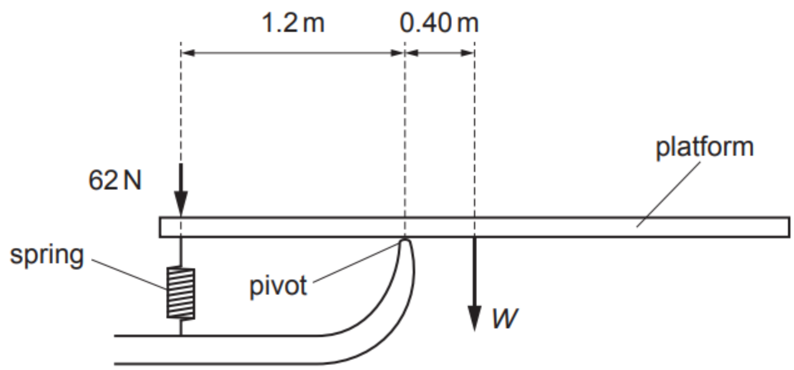


Fig. 3.2 (not to scale)

The moment of the weight *W* of the platform is balanced by the moment of the spring. The spring exerts a downward force of 62 N.

Using the information in Fig. 3.2, calculate the weight *W* of the platform.

W = ... N [3]

(ii) The graph of load against extension for a spring is shown in Fig. 3.3.

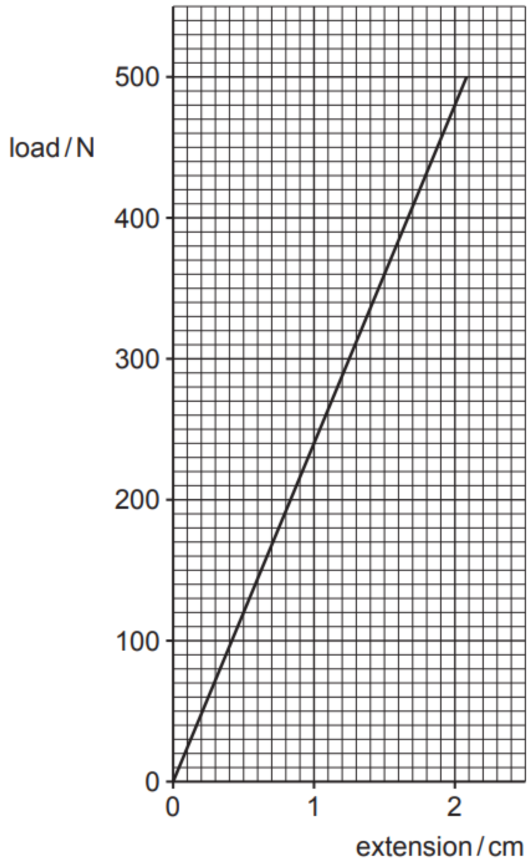


Fig. 3.3

The unstretched length of the spring is 16 cm.

Determine the length of the spring when the load on the spring is 240 N.

length of spring = ... cm [2]

7 Fig. 2.1 shows a concrete beam resting on the ground.

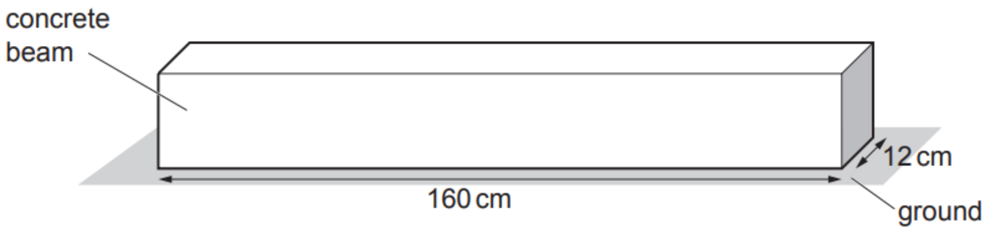


Fig. 2.1 (not to scale)

(a) The weight of the concrete beam is 1540 N.

Calculate the pressure on the ground due to the concrete beam.

pressure = ... N/cm^2 [4]

(b) A builder starts to raise one end of the beam.

He uses a force of 1030 N at a perpendicular distance of 120 cm from the pivot. Fig. 2.2 shows the arrangement.

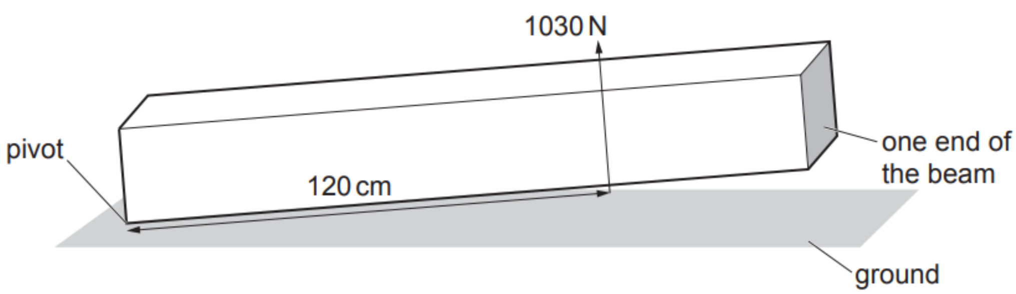


Fig. 2.2 (not to scale)

Calculate the moment of the 1030 N force about the pivot.

moment = ... N cm [3]

(c) Describe how the builder can use a smaller force to lift the beam.

.... [1]

(d) The builder positions the beam as shown in Fig. 2.3.

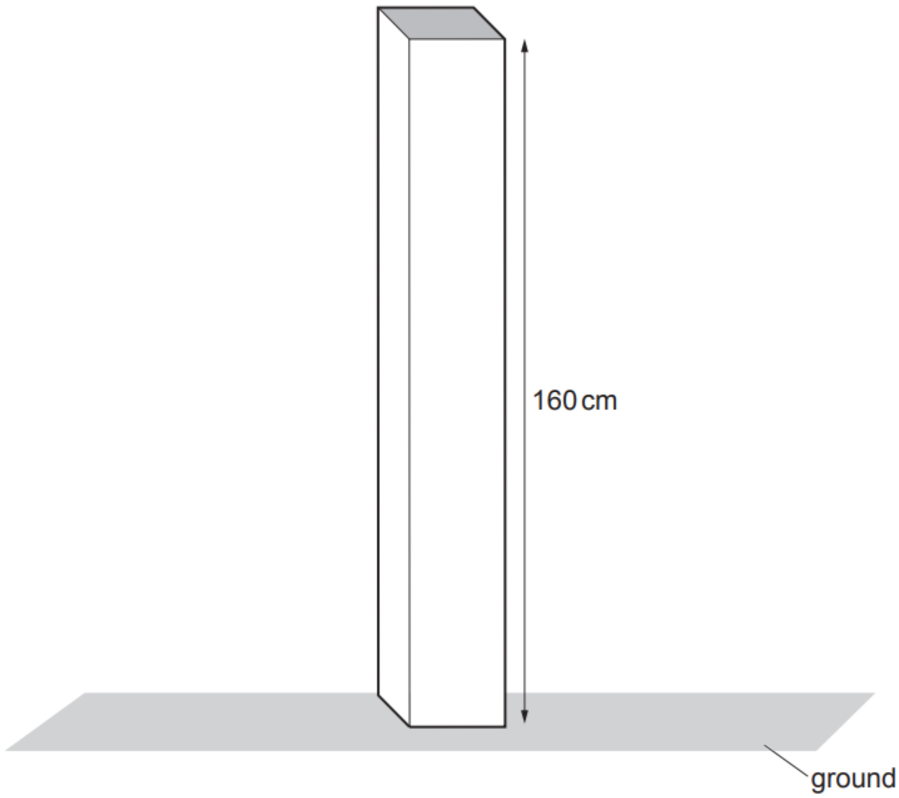


Fig. 2.3 (not to scale)

State why the beam shown in Fig. 2.3 is less stable than the beam shown in Fig. 2.1.

.... [1]

[Total: 9]

8 **(c)** Fig. 2.2 shows the horizontal forces on a cyclist.

Fig. 2.2

(i) Calculate the size of the resultant force on the cyclist.

resultant force = ... N [1]

(ii) State the effect, if any, of the resultant force on the motion of the cyclist.

.... [1]

[Total: 8]

9 Fig. 2.1 shows the horizontal forces acting on a car.

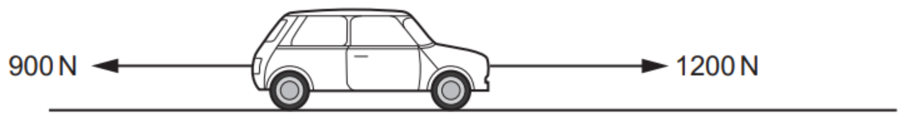


Fig. 2.1 (not to scale)

(a) Calculate the resultant horizontal force on the car.

size of force = ... N

direction ....
[3]

10 A sailor uses a winch to raise a sail on a boat. Fig. 3.1 shows the sailor turning the winch.

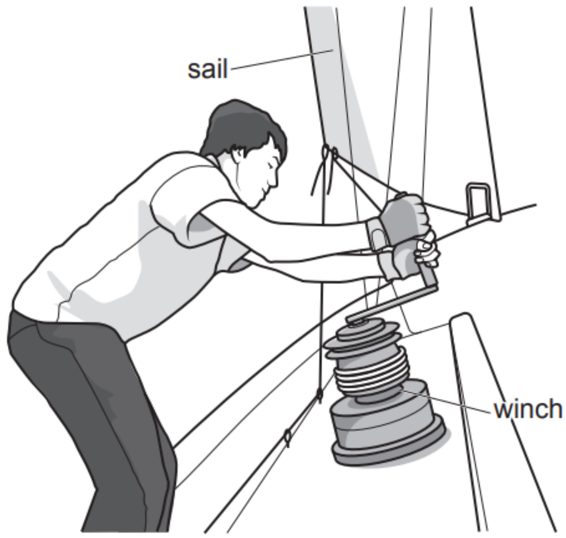


Fig. 3.1

(a) The sailor applies a force of 200 N at a distance of 30 cm from the pivot in the winch, as shown in Fig. 3.2.

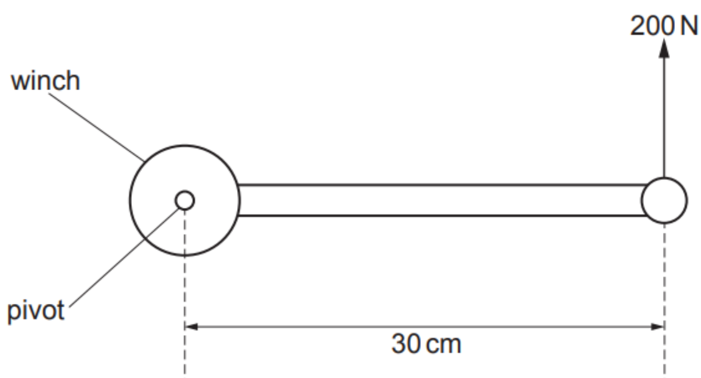


Fig. 3.2

Calculate the moment of this force about the pivot.

moment of force = ... N cm [3]

(b) **(i)** Describe **two** useful energy transfers when the sailor uses the winch to raise the sail.

1 ....

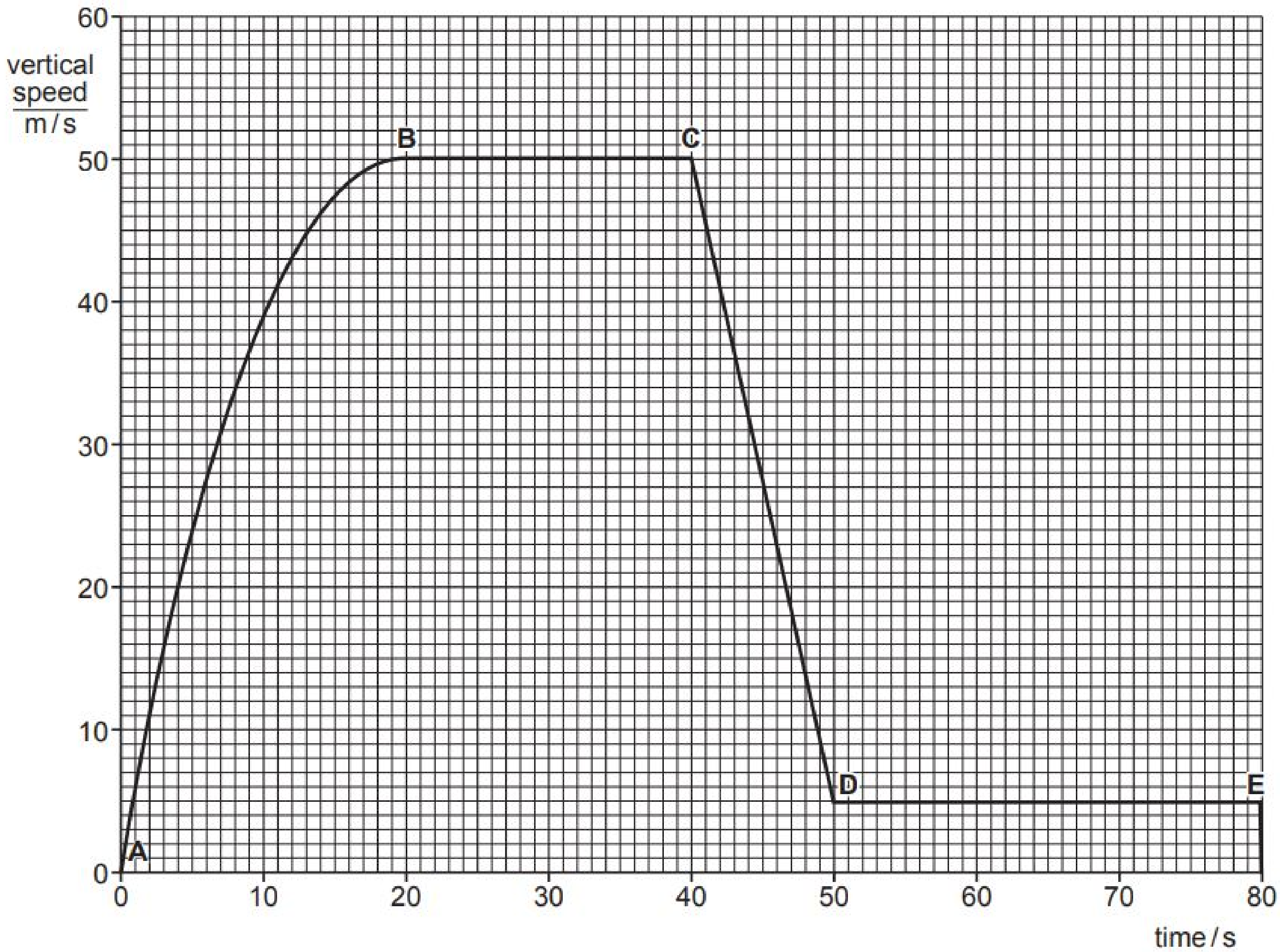
2 ....
[2]

(ii) Describe **one** non-useful energy transfer when the sailor uses the winch to raise the sail.

.... [1]

[Total: 6]

Graph for Question 11



11 **(b)** The weight of the skydiver is 750 N.

The weight of the skydiver acts downwards, as shown in Fig. 1.4.

While the skydiver is falling, another force acts upwards.

The upward force varies as the skydiver falls.

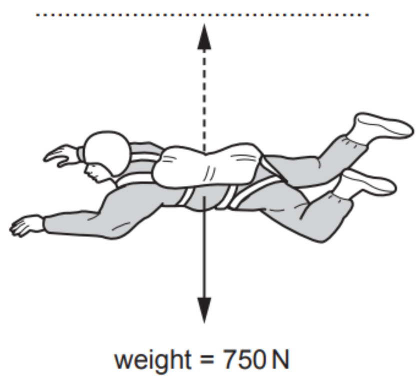


Fig. 1.4 (not to scale)

(i) On Fig. 1.4, write the name of the upward force on the dotted line above the upward force. [1]

(ii) Suggest a value for the upward force on the skydiver at time = 10 s.

.... N [1]

(iii) Determine the value of the upward force on the skydiver at time = 30 s.

.... N [1]

(c) The weight of the skydiver is 750 N.

Calculate the mass of the skydiver.

mass = ... kg [3]

[Total: 12]

12 **(b)** Fig. 4.3 shows the force on the pulley from the load M.

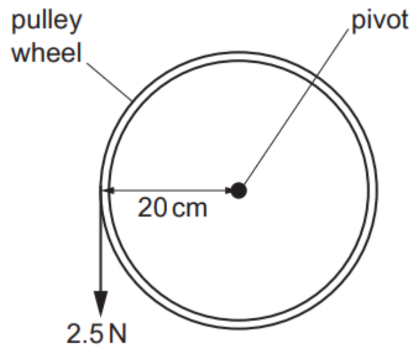


Fig. 4.3

The weight of load M is 2.5 N and the weight acts at a distance of 20 cm from the pivot of the pulley wheel.

Calculate the moment of the weight of load M about the pivot.

moment = ... N cm [3]

13 **(a)** Fig. 3.1 shows an aeroplane flying. There are horizontal forces acting on the aeroplane, as shown in Fig. 3.1.

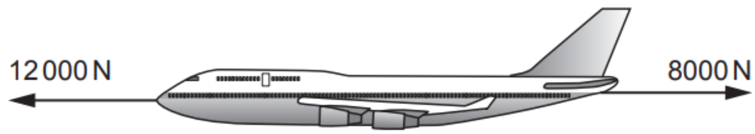


Fig. 3.1 (not to scale)

(i) Calculate the resultant horizontal force on the aeroplane.

resultant force = ... N

direction of resultant force ....
[3]

(ii) State the name of the effect producing the 8000N force on the aeroplane.

.... [1]

(iii) At a later time in the flight, the resultant horizontal force on the aeroplane is zero.

Describe the horizontal motion of the aeroplane.

.... [1]

(b) Fig. 3.2 shows the handle used to open and close a cupboard door on the aeroplane.

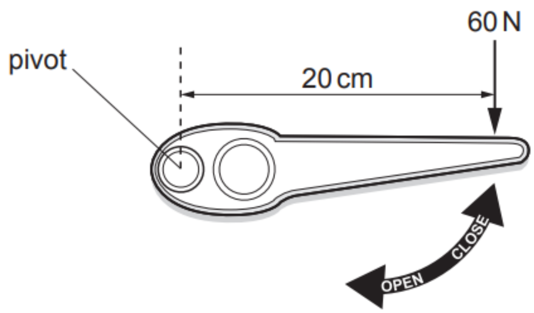


Fig. 3.2 (not to scale)

A force of 60N acts at a distance of 20cm from the pivot of the handle.

Calculate the moment of the 60N force about the pivot.

moment = ... Ncm [3]

[Total: 8]

14 **(a)** A student determines the centre of mass of a piece of card. Fig. 3.1 shows the equipment the student uses.

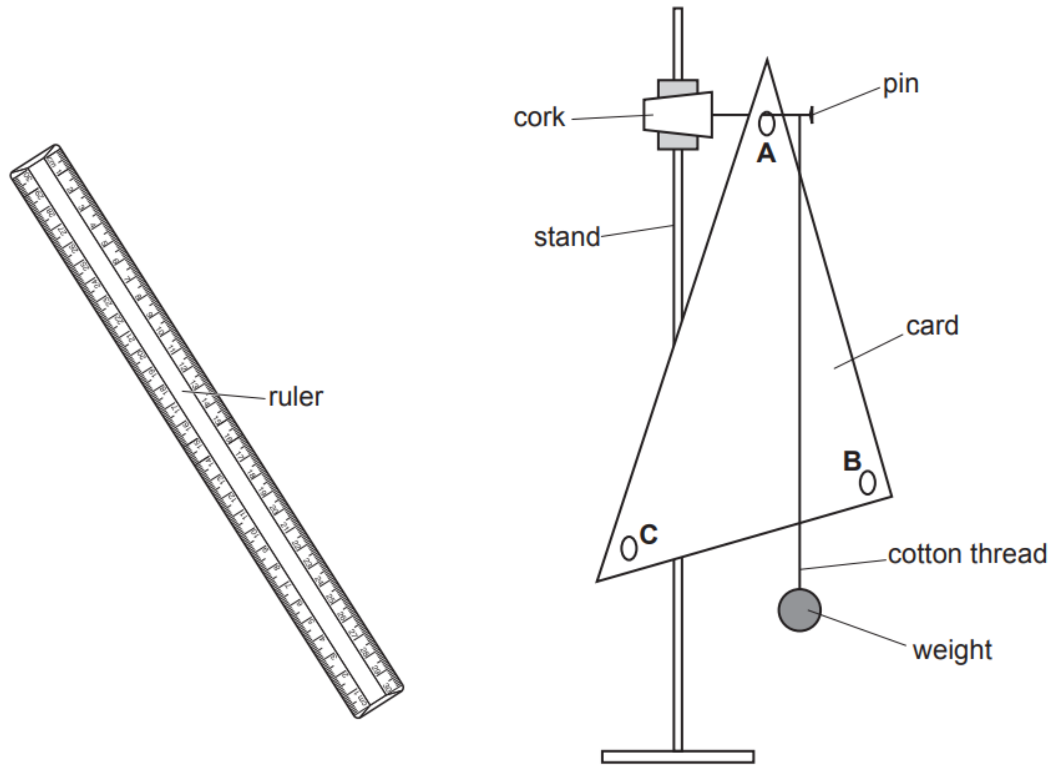


Fig. 3.1

Describe how the student determines the centre of mass of the card using the equipment in Fig. 3.1.

....

....

....

....

....

.... [3]

(b) Another card is pivoted at point P. The weight of the card is 1.4 N and acts through a point 20 cm from P.

Fig. 3.2 shows the arrangement.

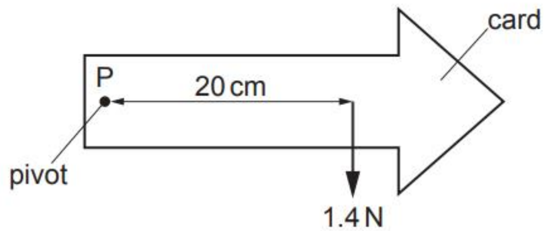


Fig. 3.2

Calculate the moment of the weight of the card about point P.

moment of weight = ... N cm [3]

[Total: 6]

15 Fig. 3.1 shows the vertical forces acting on a toy rocket as it leaves the ground.

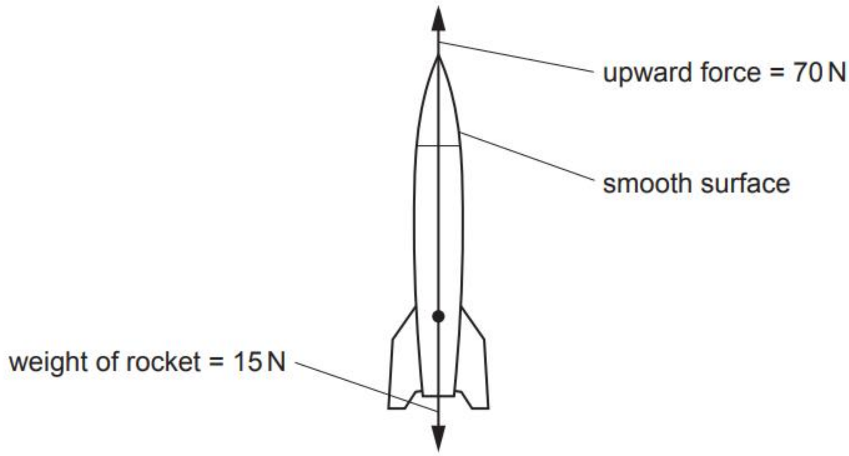


Fig. 3.1

(a) Calculate the size of the resultant vertical force on the rocket.

resultant force = ... N [2]

(b) Explain why the top of the rocket is pointed and has a smooth surface.

....

.... [2]

[Total: 4]

16 A plank balances horizontally on a log of wood, which acts as a pivot.

(a) A girl sits on one end of the plank, and her brother pushes down on the other end to make the plank balance horizontally. Fig. 3.1 shows the arrangement.

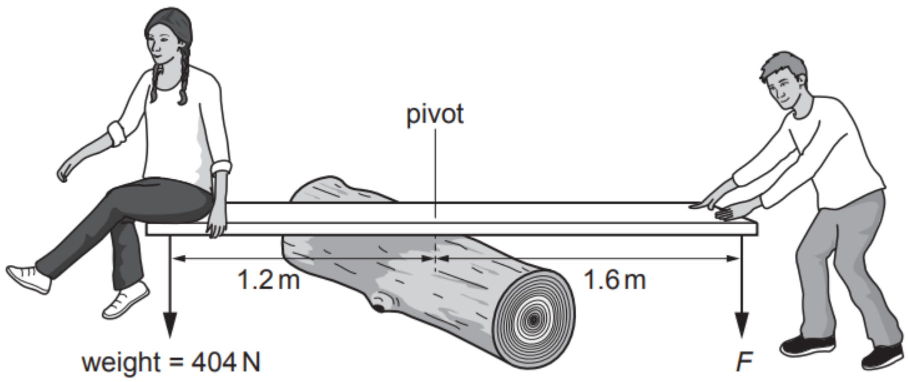


Fig. 3.1 (not to scale)

Calculate the moment of the girl's weight about the pivot and show that it is close to 480 N m.

[3]

(b) The plank balances horizontally when the boy pushes down with a force *F* at a distance of 1.6 m from the pivot.

Calculate the size of force *F*.

force *F* = ... N [3]

[Total: 6]

17 **(a)** A man starts pulling his suitcase across the floor.

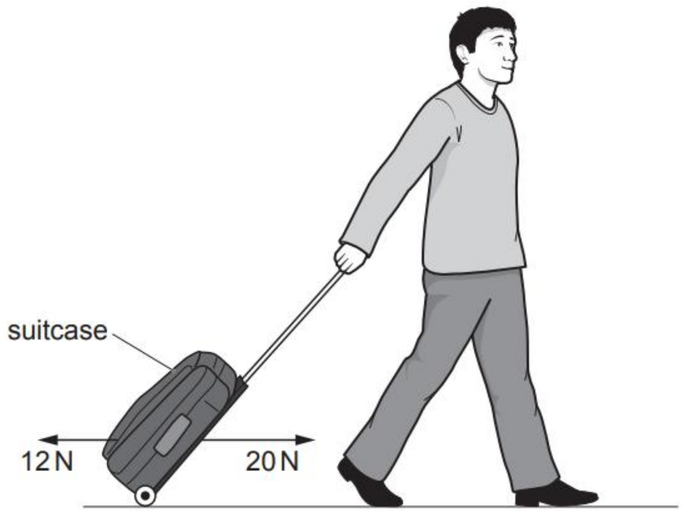


Fig. 5.1 (not to scale)

(i) Fig. 5.1 shows the horizontal forces acting on the suitcase.

Calculate the resultant horizontal force on the suitcase.

size of force = ... N

direction ....
[2]

(ii) After a short time, the suitcase is moving at a constant speed.

Suggest values for the sizes of the two horizontal forces on the suitcase when it is moving at a constant speed.

pulling force = ... (N)

friction force = ... (N) [1]

(b) The total downward force of the suitcase on the ground is 150 N. The suitcase has two wheels. Each wheel has an area of 0.60 cm^2 touching the ground.

Calculate the pressure of the suitcase on the ground.

pressure on the ground = ... N/cm^2 [4]

[Total: 7]

18 Fig. 3.1 shows a barrier used at a car park. The beam can be raised and lowered by a man rotating it about its pivot.

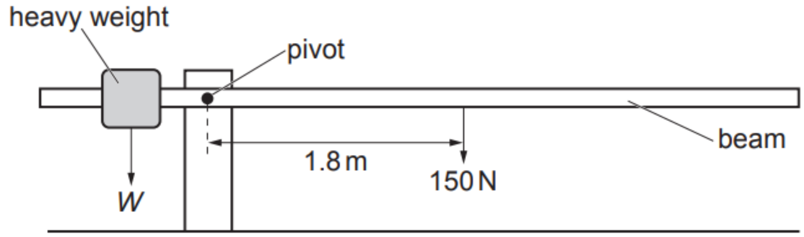


Fig. 3.1 (not to scale)

(a) The weight of the beam is 150 N. This acts at a distance of 1.8 m from the pivot as shown in Fig. 3.1.

Calculate the moment of the weight of the beam about the pivot.

Include the correct unit in your answer.

moment of weight of beam = ... unit .... [4]

(b) When the weight *W* of the heavy weight acts at a distance of 0.6 m from the pivot, the barrier is horizontal and balanced as shown in Fig. 3.1.
The man raises the barrier and the heavy weight slips to a distance of 0.8 m from the pivot.
This causes a problem for the man trying to lower the barrier.

Describe and explain the problem this causes for the man lowering the barrier.

....

....

....

....

.... [3]

[Total: 7]

19 Fig. 3.1 shows three horizontal forces acting on a car as it moves along a straight road.

The horizontal forces act along the same straight line.

Fig. 3.1

(a) (i) Calculate the size of the resultant horizontal force on the car and state its direction.

size of resultant force = ... N

direction of resultant force ....
[3]

(ii) The driver presses the brake pedal and the car slows down.
As the car slows down, the kinetic energy of the car decreases by 100 kJ.

Describe and explain what happens to this 100 kJ of energy.

....

.... [2]

(b) Fig. 3.2 shows the force applied to the brake pedal by the driver's foot.

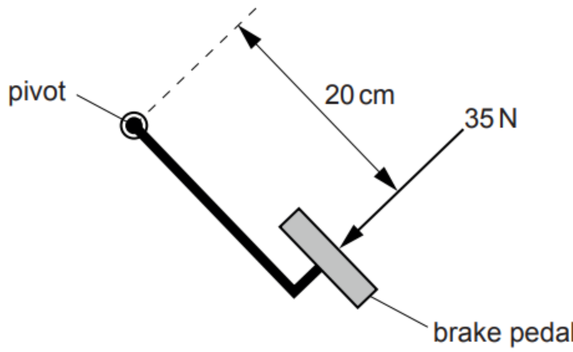


Fig. 3.2

Calculate the moment of the force about the pivot. Include the unit.

moment = ... unit .... [4]

[Total: 9]

20 Fig. 1.1 shows a box attached to a parachute. The box and the parachute are falling through the air.

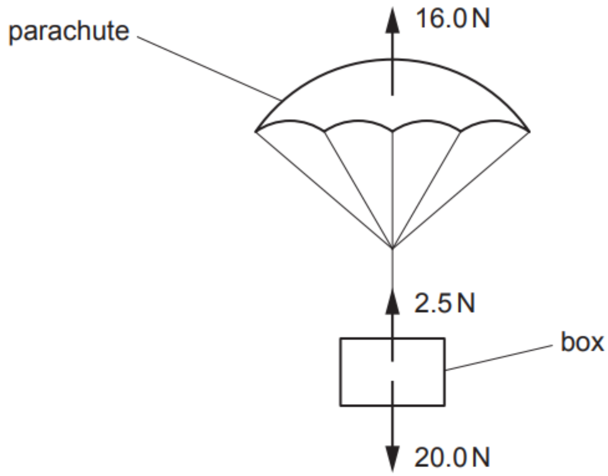


Fig. 1.1

(a) Fig. 1.1 shows **three** vertical forces acting on the box and the parachute.

(i) Calculate the resultant vertical force and state its direction.

resultant vertical force = ... N

direction ....

[3]

(ii) Suggest and explain what happens to the size of the upward vertical force on the parachute if the area of the parachute used is increased.

suggestion ....

explanation ....

....

[2]

(b) Fig. 1.2 shows the speed–time graph for the box **before** the parachute is opened.

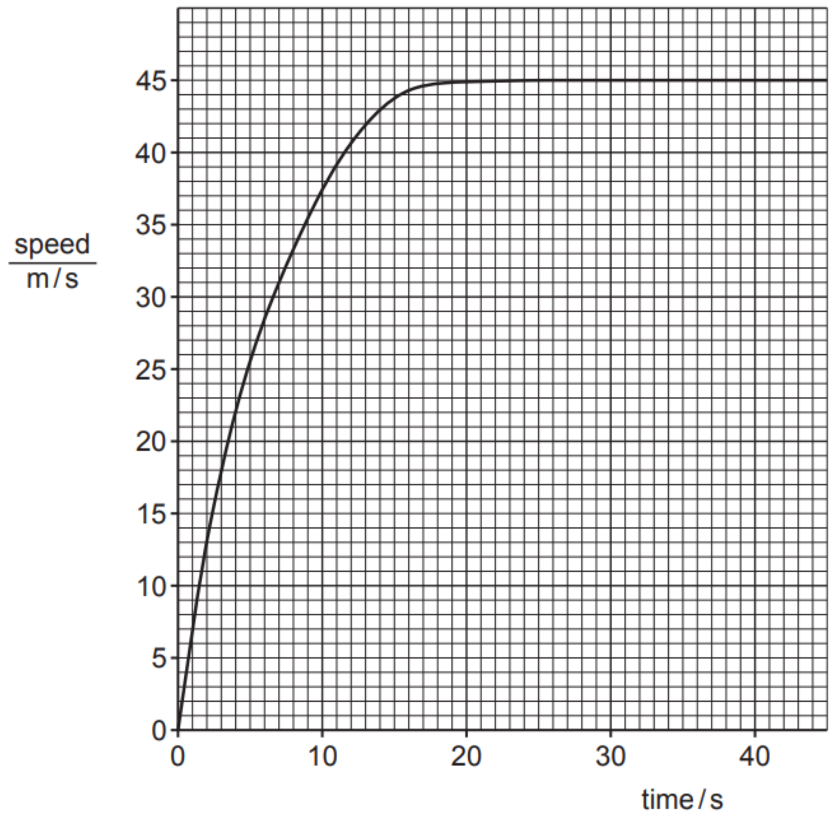


Fig. 1.2

(i) Determine the time when the speed of the box is 30 m/s.

time = ... s [1]

(ii) Deduce the size of the resultant vertical force on the box when the time is 35 s. Explain your answer.

size of resultant vertical force ....

explanation ....

....
[2]

(iii) Calculate the distance the box moves between time = 30 s and time = 40 s.

distance = ... m [3]

[Total: 11]

21 A car driver needs to remove one of the wheels on his car. He puts a spanner on a wheel nut.

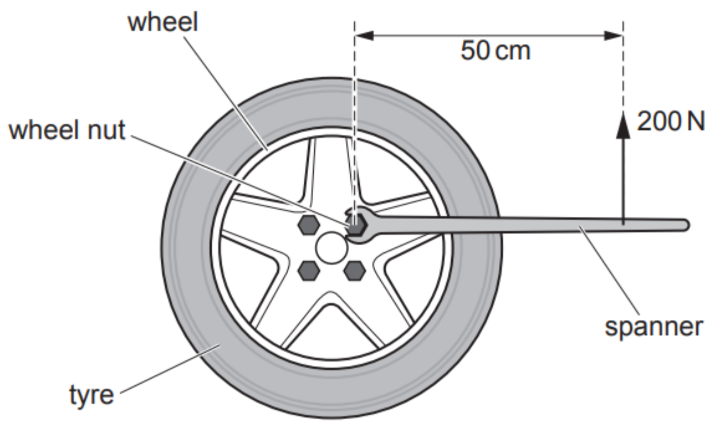


Fig. 2.1

(a) The driver applies a force of 200 N, as shown in Fig. 2.1.

Calculate the moment of the 200 N force about the centre of the wheel nut.

moment of force = ... N cm [3]

(b) The moment in **(a)** does not release the wheel nut. The driver **cannot** increase the force but can increase its moment.

State and explain how the driver can increase the moment of the force.

statement ....

explanation ....

.... [2]

22 **(a)** A student stretches a spring by adding different loads to it. She measures the length of the spring for each load. She plots a graph of the results.

Fig. 2.1 shows the graph of her results.

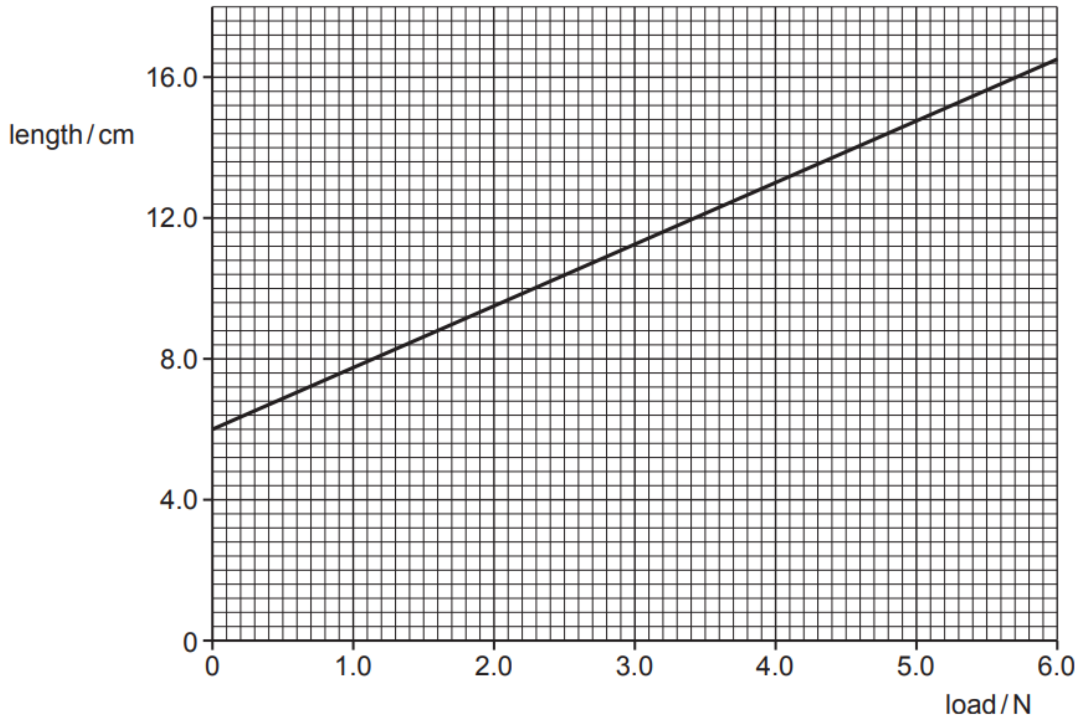


Fig. 2.1

Use the graph to determine:

(i) the length of the spring without a load

length = ... cm [1]

(ii) the length of the spring with a load of 4.0 N

length = ... cm [1]

(iii) the extension due to a 4.0 N load.

extension = ... cm [1]

(b) Complete the sentence about effects of forces. Choose words from the box.

colour	friction	pressure	shape	size	speed

Stretching a spring with a load is an example of how a force can change the

.... and the .... of an object. [2]

[Total: 5]

23 A metre rule is balanced on a pivot by three vertical forces, as shown in Fig. 5.1.

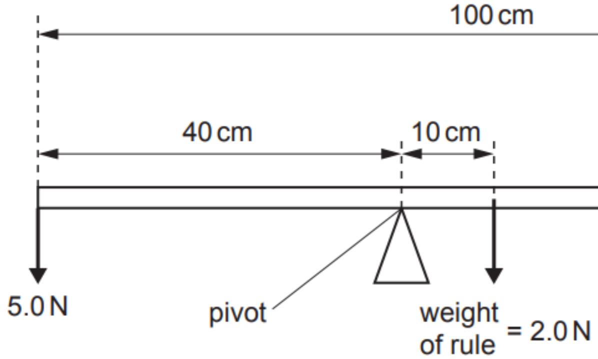


Fig. 5.1 (not to scale)

(a) Show that the moment of the 5.0 N force about the pivot is 200 N cm.

[2]

(b) Calculate the size of force F.

F = ... N [4]

[Total: 6]

24 Fig. 3.1 shows a spring with no load attached. Fig. 3.2 shows the same spring with a load attached.

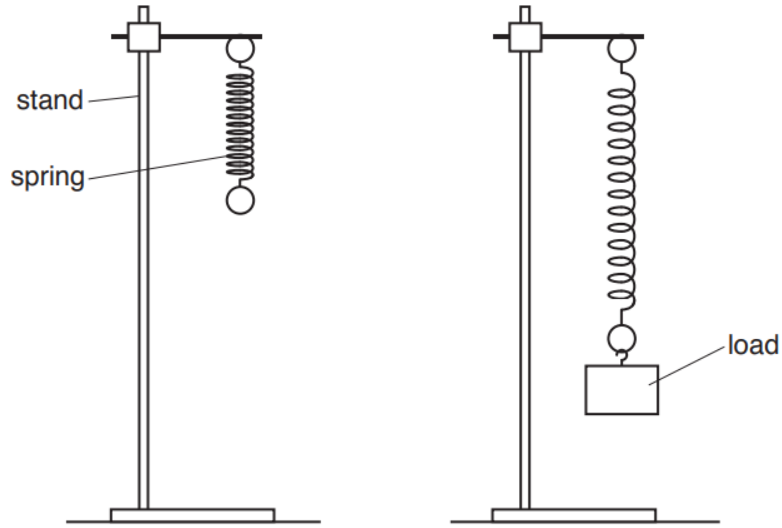


Fig. 3.1 **Fig. 3.2**

(a) Describe how a student can determine the extension of the spring. You may draw on Fig. 3.1 and Fig. 3.2 as part of your answer.

....

....

....

....

.... [3]

(b) The student plots a graph of load against extension, as shown in Fig. 3.3.

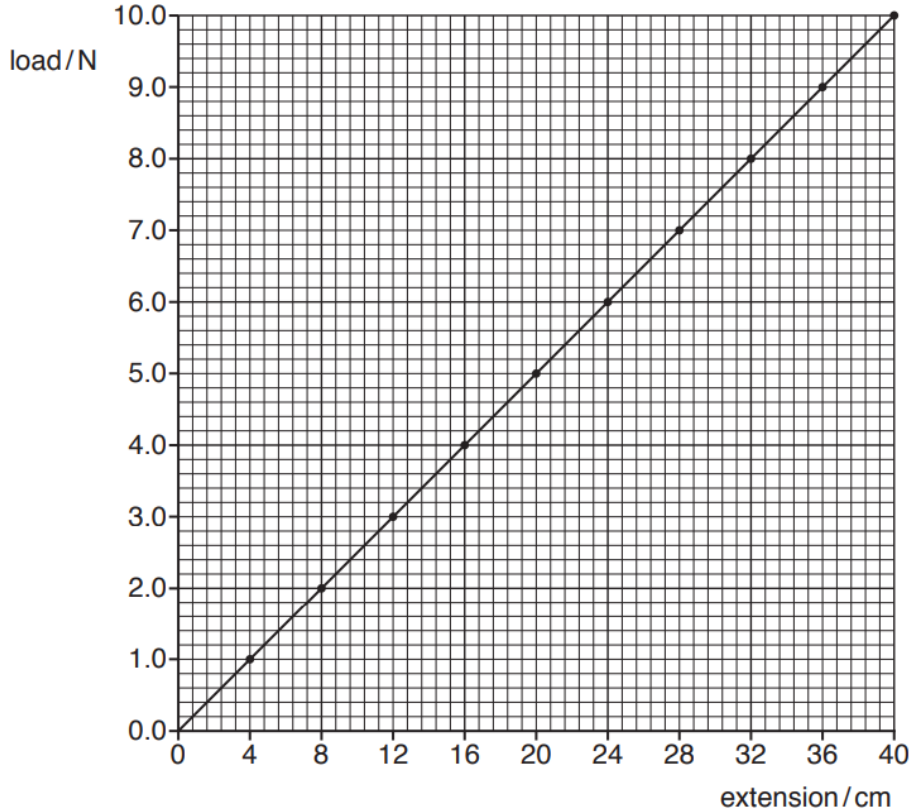


Fig. 3.3

(i) Determine the extension produced by a load of 7.5 N.

extension = ... cm [1]

(ii) Determine the load that would produce an extension of 10.0 cm.

load = ... N [1]

(c) Calculate the mass that has a weight of 6.0 N.

mass = ... kg [3]

[Total: 8]

25 Fig. 4.1 shows a tractor fitted with a device for breaking up soil in a field.

Fig. 4.1

(a) **(i)** The tractor has a heavy weight at the front. Explain why the heavy weight is needed.

....

.... [1]

(ii) Fig. 4.2 represents the weight of the device and its distance from the pivot.

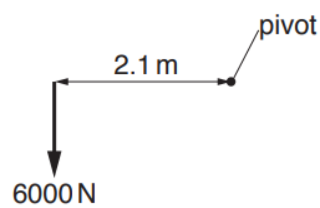


Fig. 4.2

Calculate the moment of the weight of the device about the pivot. State the unit.

moment = ... [4]

26 **(a)** Fig. 3.1 shows the horizontal forces acting on a swimmer.

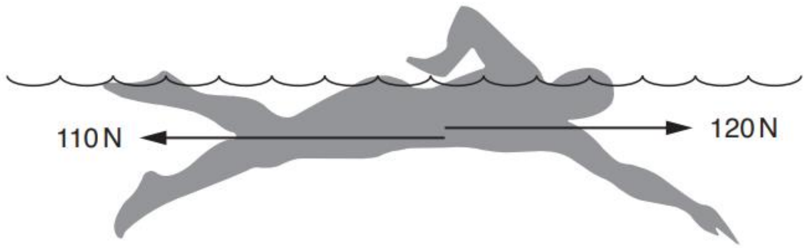


Fig. 3.1

(i) Calculate the size and direction of the resultant horizontal force on the swimmer.

size of resultant horizontal force = ... N

direction of resultant horizontal force = ...

[1]

(ii) State the name of the 110 N force on the swimmer.

.... [1]

(iii) Fig. 3.2 shows the horizontal forces acting on the swimmer as he moves forwards a short time later.

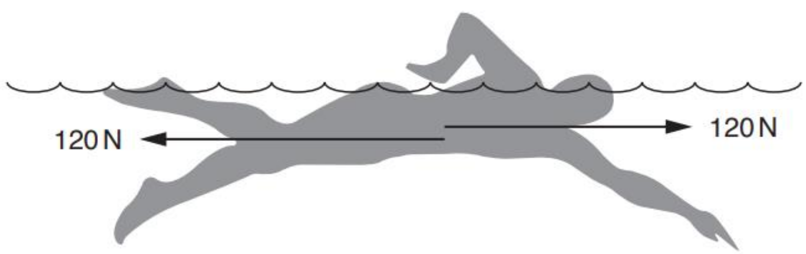


Fig. 3.2

Describe and explain the motion of the swimmer.

....

.... [2]

(b) Another swimmer weighs 700 N. He stands on a diving board, as shown in Fig. 3.3.

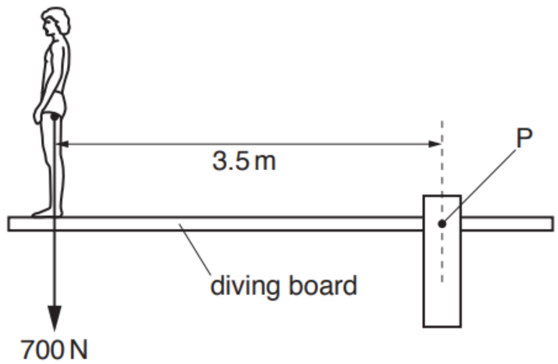


Fig. 3.3

Calculate the moment of the swimmer's weight about point P.

moment = ... N m [3]

[Total: 7]

27 **(a)** Fig. 4.1 shows a metal triangle suspended from a thread.

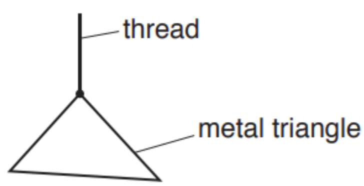


Fig. 4.1

Complete the sentence. Choose the correct word or phrase from the box.

above	below	to the left of	to the right of

The metal triangle will come to rest with its centre of mass directly .... the point of suspension. [1]

(b) A student finds the centre of mass of a shape made of thin card. Fig. 4.2 shows the equipment.

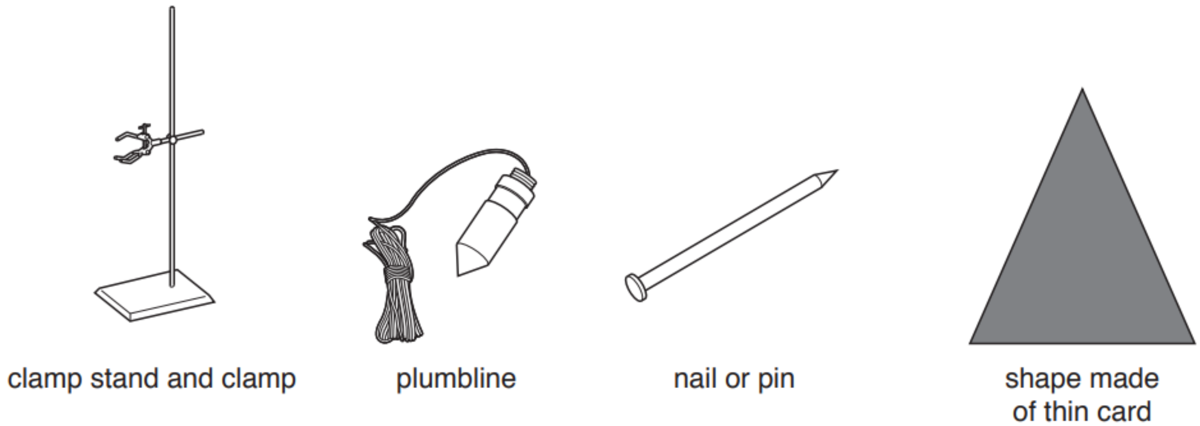


Fig. 4.2 (NOT to scale)

Describe how the student finds the centre of mass of the card. Choose from these sentences.

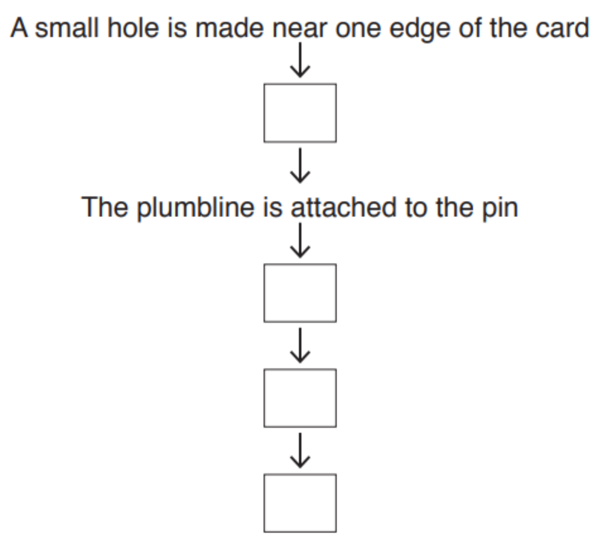
A A line is drawn on the card showing the position of the string.

B A pin held in a clamp is put through the hole in the card.

C The centre of mass is where the lines cross on the card.

D The process is repeated using holes near the other two edges.

Complete the flow chart. Write the letter for the correct sentence in each box.



[3]

[Total: 4]

28 Fig. 2.1 shows a man pushing down on a lever to lift one end of a heavy log.

Fig. 2.1

(a) State the term used to describe the turning force exerted by the man.

.... [1]

(b) **(i)** Fig. 2.2 shows the forces acting as the man starts to lift the heavy log.

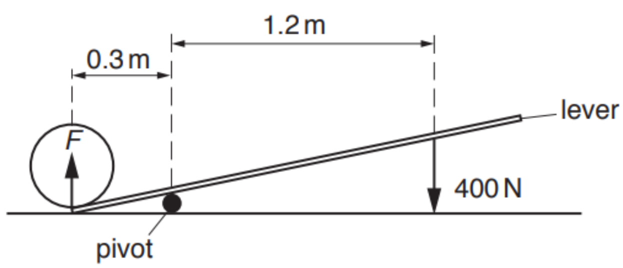


Fig. 2.2

Calculate the force *F*, exerted by the lever on the heavy log.

force *F* = ... N [3]

(ii) Describe how the man can use a smaller force to lift the heavy log.

....

.... [1]

[Total: 5]

29 Fig. 2.1 shows a raft floating on water.

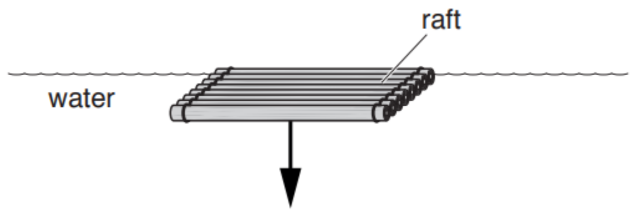


Fig. 2.1

(a) A force of 20 000 N acts on the raft in the direction of the arrow shown in Fig. 2.1.

(i) State the name given to the force shown in Fig. 2.1.

....[1]

(ii) Calculate the mass of the raft.

mass = ... kg [3]

(b) A sail is added to the raft, as shown in Fig. 2.2.

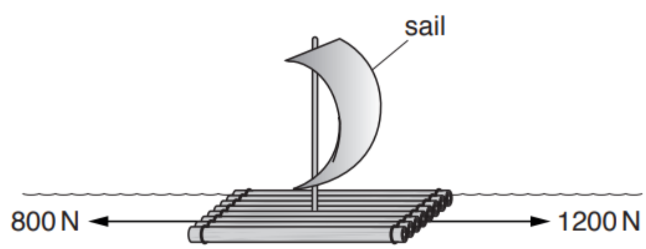


Fig. 2.2

Fig. 2.2 shows the horizontal forces acting on the raft at one moment.

Calculate the resultant horizontal force acting on the raft and state the direction of this force.

force = ... N

direction = ...[2]

[Total: 6]

30 A tower crane has a load W, as shown in Fig. 3.1.

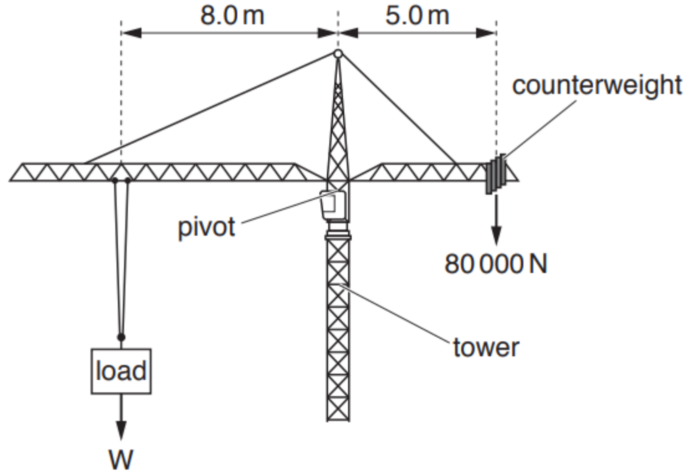


Fig. 3.1

(a) The counterweight has a weight of 80 000 N. This acts at a distance of 5.0 m from the pivot, as shown in Fig. 3.1.

Calculate the moment of the counterweight about the pivot. Give the unit.

moment = ...[3]

(b) The tower crane in Fig. 3.1 balances horizontally when holding the load W.

Calculate the weight of load W.

weight = ... N [3]

[Total: 6]

31 **(a)** Fig. 3.1 shows the vertical forces on a rocket.

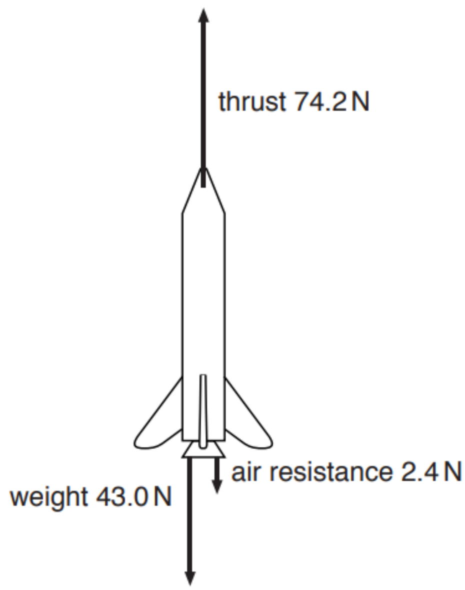


Fig. 3.1

Calculate the resultant force on the rocket.

resultant force = ... N

direction = ...[3]

(b) Fig. 3.2 shows the speed and direction of motion of an object at a point in time.

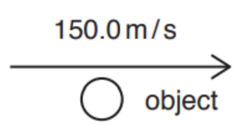


Fig. 3.2

The resultant force on the object is zero for 10 seconds.

Deduce the speed and direction of motion after 5 seconds. Indicate the speed and direction of the object by drawing a **labelled** arrow next to the object in Fig. 3.3.

Fig. 3.3

[1]

[Total: 4]

32 A man uses a metal bar to remove an iron nail from a piece of wood, as shown in Fig. 3.1.

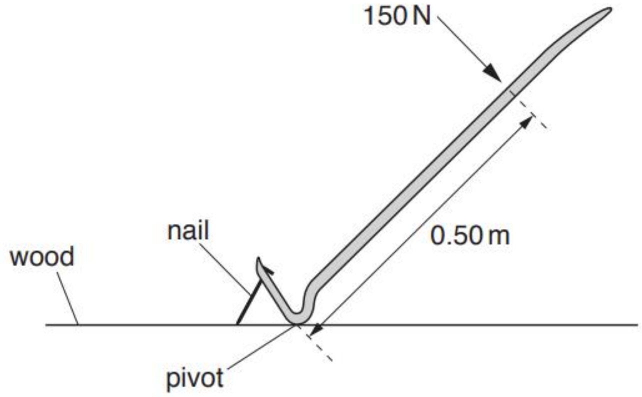


Fig. 3.1

(a) **(i)** The man applies a force of 150 N at a distance of 0.50 m from the pivot.

Calculate the moment of this force about the pivot. Include a unit.

moment = ...[4]

(ii) The force applied by the man produces a turning effect (moment) about the pivot.

Describe another example of using the turning effect of a force.

....

....[1]

(b) The man tries to use the metal bar to remove another nail from the piece of wood. He applies the same force of 150 N at a distance of 0.50 m from the pivot.

The turning effect produced is not enough to remove this nail from the piece of wood.

Describe how the man can increase the turning effect without increasing the force.

....

....[1]

[Total: 6]

Paper 4

Questions are applicable for both core and extended candidates unless indicated in the question

33 A spring is suspended from a clamp. Fig. 1.1 shows a pointer attached to the lower end of the spring.

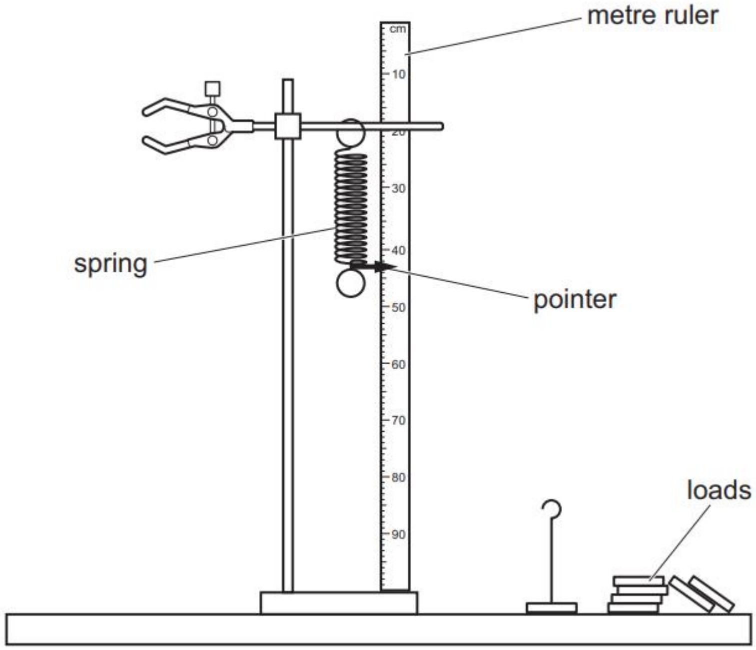


Fig. 1.1

A student suspends loads of different weights from the spring and records the readings on the metre ruler.

Fig. 1.2 is the reading–weight graph that the student obtains.

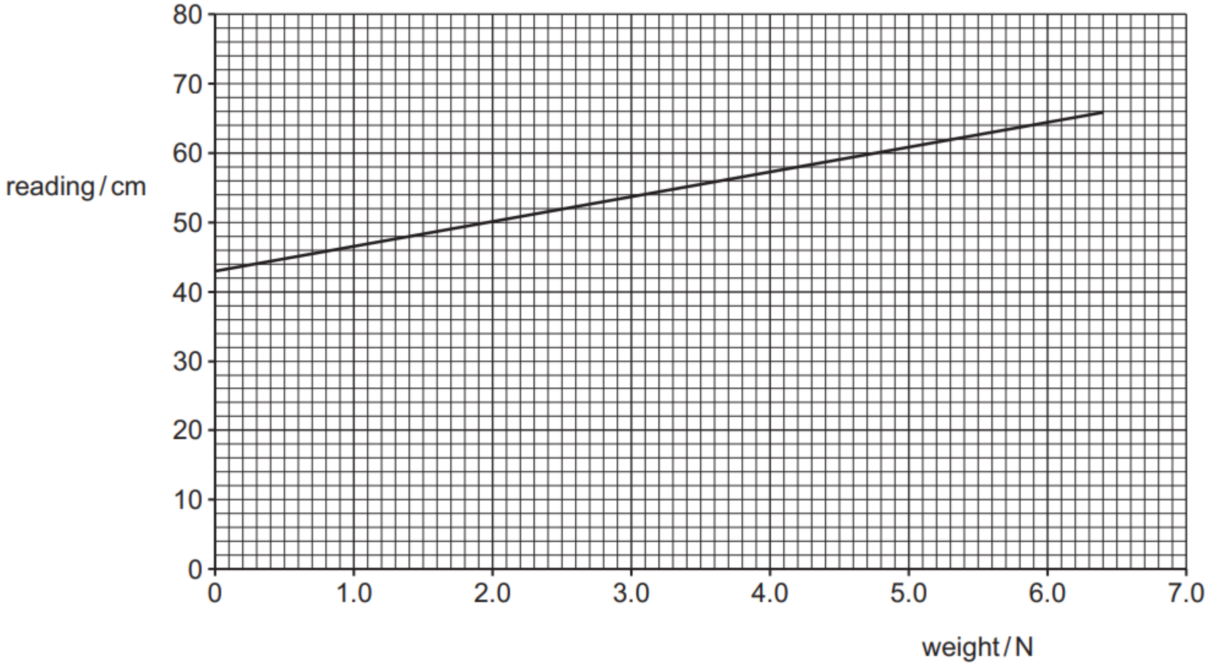


Fig. 1.2

(a) **(i)** Using Fig. 1.2, determine the reading on the metre ruler when

1. no weight is attached to the spring ....

2. a weight of 5.6 N is attached to the spring .... [1]

(ii) Calculate the **extension** of the spring when the weight attached is 5.6 N.

extension = ... [1]

(b) Using the values found in **(a)**, calculate the spring constant of the spring. **(extended only)**

spring constant = ... [2]

(c) An object of mass 0.50 kg is attached to the spring.

(i) Calculate the weight of the object.

weight = ... [1]

(ii) The object is pulled downwards until the tension in the spring is 6.5 N.

The object is released.

Calculate the acceleration of the object immediately after it is released.
(extended only)

acceleration = ... [3]

[Total: 8]

34 **(a)** Define the moment of a force and describe the effect that it measures.

....

....

....

.... [3]

(b) A large rectangular block of stone has a square base of side 3.4 m. Fig. 3.1 shows the block at rest on a horizontal surface.

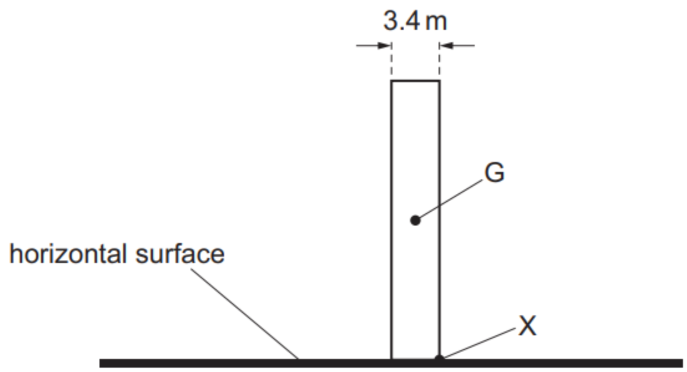


Fig. 3.1

The block is of uniform density and the centre of gravity G is at its centre.

(i) Explain what is meant by centre of gravity.

....

.... [1]

(ii) The weight of the block is 1.3×10^7 N.

Calculate the moment of the weight of the block about corner X.

moment of weight = ... [2]

(c) The block shown in Fig. 3.1 is in equilibrium.

State the **two** different conditions that apply when an object is in equilibrium.

1 ....

2 ....
[2]

[Total: 8]

35 A load is suspended from a thread. The vertical force on the thread due to the load is 0.75 N.

(a) Calculate the mass of the load.

mass = ... [2]

(b) Fig. 1.1 shows the load suspended from the thread. **(extended only)**

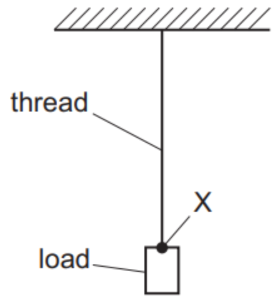


Fig. 1.1

A wire is attached to the load at point X and pulled horizontally to the right.

The tension in the horizontal wire is 1.2 N.

By drawing a scale diagram or by calculation, determine:

- the magnitude of the resultant of the force at X due to the load and due to the tension in the wire
- the direction of the resultant relative to the vertical direction.

Show your working.

magnitude of resultant force = ... N

direction of resultant relative to vertical = ... °
[4]

(c) Forces may produce changes in the size and the shape of an object.

State **two** other changes that forces may produce.

1 ....

2 ....
[2]

[Total: 8]

36 A radio transmitter is a very tall, thin cylinder. It is prevented from falling over by wires which have one end fixed to the transmitter and the other end fixed in the ground. The ends of the wires in the ground are a long distance from the transmitter.

Fig. 4.1 shows the transmitter and two of the wires.

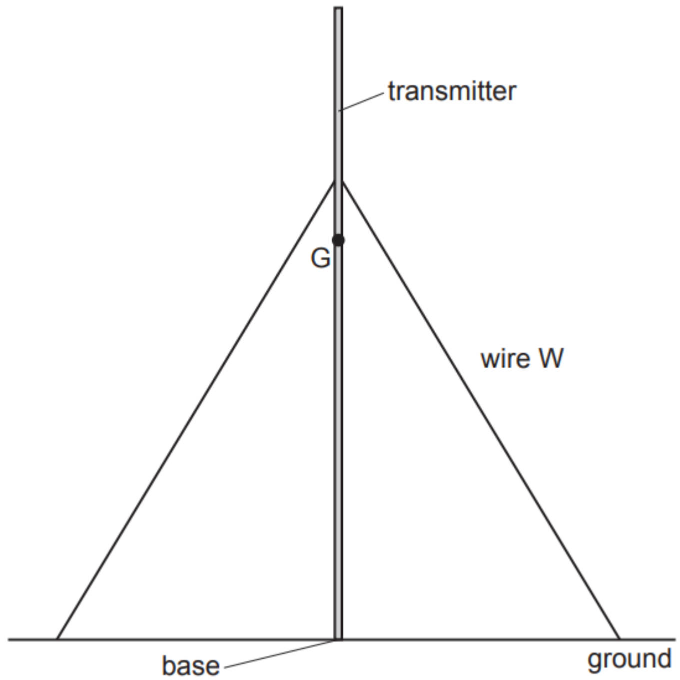


Fig. 4.1

(a) The centre of gravity G is shown on Fig. 4.1.

(i) State what is meant by centre of gravity.

....

.... [1]

(ii) Explain why the radio transmitter without the wires is a very unstable structure.

....

.... [1]

(b) Wire W is under tension and it exerts a force *T* on the transmitter.

(i) On Fig. 4.1, mark an arrow to show the force *T* exerted by wire W on the transmitter. [1]

(ii) The force *T* produces a moment on the transmitter about its base.

Describe how the moment produced by *T* is calculated and indicate on Fig. 4.1 what is meant by any other terms in the description.

....

.... [3]

(c) The radio transmitter uses radio waves to transmit radio and television programmes.

State **one** other use of radio waves.

....

.... [1]

[Total: 7]

37 Fig. 2.1 shows a motorcyclist accelerating along a straight horizontal section of track.

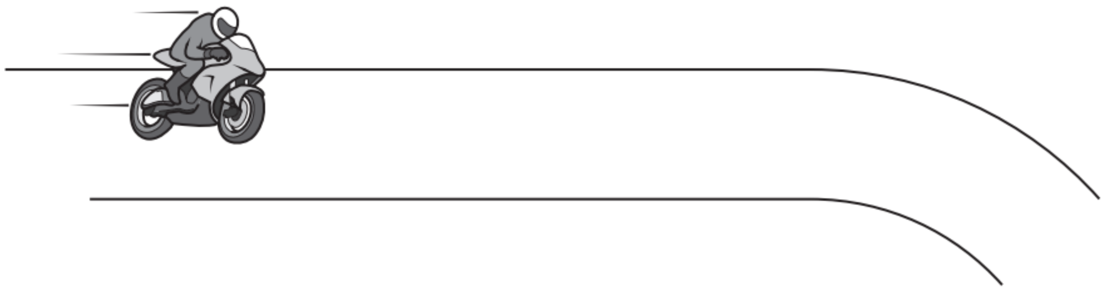


Fig. 2.1

The motorcyclist and motorcycle have a combined mass of 240 kg.

(a) On the straight horizontal section of the track, the motorcyclist accelerates from rest at 7.2 m/s^2.

(i) The motorcyclist reaches the end of the straight section of track in 5.3 s.

Calculate the speed of the motorcyclist at the end of the straight section. **(extended only)**

speed = ... [2]

(ii) Calculate the resultant force on the motorcyclist and motorcycle on the straight section of track. **(extended only)**

resultant force = ... [2]

(b) At the end of the straight section, the track remains horizontal but bends to the right, as shown in Fig. 2.1.

When the motorcyclist reaches the bend, she travels around the bend in a circular path at a constant speed.

(i) Velocity is a vector quantity. **(extended only)**

State how a vector quantity differs from a scalar quantity.

....

.... [1]

(ii) Describe what happens to the velocity of the motorcyclist as she travels around the bend at constant speed. **(extended only)**

....

.... [1]

(iii) Explain why there must be a resultant force on the motorcyclist as she travels around the bend. **(extended only)**

....

....

.... [2]

[Total: 8]

38 **(a)** Fig. 1.1 shows a helicopter which is stationary at a height of 1500 m above the ground.

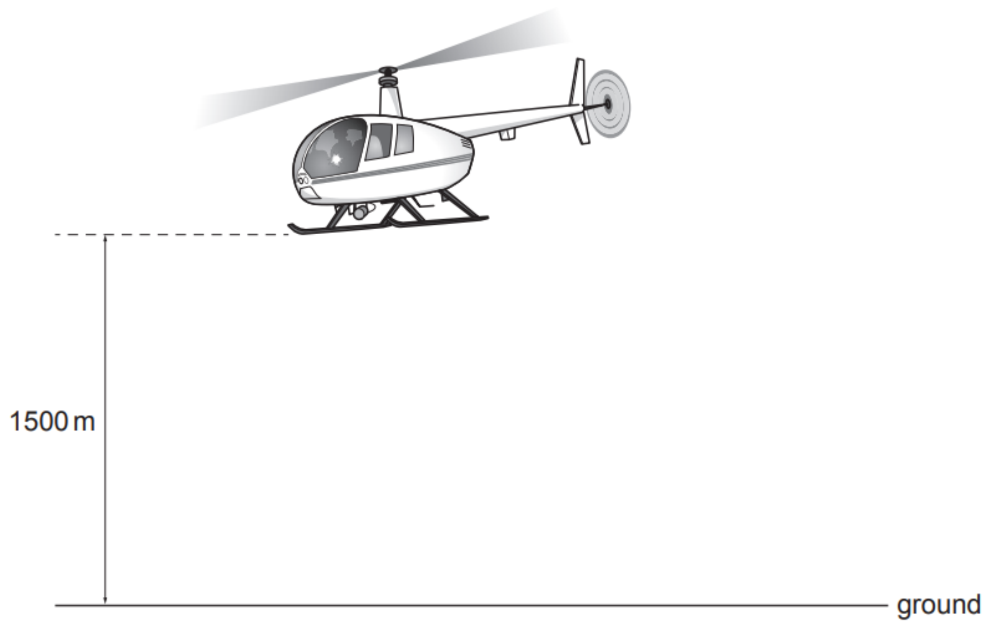


Fig. 1.1 (not to scale)

(i) State the **two** conditions necessary for the helicopter to remain in equilibrium.

condition 1 ....

....

condition 2 ....

....
[2]

(b) Fig. 1.2 shows a vertical speed–time graph for a parachutist who jumps from a stationary hot-air balloon.

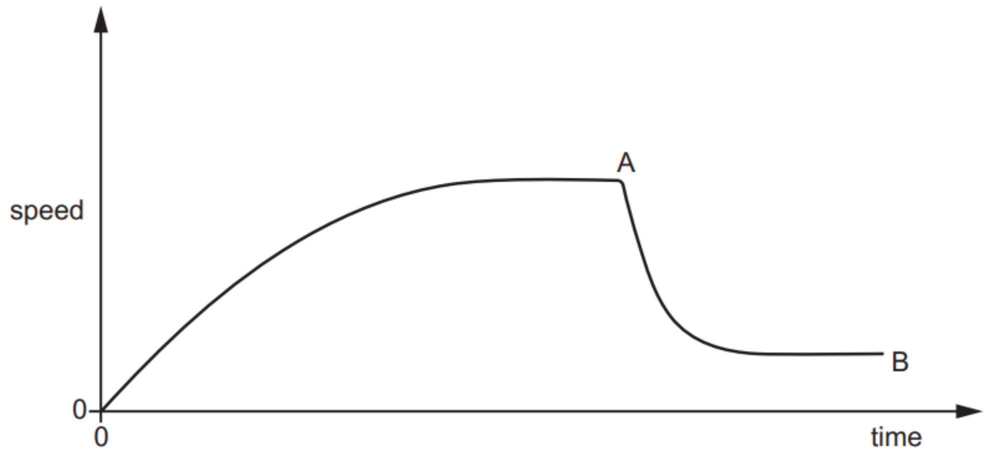


Fig. 1.2

The parachutist jumps from the balloon at time = 0 and reaches the ground at B. The point A indicates when the parachute opens.

(i) On Fig. 1.2, label a point on the graph where the acceleration is:

- zero with '1'
- negative with '2'
- decreasing with '3'. [3]

(ii) Explain, in terms of forces, the changes in motion which occur from when the parachutist leaves the hot-air balloon until point A. **(extended only)**

....

....

....

....

....

....

....

.... [4]

[Total: 11]

39 A student catches a cricket ball. The speed of the ball immediately before it is caught is 18 m/s. The mass of the cricket ball is 160 g.

(b) It takes 0.12 s to catch the ball and bring it to rest. **(extended only)**

Calculate the average force exerted on the ball.

average force = ... [2]

(c) As the student catches the ball, she moves her hands backwards. **(extended only)**

Explain the effect of this action on the student's hands.

....

.... [1]

[Total: 6]

40 A force is a vector quantity.

(a) **(i)** State **two** features of a vector quantity. **(extended only)**

1. ....

2. ....
[2]

(ii) State the names of **two** other quantities that are vectors. **(extended only)**

1. ....

2. ....
[2]

(b) A student suspends a spring from a clamp stand and measures the length l_0 of the spring.

Fig. 2.1 shows the apparatus.

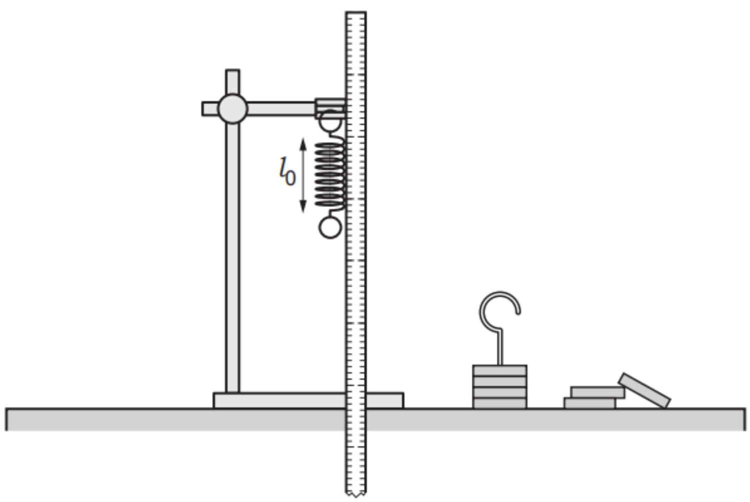


Fig. 2.1 (not to scale)

The student then suspends loads of different weights from the spring and measures the length of the spring for each load. He then plots a graph of the length of the spring against weight.

Fig. 2.2 is the graph that the student plots.

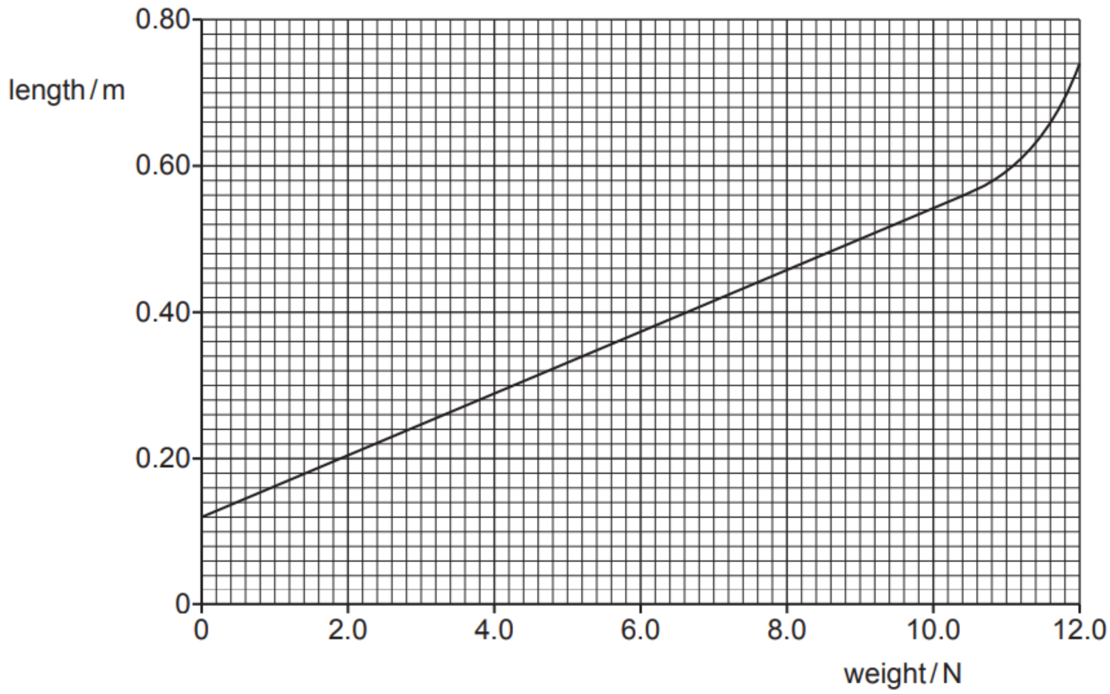


Fig. 2.2

(i) Using Fig. 2.2, determine the initial length l_0 of the spring.

l_0 = ... [1]

(ii) State what is meant by the limit of proportionality and, using Fig. 2.2, determine the weight of the load that causes this spring just to reach the limit of proportionality. **(extended only)**

limit of proportionality ....

....

....

weight = ...

[2]

(iii) Using Fig. 2.2, determine the spring constant of this spring. **(extended only)**

spring constant = ... [3]

[Total: 10]

41 A rock climber, of total mass 62 kg, holds herself in horizontal equilibrium against a vertical cliff. She pulls on a rope that is fixed at the top of the cliff and presses her feet against the cliff.

Fig. 3.1 shows her position.

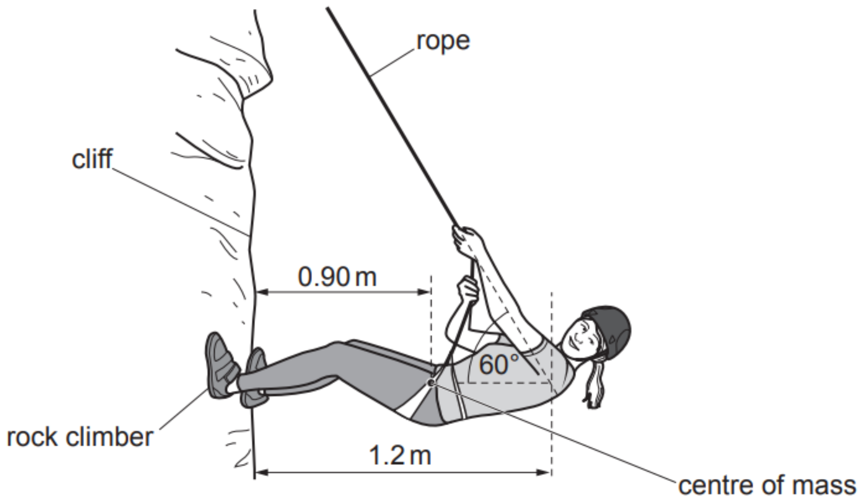


Fig. 3.1 (not to scale)

(a) Calculate the total weight of the climber.

weight = ... [1]

(b) State the **two** conditions needed for equilibrium.

1. ....

2. ....
[2]

(c) The climber's centre of mass is 0.90 m from the cliff.

(i) Calculate the moment about her feet due to her weight.

moment = ... [2]

(ii) The line of the rope meets the horizontal line through her centre of mass at a distance of 1.2 m from the cliff, as shown in Fig. 3.1. The rope is at an angle of 60° to the horizontal.

Determine the tension in the rope.

tension = ... [3]

[Total: 8]

42 Fig. 2.1 shows an object of mass 2.0 kg on a bench. This object is connected by a cord, passing over a pulley, to an object of mass 3.0 kg.

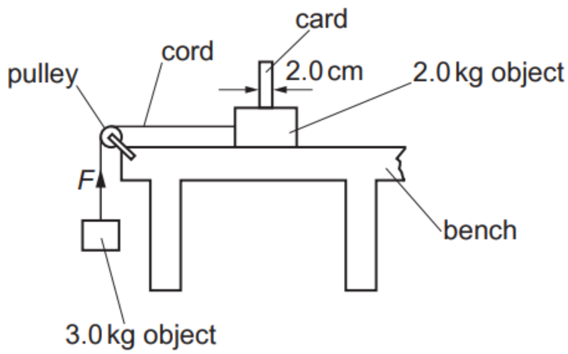


Fig. 2.1

The 2.0 kg object is released from rest and accelerates at 4.0 m/s^2.

(a) Calculate the resultant force acting on the 2.0 kg object. **(extended only)**

force = ... [2]

(b) Calculate the upward force *F* exerted by the cord on the 3.0 kg object. **(extended only)**

force *F* = ... [3]

(c) The objects have a constant acceleration.

(i) Show that the speed of the objects 0.80 s after release is 3.2 m/s. **(extended only)**

[2]

(ii) A card, of width 2.0 cm, is fixed to the 2.0 kg object. As the 2.0 kg object moves to the left, the card passes through a beam of light that is perpendicular to the card.

Using the speed given in **(c)(i)**, calculate the time taken for the card to pass through the beam of light.

time = ... [2]

[Total: 9]

43 **(a)** Fig. 3.1 shows water in a river moving parallel to the river bank at 4.0 m/s and a canoe travelling in the river. **(extended only)**

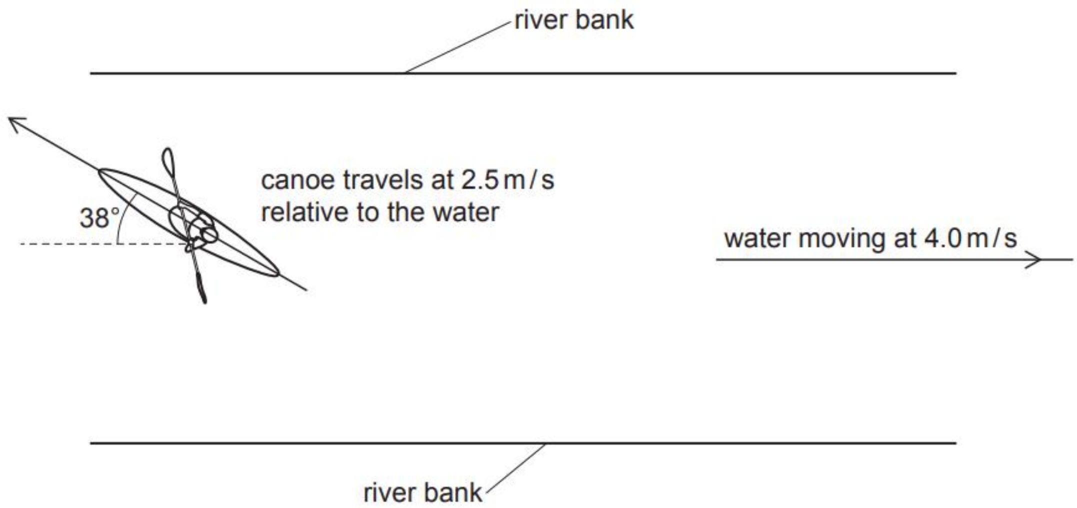


Fig. 3.1

The canoe travels at 2.5 m/s relative to the water and heads at an angle of 38° to the river bank.

Draw a scale diagram to determine the canoe's resultant velocity and state the scale you used.

scale ....

magnitude of resultant velocity ....

direction of resultant velocity (angle from the river bank) ....

[4]

(b) The mass of the canoeist is 65 kg. **(extended only)**

Calculate her kinetic energy when travelling on still water at 2.5 m / s.

energy = ... [2]

[Total: 6]

44 **(a)** State Hooke's law. **(extended only)**

....

.... [1]

(b) Fig. 2.1 shows the extension–load graph for a spring.

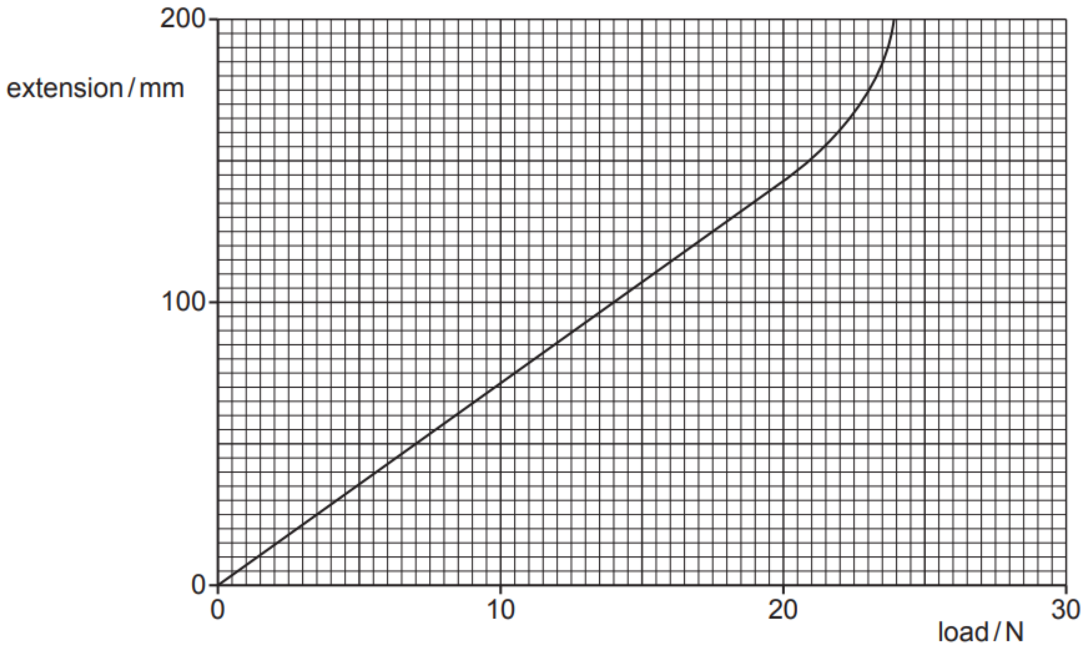


Fig. 2.1

(extended only)

(i) On Fig. 2.1, mark and label the region where the spring obeys Hooke's law. [1]

(ii) Calculate the spring constant *k*. **(extended only)**

k = ... [2]

(iii) The original length of the spring is 120 mm. **(extended only)**

Calculate the length of the spring when a load of 8.5 N is applied to the spring.

length = ... [2]

(c) The weight of an object is 4.0 N on a planet where the acceleration of free fall is 8.7 m/s^2.

Calculate the mass of the object.

mass = ... [2]

[Total: 8]

45 A skydiver of mass 76 kg is falling vertically in still air. At time $t = 0$, the skydiver opens his parachute.

Fig. 1.1 is the speed–time graph for the skydiver from $t = 0$.

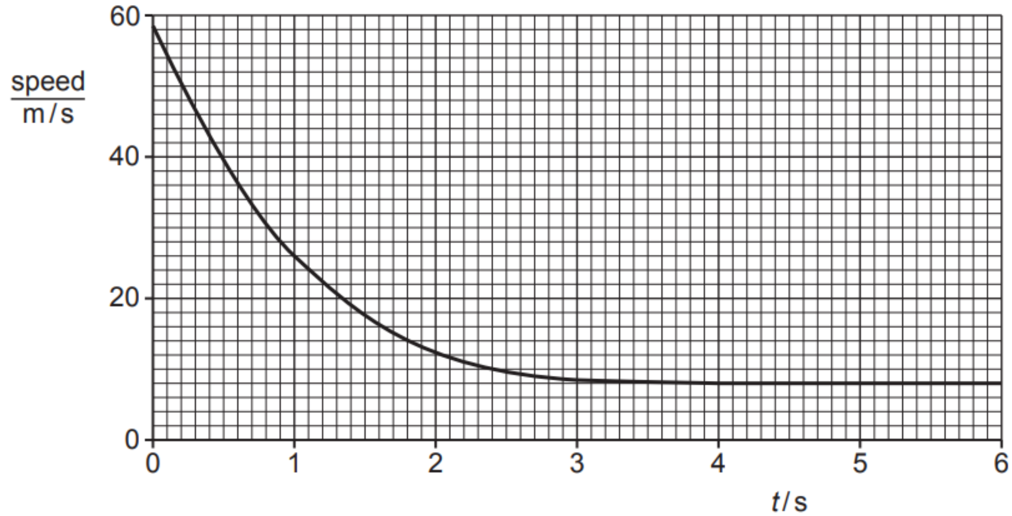


Fig. 1.1

(a) Using Fig. 1.1, determine:

(i) the deceleration of the skydiver immediately after the parachute opens **(extended only)**

deceleration = ... [2]

(ii) the force due to air resistance acting on the skydiver immediately after the parachute opens. **(extended only)**

force = ... [3]

(b) Explain, in terms of the forces acting on the skydiver, his motion between $t = 0$ and $t = 6.0$ s. **(extended only)**

....

....

....

.... [3]

(c) Explain why opening the parachute cannot reduce the speed of the skydiver to zero. **(extended only)**

....

....

.... [2]

[Total: 10]

46 **(a)** Define the *moment* of a force.

.... [1]

(b) Fig. 2.1 shows an object of negligible weight. The object is in equilibrium.

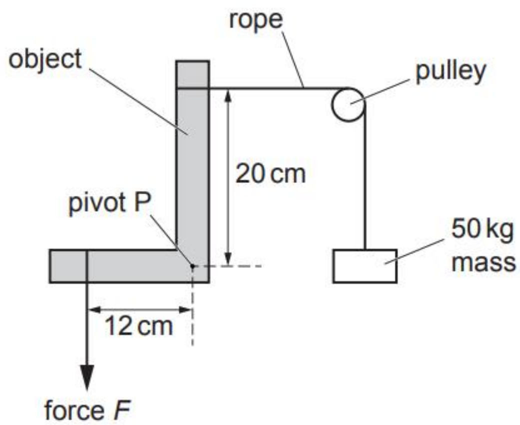


Fig. 2.1

The object is free to rotate about its pivot P.

Calculate the value of force F.

F = ... [2]

(c) Describe an experiment involving vertical forces to show that there is no net moment on an object in equilibrium. You may draw a diagram in the space provided. **(extended only)**

....

....

....

....

....

.... [3]

[Total: 6]

47 Fig. 3.1 shows water flowing at very slow speed over a cliff edge.

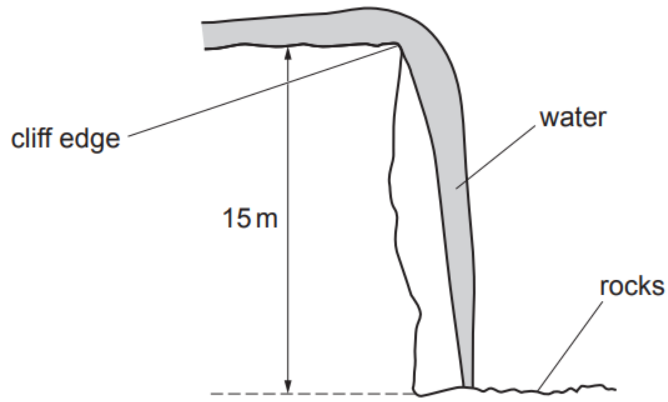


Fig. 3.1

The water falls 15 m onto the rocks below.

(a) Show that the velocity of the water when it strikes the rocks is 17 m/s. **(extended only)**

[4]

(b) 30 kg of water flows over the cliff edge every second. **(extended only)**

Calculate the force exerted by the rocks on the falling water. Ignore any splashing.

force = ... [3]

[Total: 7]

48 **(a)** Define the moment of a force about a point.

....

.... [1]

(b) Fig. 2.1 shows a uniform rod of wood suspended from a pivot.

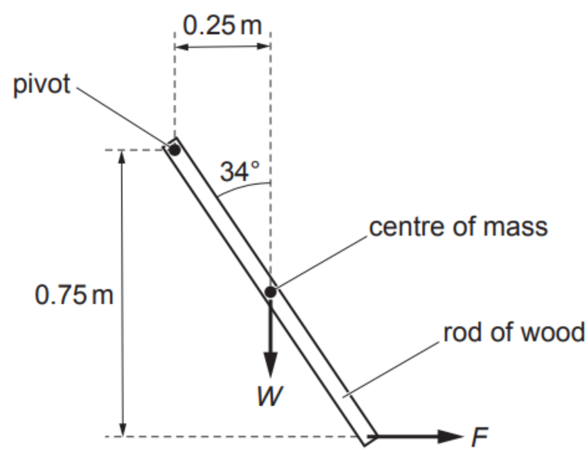


Fig. 2.1 (not to scale)

The rod is held stationary by a horizontal force F acting as shown.
The mass of the rod is 0.080 kg.

Calculate:

(i) the weight W of the rod

weight = ... [1]

(ii) the moment of W about the pivot

moment = ... [2]

(iii) the moment of F about the pivot

moment = ... [1]

(iv) the force F.

force = ... [2]

(c) The angle between the rod and the vertical is increased.

State whether the force *F* needed to hold the rod stationary must be increased, decreased or stay the same.
Explain your answer.

....

....

....

.... [2]

[Total: 9]

49 Fig. 2.1 shows a train.

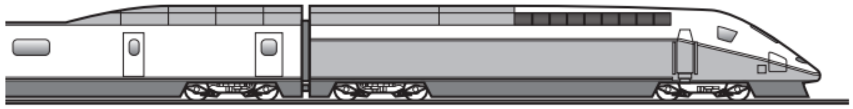


Fig. 2.1

The total mass of the train and its passengers is 750 000 kg. The train is travelling at a speed of 84 m/s. The driver applies the brakes and the train takes 80 s to slow down to a speed of 42 m/s.

(b) Calculate the average resultant force applied to the train as it slows down. **(extended only)**

force = ... [2]

(c) Suggest how the shape of the train helps it to travel at high speeds.

....

.... [1]

(d) The train took 80 s to reduce its speed from 84 m/s to 42 m/s. Explain why, with the same braking force, the train takes more than 80 s to reduce its speed from 42 m/s to zero.

....

.... [1]

(e) On a wet day, the train travels a greater distance before it stops along the same track. The train has the same speed of 84 m/s before the brakes are applied.

Suggest a reason for this.

....

.... [1]