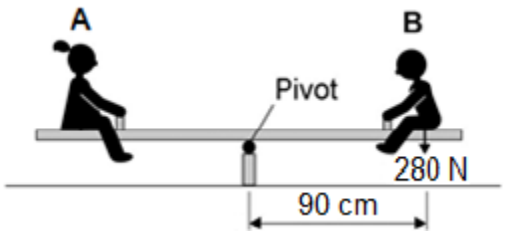
1 Two children, **A** and **B**, are sitting on a see-saw, as shown in the figure below.

The see-saw is balanced.



(a) Use the following equation to calculate the moment of child **B** about the pivot of the see-saw.

moment of a force = force × distance

Give your answer in newton-metres

.....

.....

.....

Moment = ... Nm

(2)

(b) Use the idea of moments to explain what happens when child **B** moves closer to the pivot.

.....

.....

.....

.....

.....

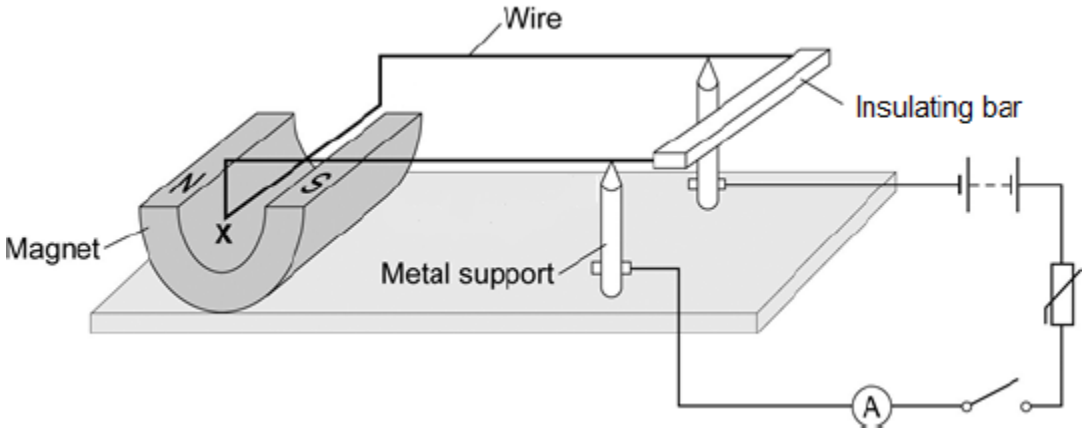
.....

(3)

(Total 5 marks)

2 **Figure 1** shows a piece of apparatus called a current balance.

Figure 1



When the switch is closed, the part of the wire labelled **X** experiences a force and moves downwards.

(a) What is the name of the effect that causes the wire **X** to move downwards?

.....

(1)

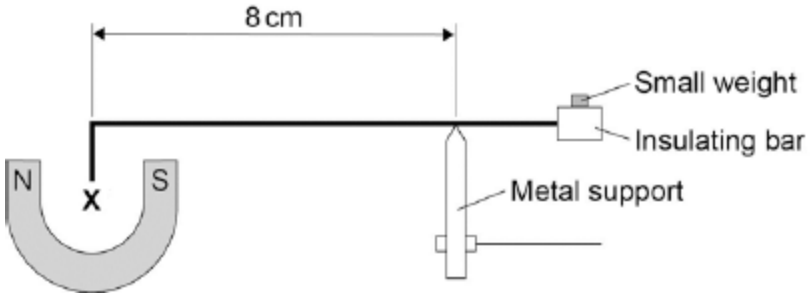
(b) Suggest one change you could make to the apparatus in **Figure 1** that would increase the size of the force that wire **X** experiences.

.....

(1)

(c) **Figure 2** shows how a small weight placed on the insulating bar makes the wire **X** go back and balance in its original position.

Figure 2



The wire **X** is 5 cm long and carries a current of 1.5 A.

The small weight causes a clockwise moment of 4.8×10^{-4} Nm.

Calculate the magnetic flux density where the wire **X** is positioned

Give the unit.

.....

.....

.....

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.....

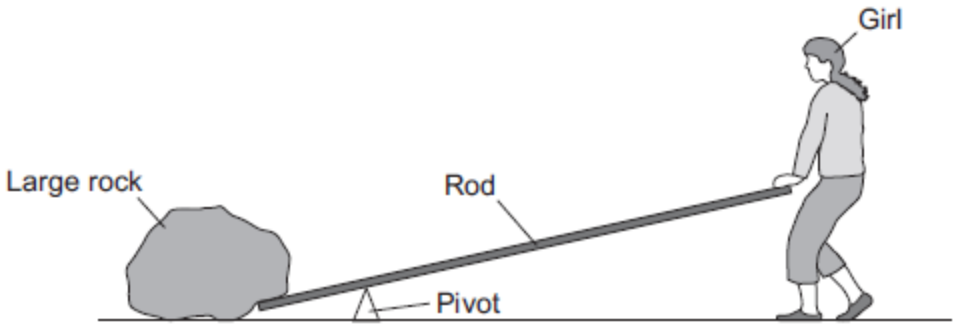
Magnetic flux density = ... Unit .....

(6)
(Total 8 marks)

3 Levers and hydraulic systems can act as force multipliers.

(a) **Figure 1** shows a girl trying to lift a large rock using a long rod as a lever.

Figure 1



The girl is pushing down on the rod but is just unable to lift the rock.

Which of the following changes would allow her to lift the rock?

Tick (✓) **two** boxes.

Change	**Tick (✓)**
Move the pivot away from the rock	
Make the rod longer	
Push the rod upwards	
Push down on the rod with a greater force	

(2)

(b) Liquids are used in hydraulic systems because they are virtually incompressible.

Explain how the spacing of particles in a liquid cause it to be virtually incompressible.

.....

.....

.....

.....

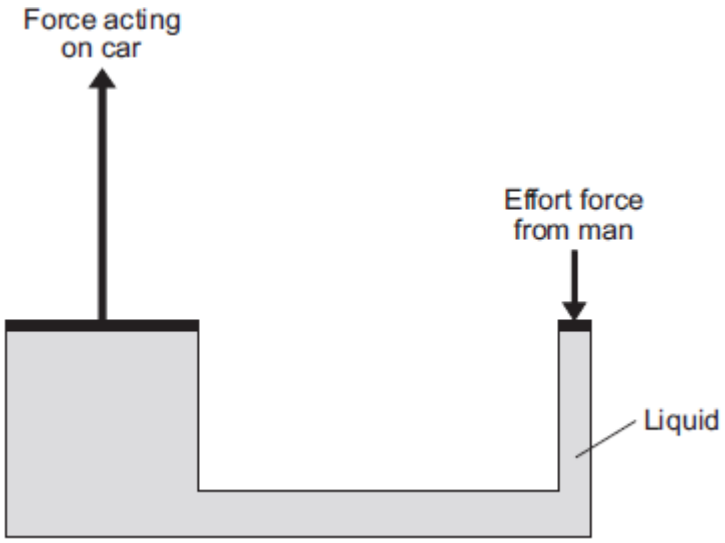
(2)

(c) **Figure 2** shows a man using a car jack to lift his car.

Figure 2

Figure 3 shows a simple diagram of a car jack.

Figure 3



(i) The man pushes down with an effort force. This results in a much larger force acting upwards on the car.

Use information from **Figure 3** to explain how.

.....

.....

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.....

.....

(4)

(ii) Which of the following statements about the forces in **Figure 3** is correct?

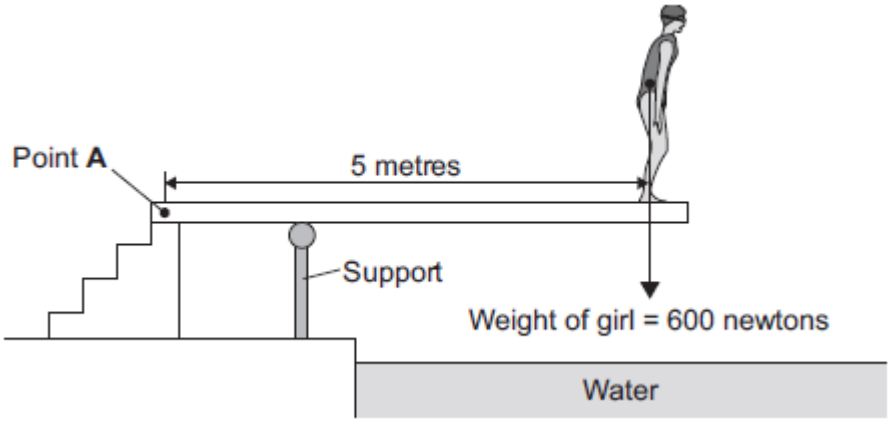
Tick (✓) **one** box.

	Tick (✓)
The force acting on the car moves a greater distance than the effort force.	
The force acting on the car moves less distance than the effort force.	
The force acting on the car moves the same distance as the effort force.	

(1)
(Total 9 marks)

4 **Figure 1** shows a girl standing on a diving board.

Figure 1



(a) Calculate the moment of the girl's weight about Point **A**.

.....

.....

.....

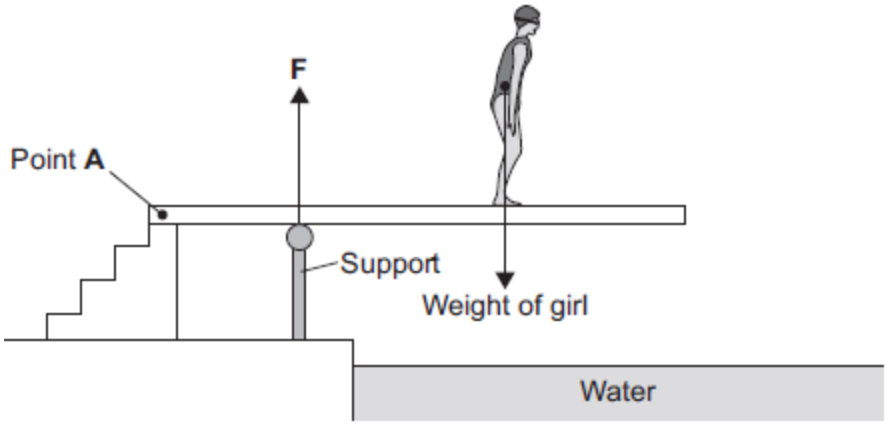
Moment = ... newton metres

(2)

(b) **Figure 2** shows the girl standing at a different place on the diving board.

The support provides an upward force **F** to keep the diving board balanced.

Figure 2



Complete the following sentence.

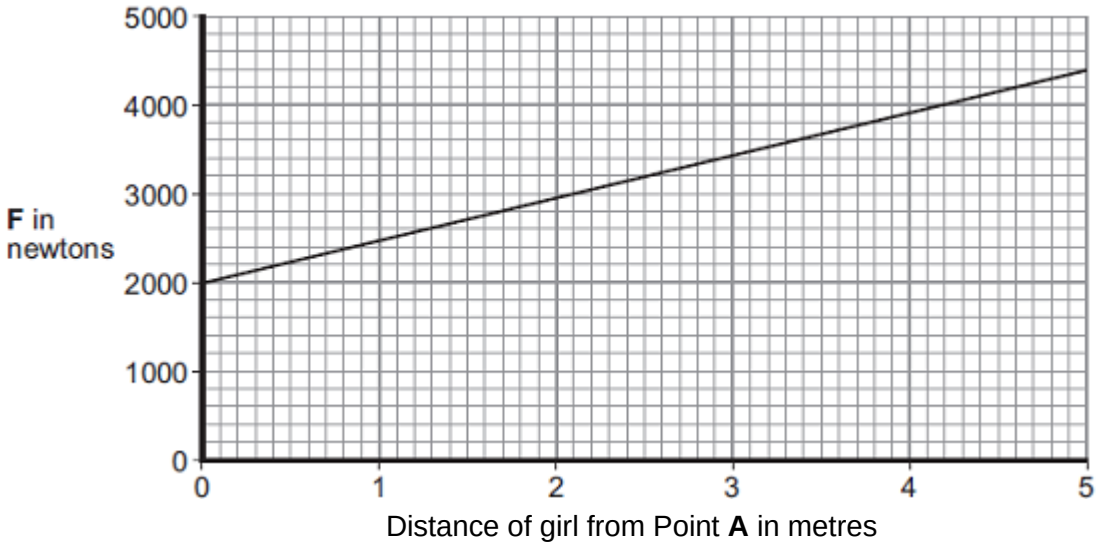
The diving board is not turning. The total clockwise moment is balanced

by the total ..... .

(1)

(c) **Figure 3** shows how the upward force **F** varies with the distance of the girl from Point **A**.

Figure 3



(i) Use **Figure 3** to determine the upward force **F** when the girl is standing at a distance of 3 metres from point **A**.

Upward force **F** = ... newtons

(1)

(ii) What conclusion should be made from **Figure 3**?

.....

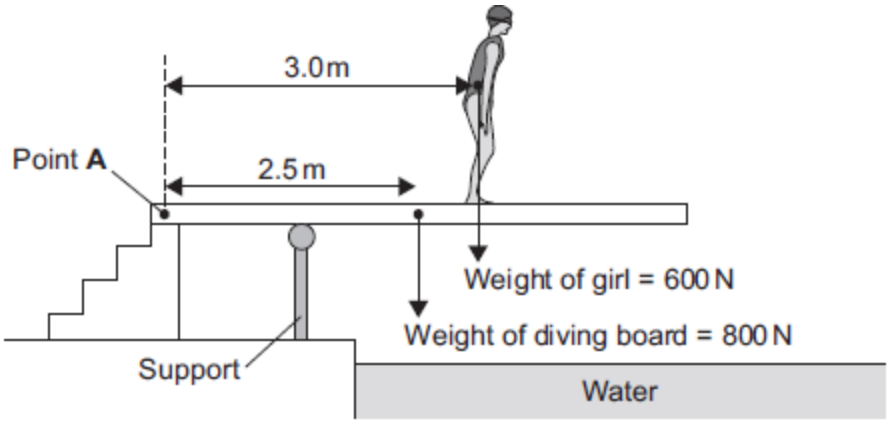
.....

.....

(1)
(Total 5 marks)

5 (a) **Figure 1** shows a girl standing on a diving board.

Figure 1



Calculate the total clockwise moment of the weight of the diving board and the weight of the girl about Point **A**. Give the unit.

.....

.....

.....

.....

.....

.....

.....

Total clockwise moment about Point **A** = ...

(4)

(b) **Figure 2** shows the girl standing at a different place on the diving board.

The support provides an upward force **F** to keep the diving board balanced.

Figure 2

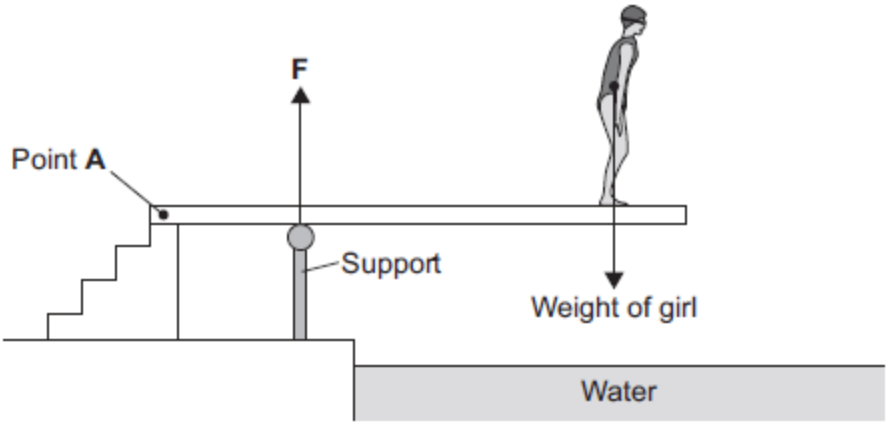
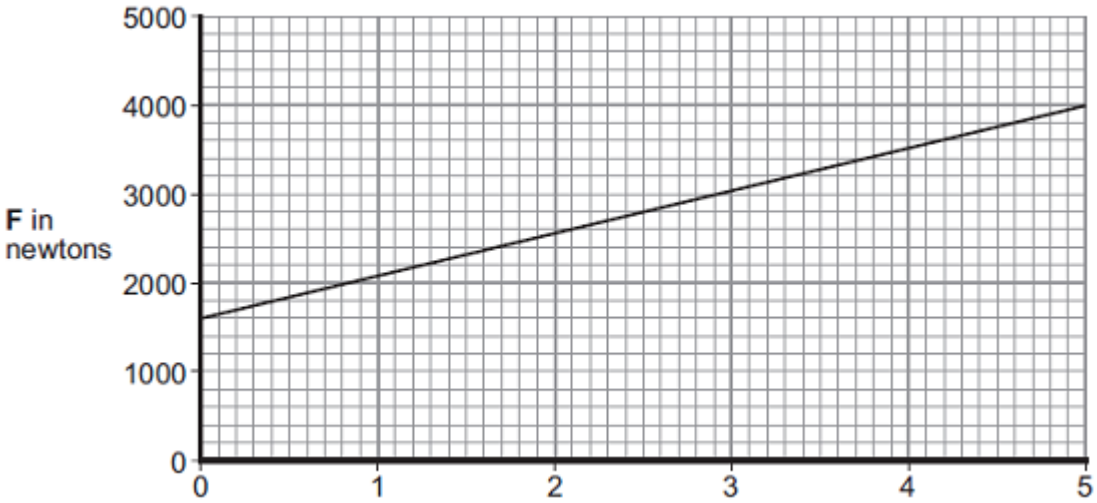


Figure 3 shows how the upward force **F** varies with the distance of the girl from Point **A**.

Figure 3



Explain, in terms of clockwise and anticlockwise moments, why the upward force **F** increases as shown in **Figure 3**.

.....

.....

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.....

(3)
(Total 7 marks)

6 Forces have different effects.

(a) (i) Use the correct answer from the box to complete the sentence.

slowing	**stretching**	**turning**

The moment of a force is the ..... effect of the force.

(1)

(ii) What is meant by the centre of mass of an object?

.....

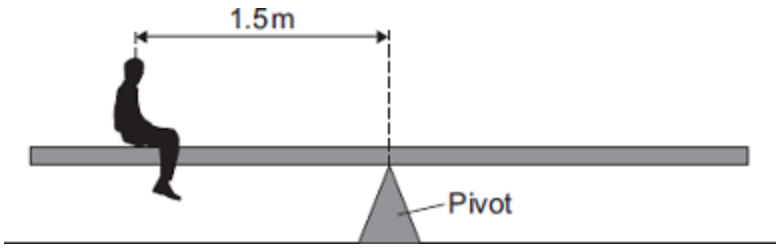
.....

(1)

(b) Some children build a see-saw using a plank of wood and a pivot.
The centre of mass of the plank is above the pivot.

Figure 1 shows a boy sitting on the see-saw. His weight is 400 N.

Figure 1



Calculate the anticlockwise moment of the boy in Nm.

.....

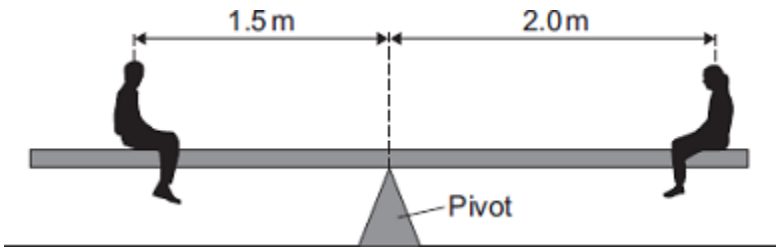
.....

Anticlockwise moment = ... Nm

(2)

(c) **Figure 2** shows a girl sitting at the opposite end of the see-saw. Her weight is 300 N.

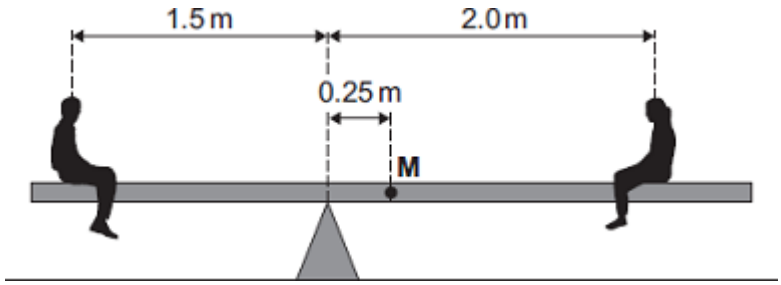
Figure 2



The see-saw is now balanced.

The children move the plank. Its centre of mass, **M**, is now 0.25 m from the pivot as shown in **Figure 3**.

Figure 3



The boy and girl sit on the see-saw as shown in **Figure 3**.

(i) Describe **and** explain the rotation of the see-saw.

.....

.....

.....

.....

.....

.....

.....

(3)

(ii) The boy gets off the see-saw and a bigger boy gets on it in the same place. The girl stays in the position shown in **Figure 3**. The plank is balanced. The weight of the plank is 270 N.

Calculate the weight of the bigger boy.

.....

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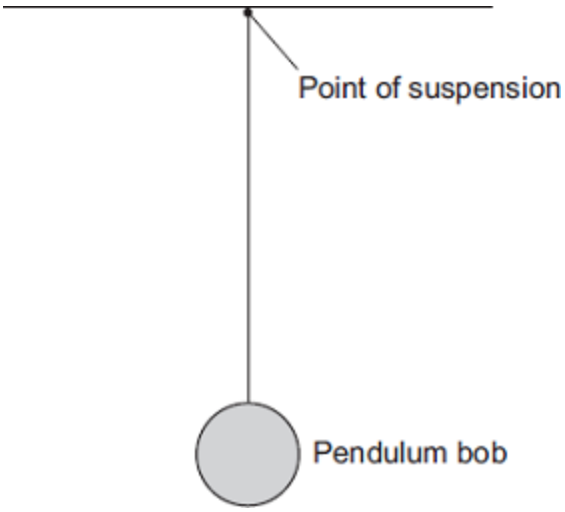
.....

Weight of the bigger boy = ... N

(3)

(Total 10 marks)

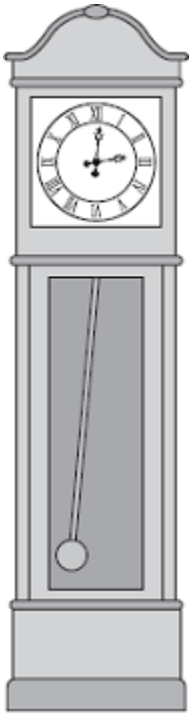
7 (a) The diagram shows a pendulum.



Draw an X on the diagram above, so that the centre of the **X** marks the centre of mass of the pendulum bob.

(1)

(b) A large clock keeps time using the swing of a pendulum.



(i) The frequency of the swinging pendulum is 0.5 hertz.

Calculate the periodic time of the pendulum.

.....

.....

.....

Periodic time = ... seconds

(2)

(ii) Calculate the number of complete swings the pendulum would make in 60 seconds.

Use your answer from part (b)(i) in your calculation.

.....

.....

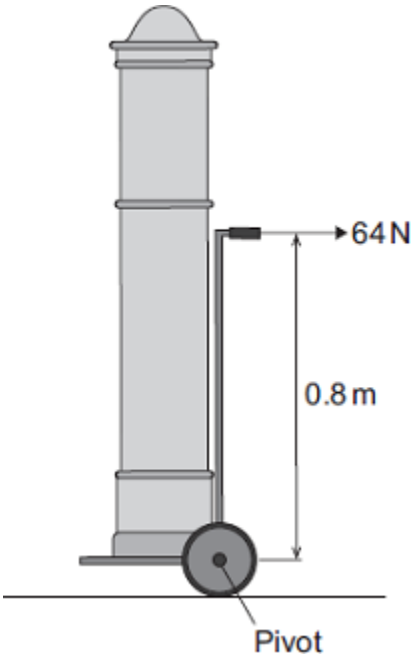
.....

Number of swings in 60 seconds = ...

(2)

(c) The diagram shows a clock on a trolley.

The trolley is being used to move the clock.



Calculate the moment of the 64 N force about the pivot.

.....

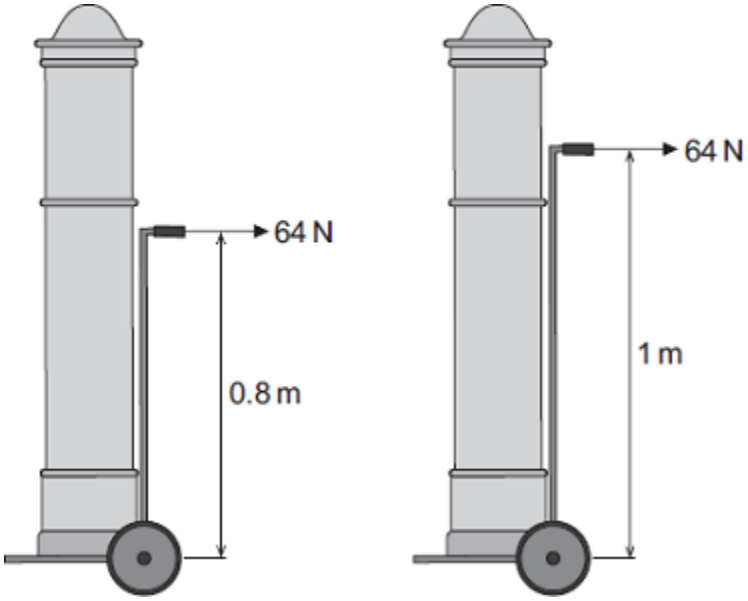
.....

.....

Moment of the force = ... Nm

(2)

(d) The design of the trolley is now changed to make it taller.



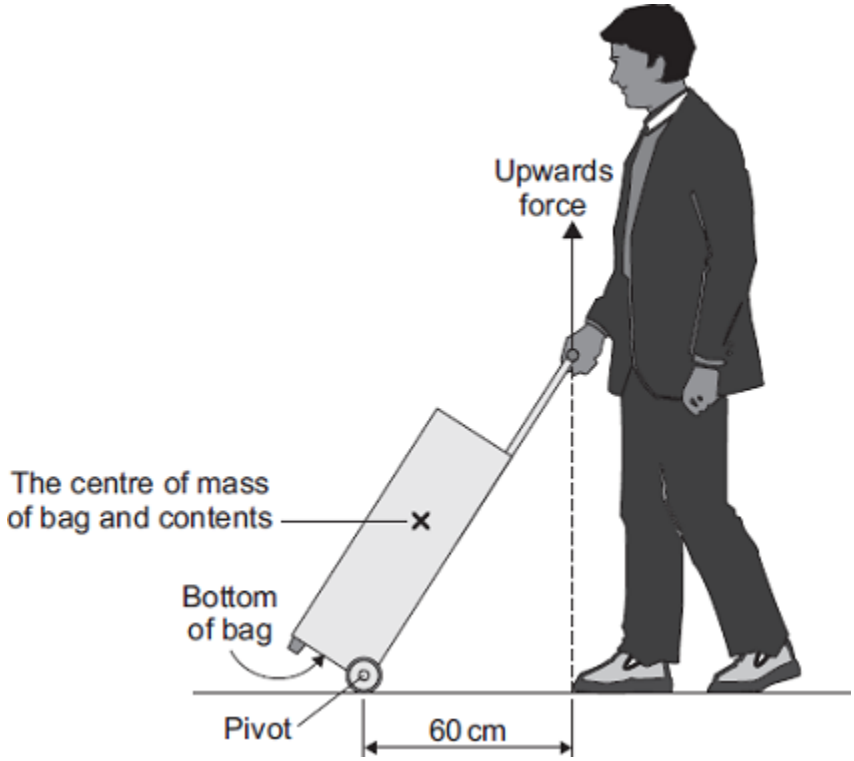
How does making the trolley taller affect the moment produced by the 64 N force about the pivot?

.....

.....

(1)
(Total 8 marks)

8 The diagram shows a man standing in an airport queue with his wheeled bag.



(a) The man applies an upward force to the handle of his bag to stop the bag from falling. The moment of this force about the pivot is 36 Nm.

Calculate the upward force the man applies to the handle of his bag.

.....

.....

.....

.....

Force = ... N

(2)

(b) When the man lets go of the bag handle, the bag falls and hits the floor.

Explain why.

.....

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.....

.....

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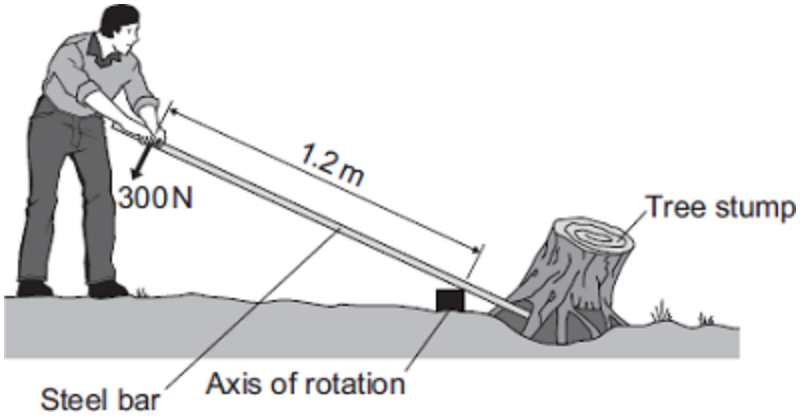
.....

(2)
(Total 4 marks)

9 The diagram shows a gardener using a steel bar to lift a tree stump out of the ground.



When the gardener pushes with a force of 300 **N**, the tree stump just begins to move.

(a) Use the equation in the box to calculate the moment produced by the 300 N force.

moment = force x	perpendicular distance from the line of action of the force to the axis of rotation

Show clearly how you work out your answer.

.....

.....

Moment = ... newton metres

(2)

(b) Using a longer steel bar would have made it easier for the gardener to lift the tree stump out of the ground.

Explain why.

.....

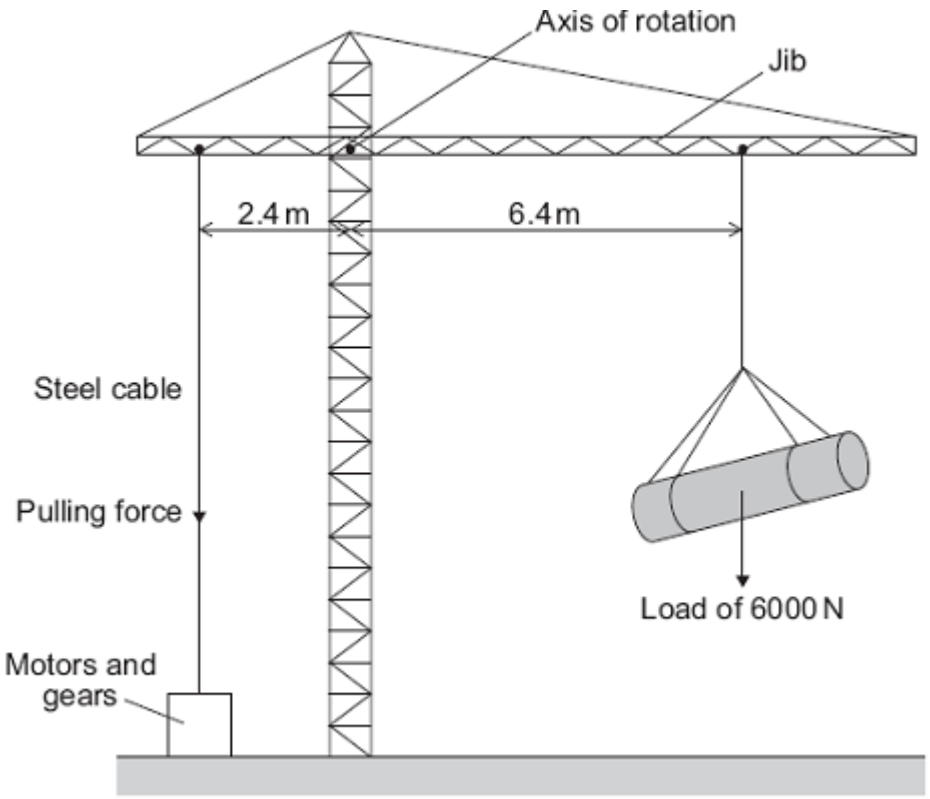
.....

.....

.....

(2)
(Total 4 marks)

10 The diagram shows a design for a crane. The crane is controlled by a computer.



The purpose of the motors and gears is to change the pulling force in the steel cable.
This is done so that the jib stays horizontal whatever the size of the load or the position of the load.

(a) Calculate the moment caused by the load in the position shown in the diagram.

Show clearly how you work out your answer and give the unit.

.....

.....

Moment = ...

(3)

(b) Calculate the pulling force that is needed in the steel cable to keep the jib horizontal.

Show clearly how you work out your answer.

.....

.....

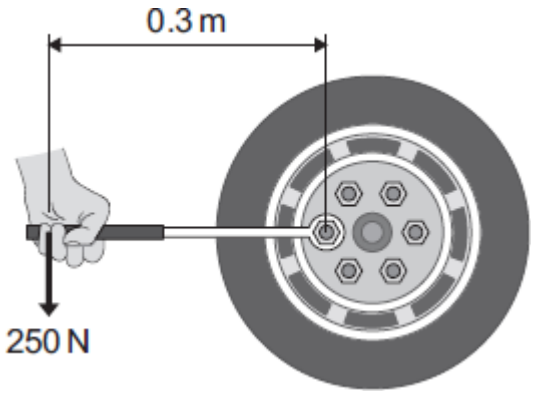
Pulling force = ... N

(2)

(Total 5 marks)

11 A company makes a wheel wrench with an extending handle. The company claims that the extending handle makes it easier to loosen the wheel nuts on a car.

The diagram shows the wheel wrench being used without the handle extended.



(a) (i) Use the equation in the box to calculate the moment produced by the force on the wrench.

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation

Show clearly how you work out your answer.

.....

.....

Moment = ... newton metres

(2)

(ii) Units can be written in words or symbols.

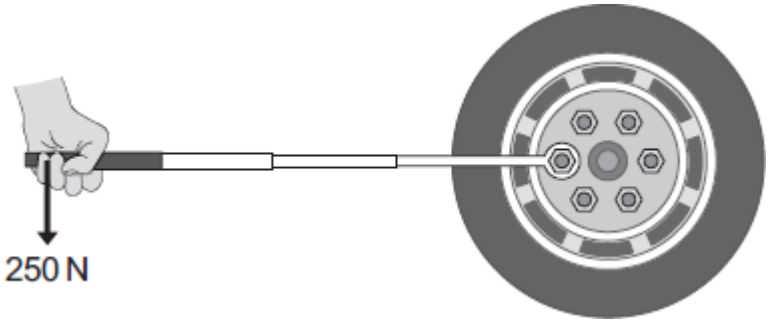
Which of the following is the unit for a moment written using symbols?

Draw a ring around your answer.

nm **Nm** **nM** **NM**

(1)

(b) The wheel nut will not move and so the handle of the wrench is extended.



It is now easy to loosen the wheel nut using the same force as before.

Explain why.

.....

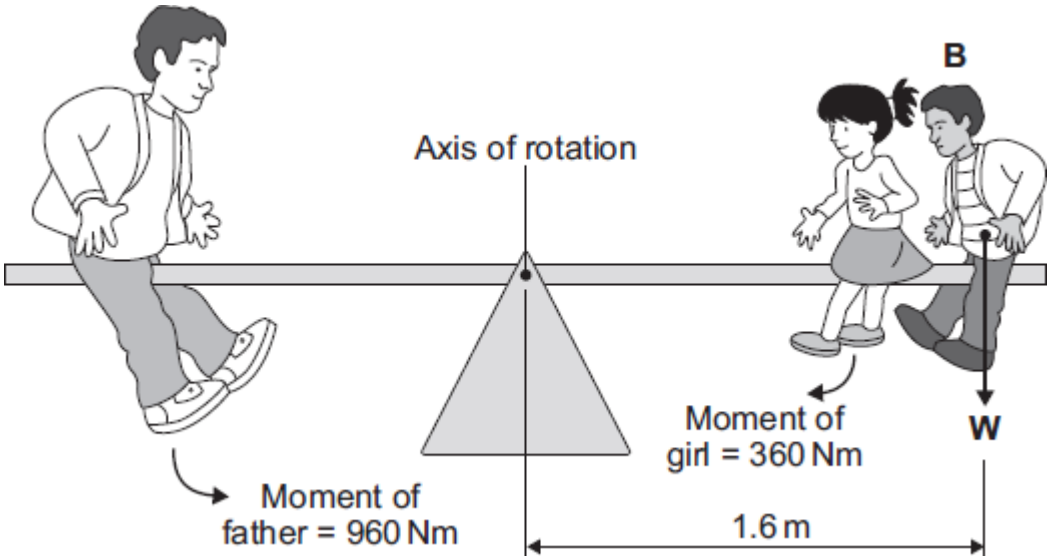
.....

.....

.....

(2)
(Total 5 marks)

12 The diagram shows a father and his two children sitting on a playground see-saw.
The see-saw is not moving.



(a) What is the total clockwise moment of the two children about the axis of rotation?

.....

Explain the reason for your answer.

.....

.....

.....

.....

.....

.....

(3)

(b) (i) What is the clockwise moment of the boy, **B**, about the axis of rotation?

.....

Moment = ... Nm

(1)

(ii) Use the information in the diagram to calculate the weight, **W**, of the boy, **B**.

Show clearly how you work out your answer.

.....

.....

.....

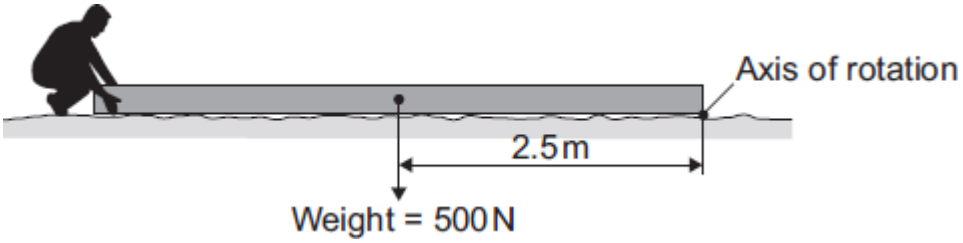
.....

Weight of boy **B** = ... N

(2)

(Total 6 marks)

13 The diagram shows someone starting to lift the end of a heavy wooden pole.



(a) Use the equation in the box to calculate the moment produced by the weight of the pole.

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation

.....

.....

Moment = ... Nm

(2)

(b) (i) Complete the following sentence by drawing a ring around the correct line in the box.

The smallest force needed to lift the end of the pole will be

bigger than
the same as
smaller than

the weight of the pole.

(1)

(ii) Give a reason for your answer to part (b)(i).

.....

.....

(1)

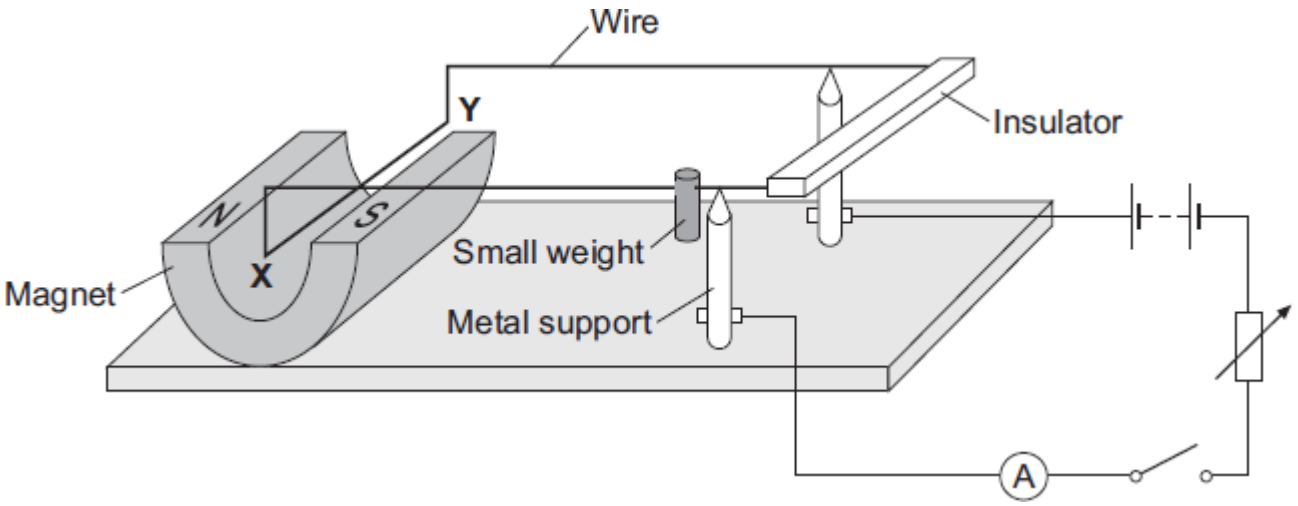
(c) How could the person lifting the end of the pole increase the moment?

.....

.....

(1)
(Total 5 marks)

14 The diagram shows a device called a current balance.



(a) (i) When the switch is closed, the part of the wire labelled **XY** moves upwards.

Explain why.

.....

.....

.....

.....

(2)

(ii) What is the name of the effect that causes the wire **XY** to move?

.....

(1)

(iii) An alternating current (a.c.) is a current which reverses direction. How many times the current reverses direction in one second depends on the frequency of the alternating supply.

Describe the effect on the wire **XY** if the battery is replaced by an a.c. supply having a frequency of 5 hertz.

.....

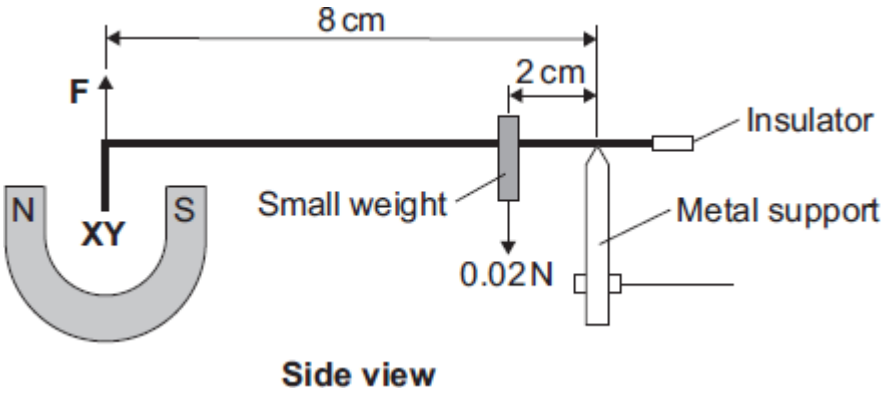
.....

.....

.....

(2)

(b) The diagram shows how a small weight can be used to make the wire **XY** balance horizontally.



Side view

Use the data in the diagram and the equation in the box to calculate the force, **F**, acting on the wire **XY**.

moment = force × perpendicular distance from the line of action of the force to the axis of rotation

Show clearly how you work out your answer.

.....

.....

.....

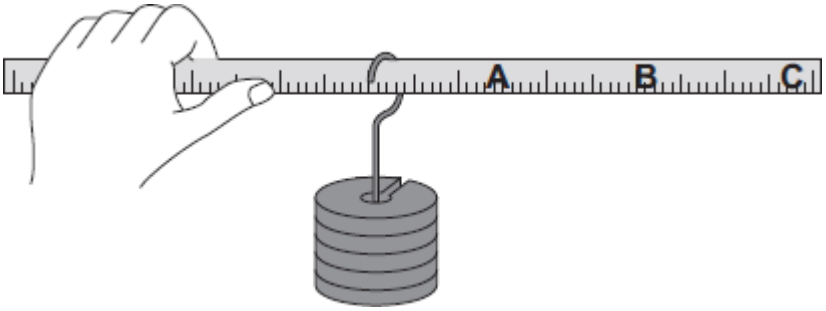
.....

Force = ... N

(3)

(Total 8 marks)

15 (a) A student holds a ruler at one end and slides a weight along the ruler.



At which point, **A**, **B** or **C**, will the turning effect of the weight feel greatest?

Write your answer, **A**, **B** or **C**, in the box. Point ☐

(1)

(b) Complete the following sentence by drawing a ring around the correct word in the box.

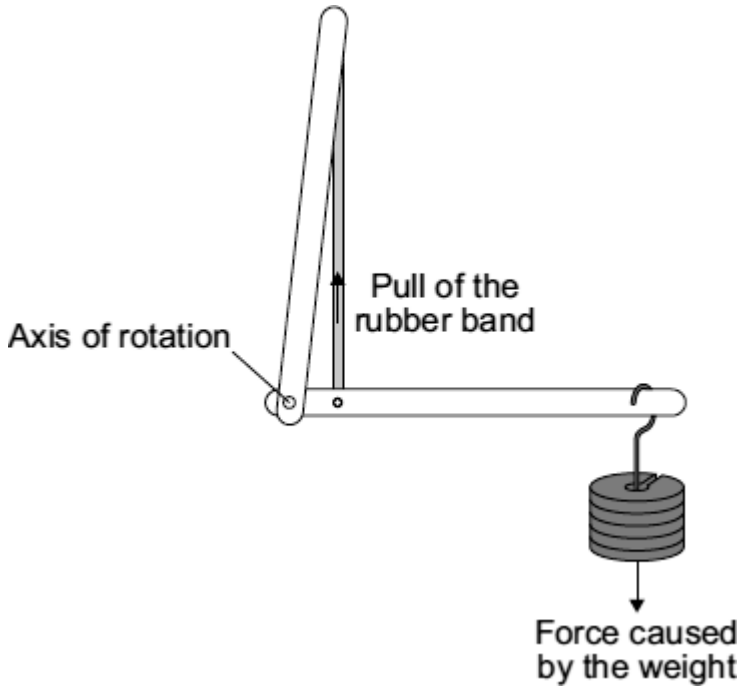
The turning effect of a force is called the

axis
equilibrium
moment

of the force.

(1)

(c) In a human arm, the biceps muscle provides the force needed to hold the arm horizontal.
A student uses a model in which a rubber band represents the biceps muscle.



Complete the following sentence by drawing a ring around the correct line in the box.

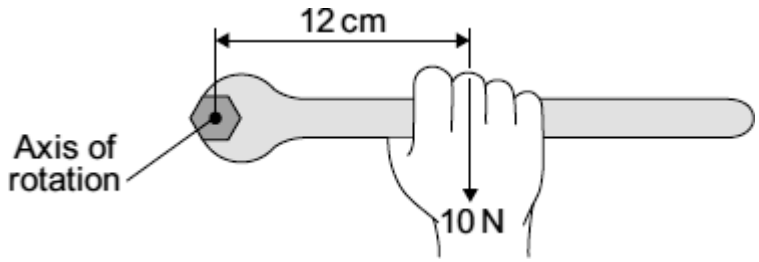
To hold the model arm horizontal, the pull from the rubber band will be

bigger than
smaller than
the same as

the force caused by the weight.

(1)

(d) The diagram shows a long spanner.



Use the equation in the box to calculate the moment, in N cm, being produced.

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation

Show clearly how you work out your answer.

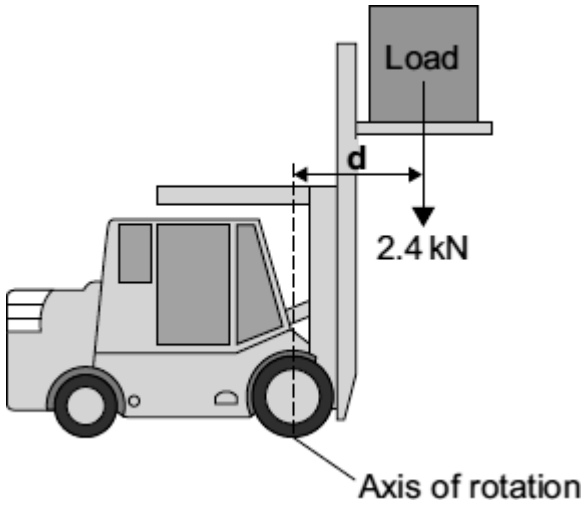
.....

.....

Moment = ... N cm

(2)
(Total 5 marks)

16 The diagram shows a fork-lift truck with a load of 2.4 kN. The clockwise moment caused by this load is 2880 Nm.



(a) Use the equation in the box to calculate the distance **d**.

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation

Show clearly how you work out the answer and give the unit.

.....

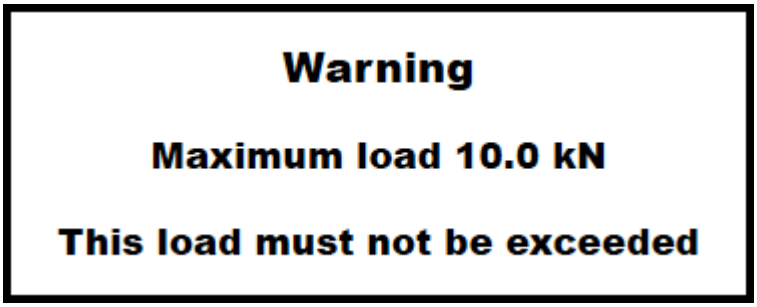
.....

.....

Distance **d** = ...

(3)

(b) This warning notice is in the driver's cab.



Explain in terms of moments why the maximum load must not be exceeded.

.....

.....

.....

.....

.....

.....

(2)
(Total 5 marks)

17 (a) A student investigates the moment of a force.

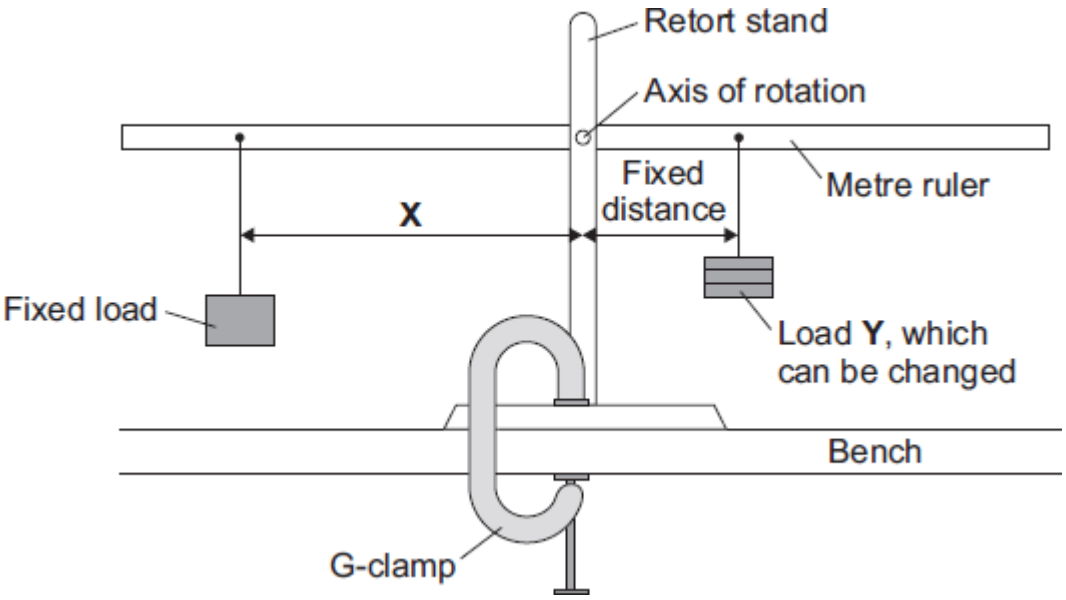
(i) What does the word *moment* mean in this sentence?

.....

.....

(1)

(ii) The diagram shows how she sets up her apparatus.



Suggest the purpose of the G-clamp.

.....

.....

(1)

(iii) A horizontal rod fits into a hole at the centre of the metre ruler. This is the axis of rotation. The student changes the load **Y** and adjusts the distance **X** until the metre ruler is horizontal. She takes six pairs of measurements which are shown in the table.

Load Y in newtons	**Distance X in centimetres**
1	7
2	14
3	21
4	28
5	35
6	42

Explain fully how distance **X** varies with load **Y**.

.....

.....

.....

.....

.....

(2)

(iv) The weight of the ruler can be ignored in this experiment.

Which statement gives the reason why?

Put a tick (✓) in the box next to your answer.

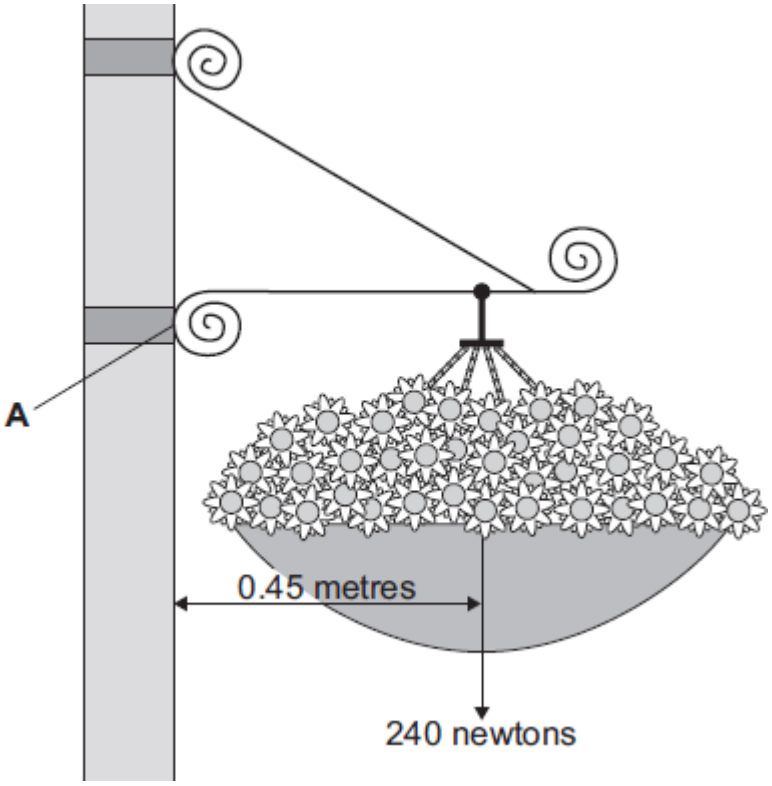
The weight of the ruler is so small it is negligible. ☐

The centre of mass of the ruler is at the axis of rotation. ☐

The ruler is a symmetrical object. ☐

(1)

(b) In the summer, a town council fits hanging baskets to some of its lamp posts.



Use the information in the diagram and the equation in the box to calculate the moment produced by the weight of the hanging basket about an axis through point **A**.

moment	=	force	×	perpendicular distance from the line of action of the force to the axis of rotation

Show clearly how you work out your answer **and** give the unit.

.....

.....

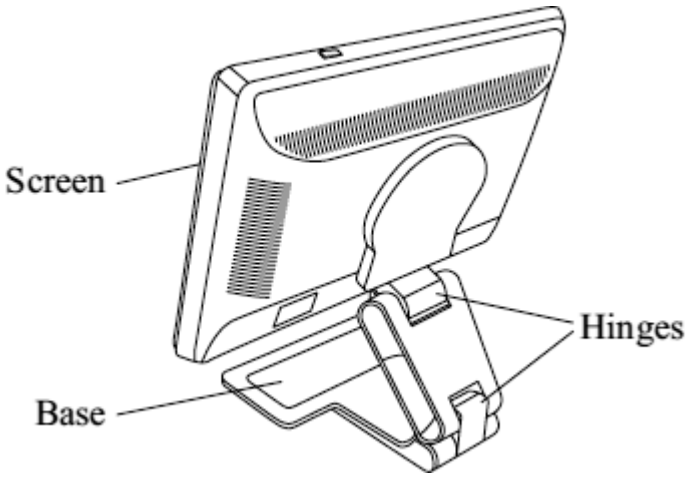
.....

.....

Moment =.....

(3)
(Total 8 marks)

18 The diagram shows a back view of a computer monitor.



(a) In normal use, the monitor is *stable.*

(i) Explain the meaning, in the above sentence, of the word *stable.*

.....

.....

.....

.....

(2)

(ii) State the relationship between the total clockwise moment and the total anticlockwise moment about any axis of the monitor when it is stable.

.....

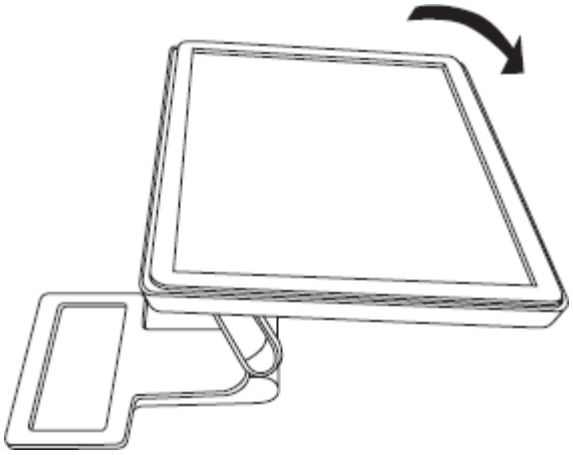
.....

(1)

(b) The instruction booklet explains that the screen can be tilted.
It also includes a warning.

Caution

The monitor can tip over if the screen is tilted too far back.



Explain why the monitor will tip over if the screen is tilted too far back.

Include the words *centre of mass, weight* and *moment* in your explanation.

.....

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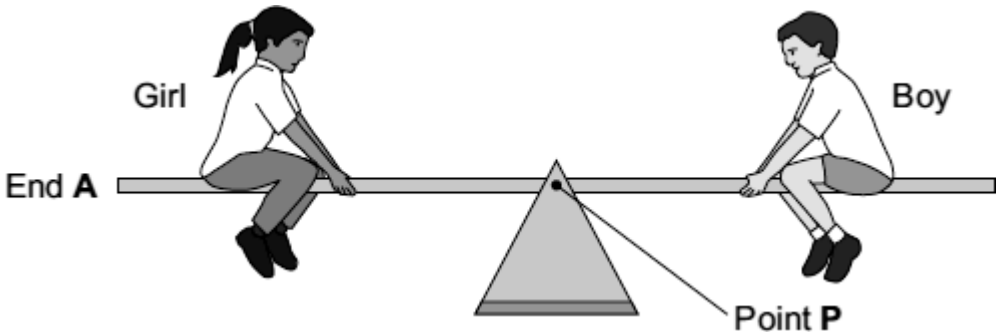
(3)
(Total 6 marks)

19 Two children visit a playground.

(a) The diagram shows them on a see-saw. The see-saw is balanced.



Complete the following sentences by drawing a ring around the correct word or line in the box.

(i) The turning effect of the girl's weight is called her

force.
load.
moment.

(1)

(ii) Point **P** is the axis of

balance
rotation
turning

of the see-saw.

(1)

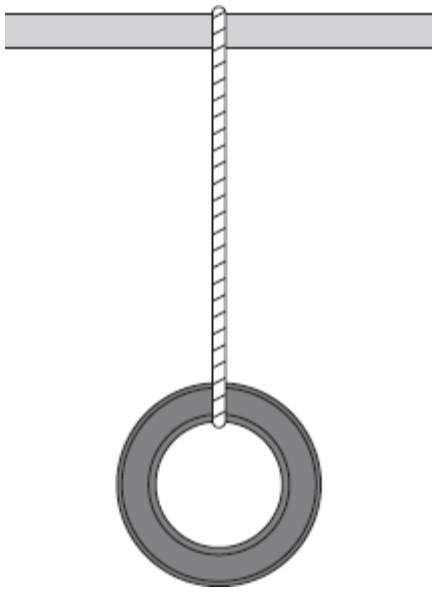
(iii) To make end **A** of the see-saw go up,

the boy moves nearer to point **P**.
the girl moves nearer to point **P**.
the girl moves nearer to end **A**.

(1)

(b) In another part of the playground, a tyre has been suspended from a bar.

(i) Draw an **X** on the diagram so that the centre of the **X** marks the centre of mass of the tyre.



(1)

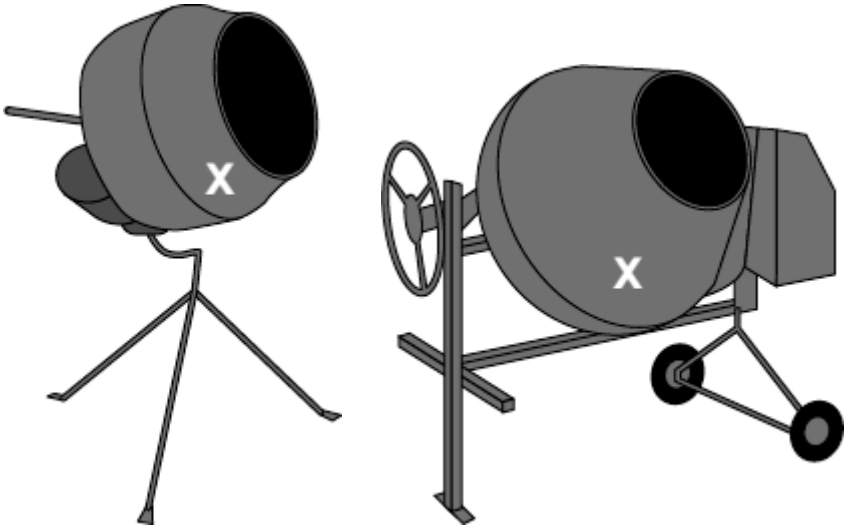
(ii) Complete the sentence by using the correct word or phrase from the box.

above	**below**	**to the left of**	**to the right of**

If the suspended tyre is pushed, it will come to rest with its centre of mass directly ..... the point of suspension.

(1)
(Total 5 marks)

20 The diagrams show two concrete mixers.



Concrete mixer **A** Concrete mixer **B**

On each diagram, the centre of the white **X** marks the centre of mass of the concrete mixer and its contents.

(a) Complete the sentence to explain what the term *centre of mass* means.

The centre of mass of a concrete mixer and its contents is .....

.....

.....

(1)

(b) Both diagrams are drawn to the same scale.

Concrete mixer **B** is more stable than concrete mixer **A**.

The two features which make concrete mixer **B** more stable are:

1 .....

.....

2 .....

.....

(2)

(c) Use the terms ‘line of action of the weight’ and ‘resultant moment’ to explain why a stable concrete mixer does not fall over when it is given a small push.

.....

.....

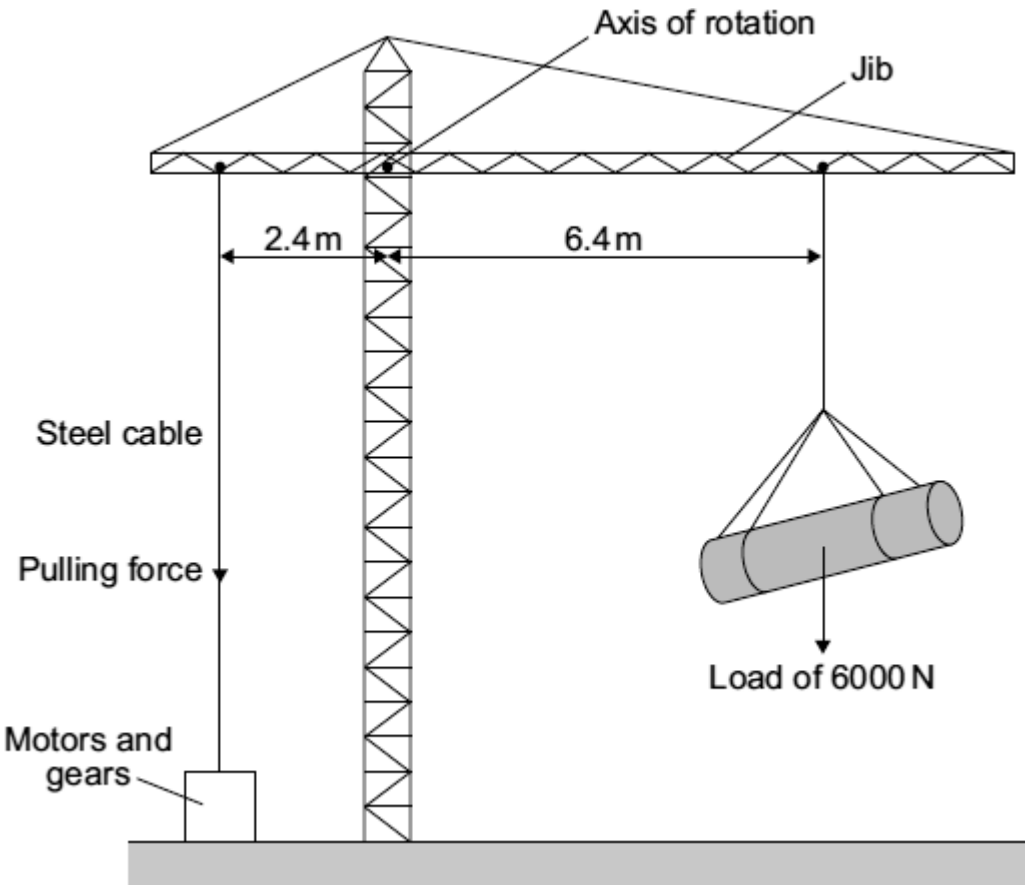
.....

.....

.....

(2)
(Total 5 marks)

21 The diagram shows a design for a crane. The crane is controlled by a computer.



The purpose of the motors and gears is to change the pulling force in the steel cable.
This is done so that the jib stays horizontal whatever the size of the load or the position of the load.

(a) Calculate the moment caused by the load in the position shown in the diagram.

Show clearly how you work out your answer and give the unit.

.....

.....

Moment = ...

(3)

(b) Calculate the pulling force that is needed in the steel cable to keep the jib horizontal.

Show clearly how you work out your answer.

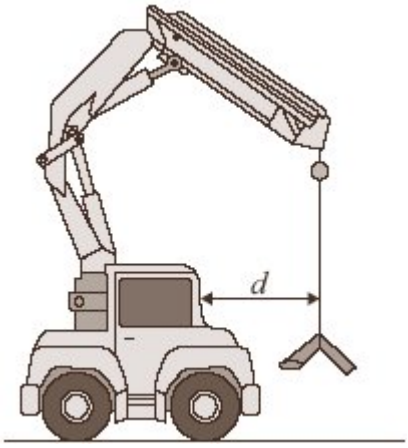
.....

.....

Pulling force = ... N

(2)
(Total 5 marks)

22 The diagram shows a small mobile crane. It is used on a building site.



The distance, d, is measured to the front of the cab.

The table shows information from the crane driver's handbook.

Load in kilonewtons (kN)	**Maximum safe distance, *d*, in metres (m)**
10	6.0
15	4.0
24	2.5
40	1.5
60	1.0

(a) What is the relationship between the load and the maximum safe distance?

.....

.....

.....

(2)

(b) The crane driver studies the handbook and comes to the conclusion that a load of 30 kN would be safe at a distance, *d*, of 2.0 metres.

Is the driver correct?

Explain your answer.

.....

.....

.....

.....

(2)

(c) What is the danger if the driver does not follow the safety instructions?

.....

.....

(1)

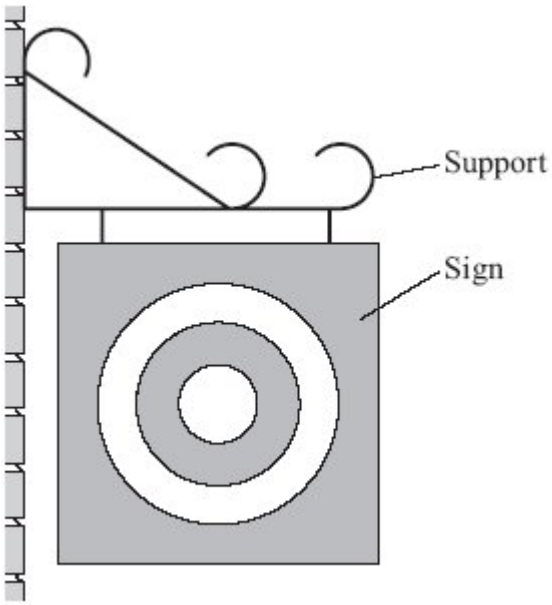
(d) How should the data in the table have been obtained?

Put a tick (✓) in the box next to your answer.

average results from an opinion poll of mobile crane drivers	☐
copied from a handbook for a similar crane	☐
results of experiments on a model mobile crane	☐
results of experiments on this mobile crane	☐

(1)
(Total 6 marks)

23 The drawing shows a sign which hangs outside a shop.



(a) Draw an **X** on the sign so that the centre of your **X** is at the centre of mass of the sign.

(1)

(b) Use a ruler to draw **one** axis of symmetry on the sign.

(1)

(c) One force which acts on the sign is its weight.

Complete the following sentence by drawing a ring around the correct line in the box.

The moment of the weight produces

an accelerating
a balancing
a turning

effect.

(1)
(Total 3 marks)

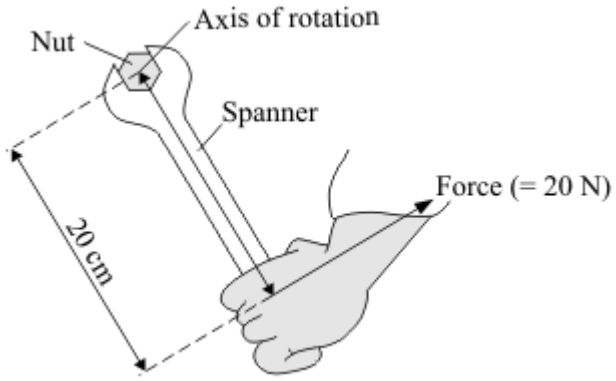
24 A spanner gives a turning effect to undo a nut.

(a) Complete the sentence.

The turning effect of a force is called the ..... of the force.

(1)

(b) The diagram shows a spanner being used.



Calculate the spanner's turning effect in newton metres.

Show clearly how you work out your answer.

.....

.....

Turning effect = ... Nm

(2)

(c) Give **two** ways in which you can increase the spanner's turning effect.

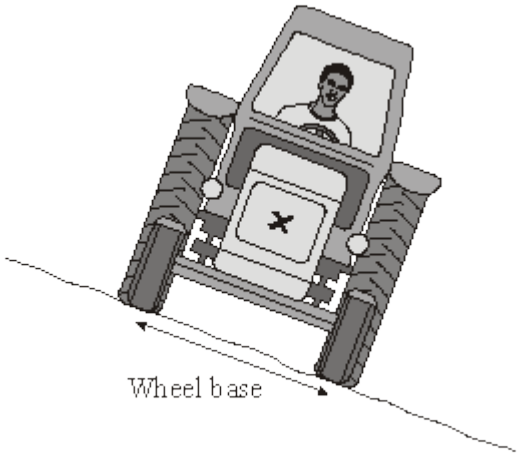
1 .....

2 .....

(2)
(Total 5 marks)

25 Tractors are often used on sloping fields, so stability is important in their design.

On the diagram, the centre of the **X** marks the centre of mass of the tractor.



(a) Explain why the tractor has **not** toppled over. You may add to the diagram to help you to explain.

.....

.....

.....

.....

.....

.....

(3)

(b) Give **two** features of the tractor which affect its stability and state how each feature could be changed to increase the tractor's stability.

Feature 1 .....

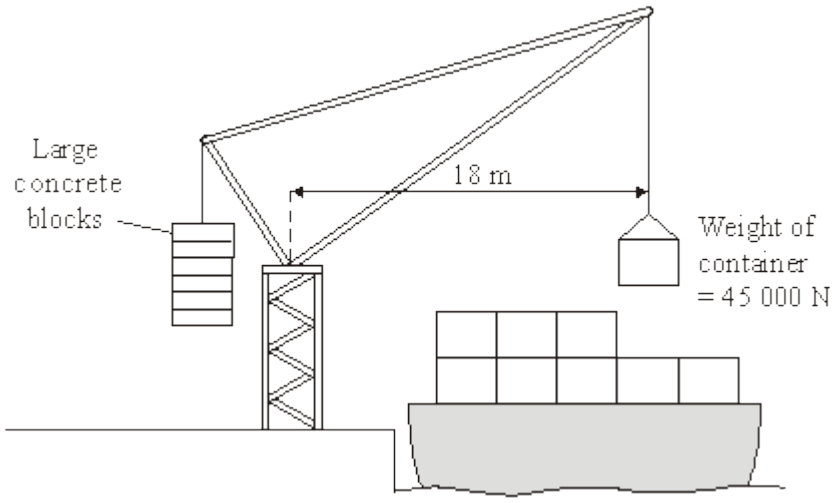
.....

Feature 2 .....

.....

(2)
(Total 5 marks)

26 The diagram shows a crane which is loading containers onto a ship.



(a) Calculate the moment of the container which is being loaded.

Show clearly how you work out your answer and give the unit.

.....

.....

Moment of the container = ...

(3)

(b) Suggest and explain the purpose of the large concrete blocks.

.....

.....

.....

.....

.....

(3)
(Total 6 marks)

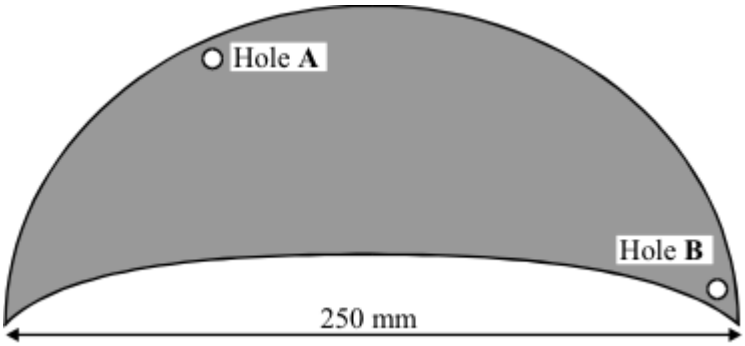
27 (a) Every object has a *centre of mass*. What is meant by the *centre of mass*?

.....

.....

(1)

(b) The drawing shows a thin sheet of plastic. The sheet is 250 mm wide. Two holes, each with a radius of 2 mm, have been drilled through the sheet.



Describe how you could use:

- a clamp and stand
- a steel rod 100 mm long and with a radius of I mm
- a weight on a thin piece of string (= a plumb line)
- a ruler
- a pen which will write on the plastic sheet

to find the centre of mass of the plastic sheet.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

.....

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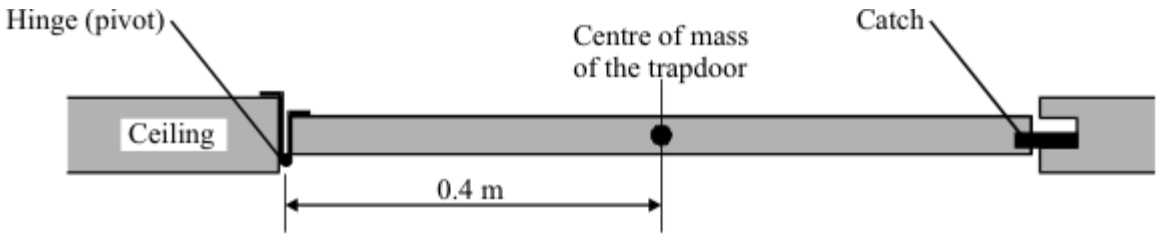
(5)

(c) There is a trapdoor in the ceiling of a house.
The trapdoor weighs 44 N.
The drawing shows a side view of the trapdoor.



(i) Complete the **three** spaces to give the equation which is used to calculate the turning effect of a force.

..... = ... × perpendicular between .....
line of action and pivot

(1)

(ii) Calculate the turning effect, about the hinge, due to the weight of the trapdoor.

Show clearly how you work out your final answer and give the unit.

.....

.....

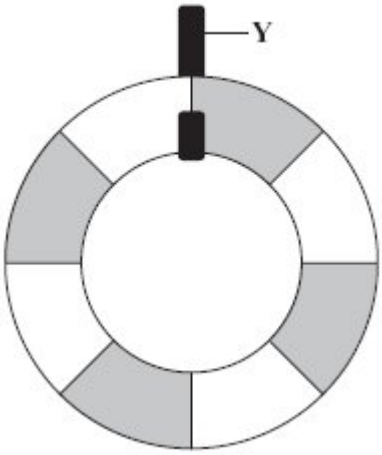
Turning effect = ...

(3)

(Total 10 marks)

28 (a) The diagram shows a lifebelt. It is hanging freely from hook **Y**.

(i) On the diagram, mark with an **X** the point where you think the centre of mass of the lifebelt will be.



(1)

(ii) Explain why you have chosen this point.

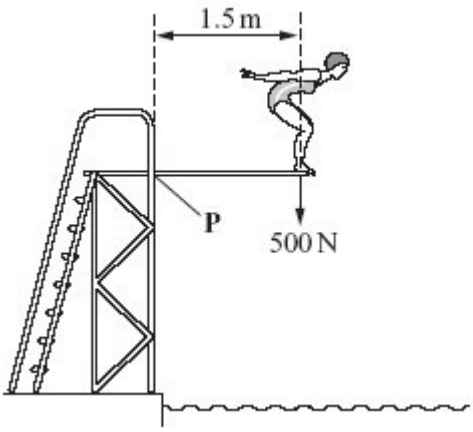
.....

.....

.....

(2)

(b) The drawing shows Susan on a diving board. She is 1.5 metres from point **P** and she weighs 500 N.



Calculate her moment (turning effect) about point **P**.
Show clearly how you work out your answer and give the unit.

.....

.....

Moment about **P** = ...

(3)

(c) Susan has a case with wheels.

When she packs this case, she puts the heaviest items at the end where the wheels are. This means that the heaviest items are less likely to crush the other contents and it helps her to find things when she opens the case.

Explain another advantage of packing her case in this way.

To gain full marks in this question you should write your ideas in good English. Put them into a sensible order and use the correct scientific words.

.....

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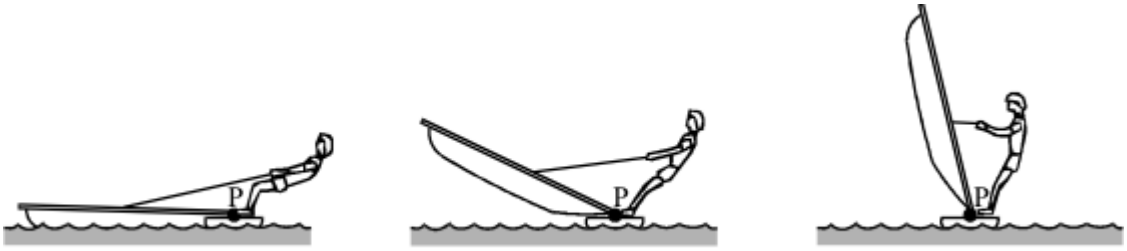
.....

(4)
(Total 10 marks)

29 (a) The diagrams show a windsurfer pulling up the sail of a sailboard. The mast pivots at point P.



A **B** **C**

In which position, **A**, **B** or **C** must the windsurfer pull with the largest force? Give a reason for your answer.

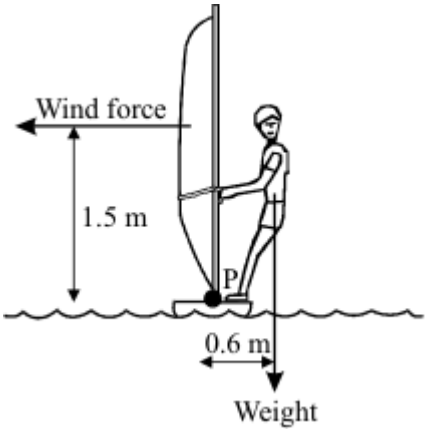
.....

.....

.....

(2)

(b) Once the mast is upright, the windsurfer and the sailboard are *in equilibrium.*



(i) What does *in equilibrium* mean?

.....

.....

(1)

(ii) The weight of the windsurfer is 700 newtons. Calculate the moment exerted by the windsurfer on the sailboard. Show clearly how you work out your answer.

.....

.....

Moment = ... Nm

(2)

(iii) Calculate the horizontal force of the wind on the sail. Show clearly how you work out your answer.

.....

.....

Force = ... N

(2)

(c) As the wind speed increases the windsurfer leans further out from the sailboard.

This position allows the windsurfer and sailboard to stay in equilibrium. Explain why.

.....

.....

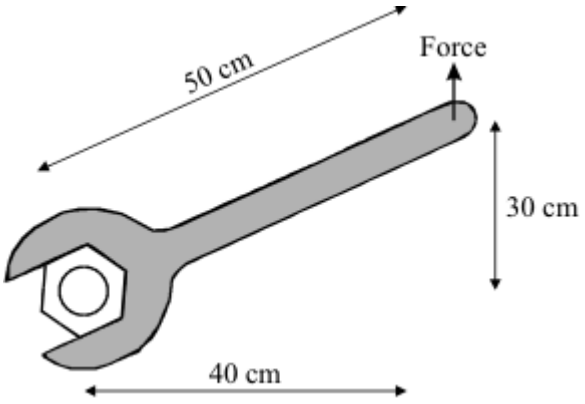
.....

.....

.....

(3)
(Total 10 marks)

30 The diagram shows a spanner being used to undo a tight nut.



The nut was tightened using a moment of 120 newton metres.

Calculate the force needed to undo the nut. Show clearly how you work out your answer.

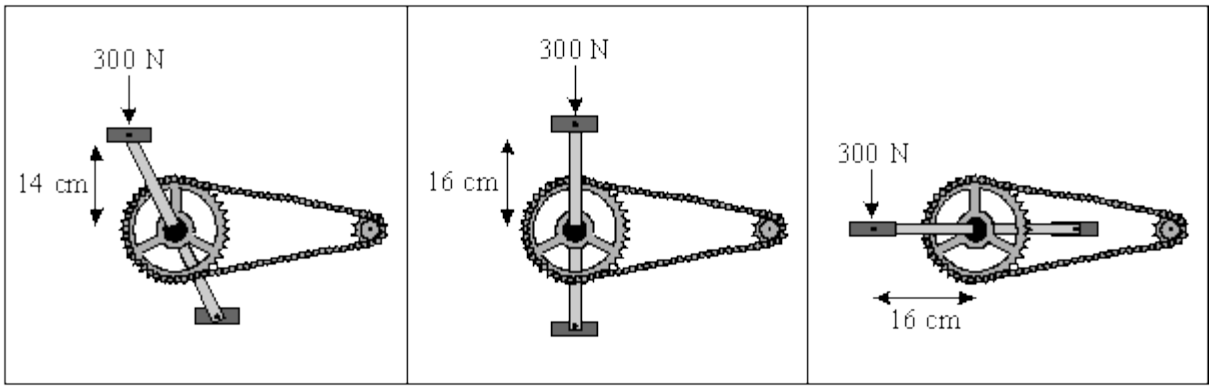
.....

.....

Force = ... N

(Total 2 marks)

31 For part of the ride the cyclist pushed on the pedals with a constant vertical force of 300 N. The simplified diagrams show the pedals in three different positions.



A **B** **C**

(i) Which position, **A**, **B**, or **C**, gives the largest moment on the pedal?

.....

(1)

(ii) Calculate the size of the largest moment on the pedal, in Newton metres.

.....

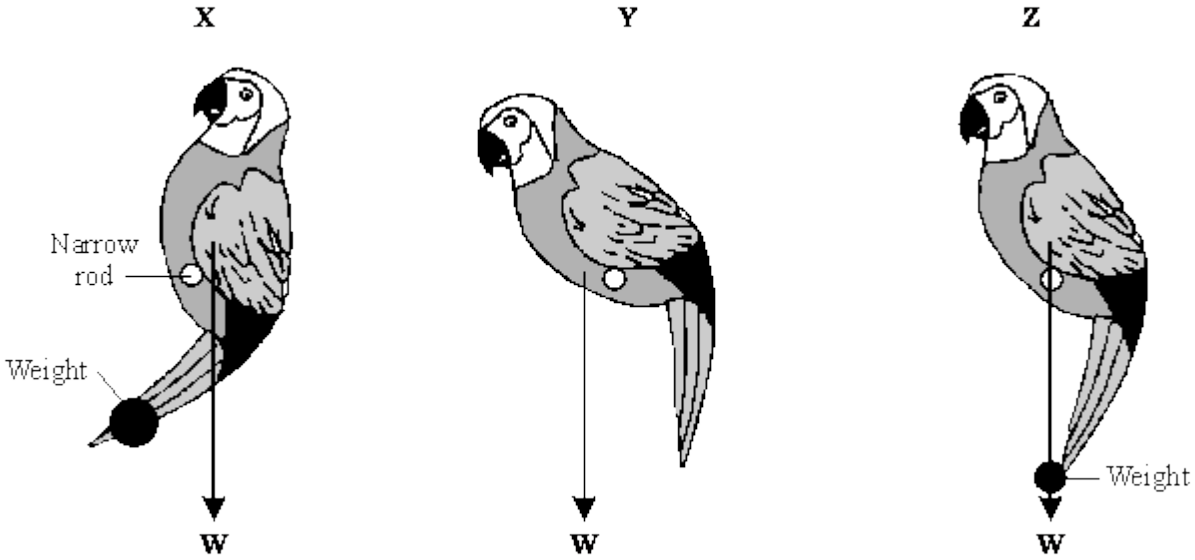
.....

Moment = ... Nm

(2)

(Total 3 marks)

32 (a) The diagram shows three similar toys. Each toy should be able to balance on a narrow rod. The arrows show the direction in which the weight of the toy acts.



Only one of the toys balances on the rod, the other two fall over. Which **one** of the toys is balanced? Explain the reason for your choice.

.....

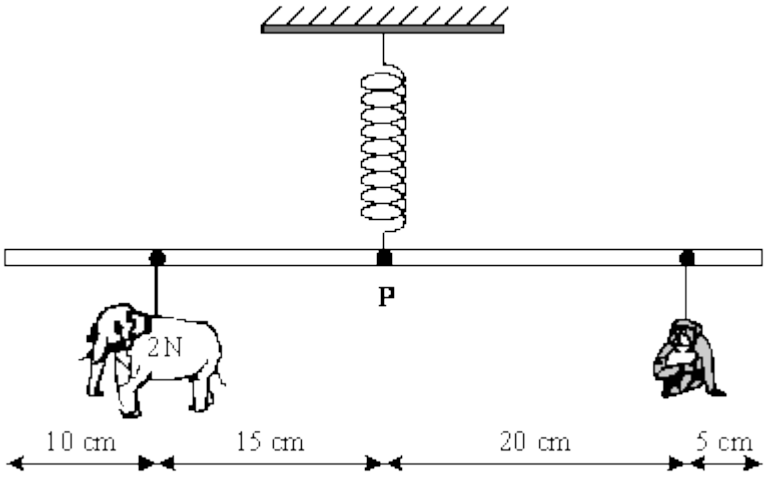
.....

.....

.....

(3)

(b) The diagram shows a simple toy. Different animal shapes can be positioned so that the 50 cm rod balances horizontally.



(i) Calculate the moment exerted by the elephant shape of weight 2N about the pivot **P**. Show clearly how you work out your answer and give the unit.

.....

.....

Moment = ...

(3)

(ii) Use the following relationship to calculate the weight of the monkey shape.

total clockwise moment = total anticlockwise moment

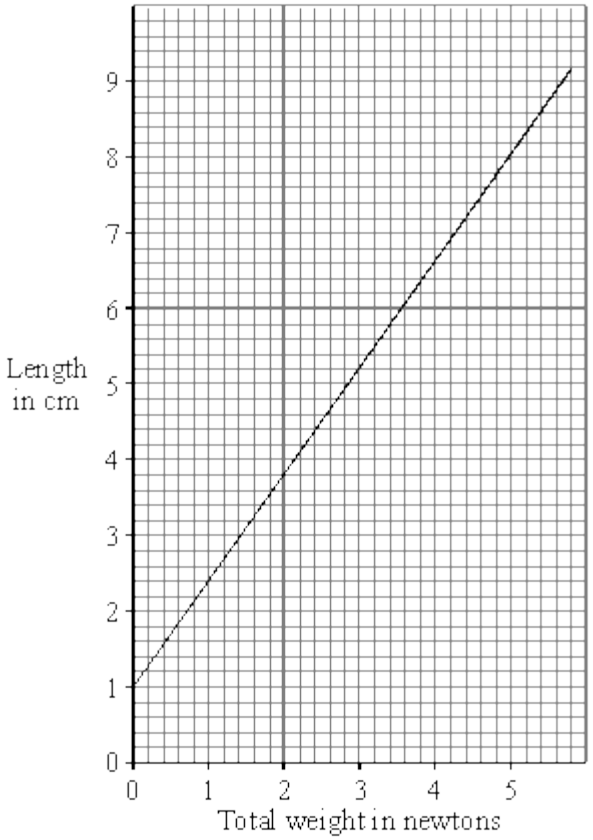
.....

.....

Weight = ... N

(2)

(c) The graph shows how the length of the spring changes as the total weight of the different animal shapes change.



Use the graph to find how much the spring extends when the elephant shape and the monkey shape are hung from the rod. Show how you get your answer.

.....

.....

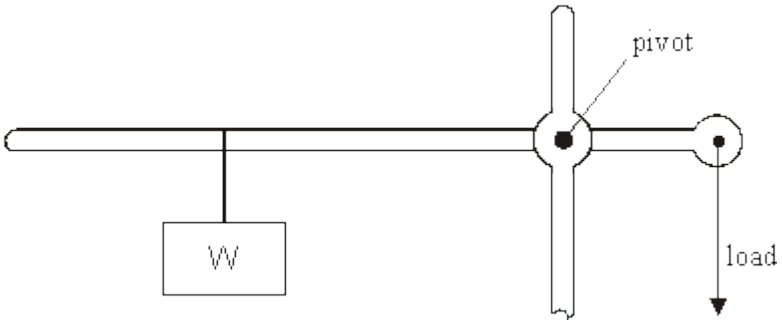
Extension of spring = ... cm

(2)

(Total 10 marks)

33 The diagram below shows an outline of a balance. The balance is used to weigh lorries. A fraction of the weight of a lorry is used as the load on the right side of the pivot.

A standard weight W is moved along the arm until the weight of the load is balanced.



(a) As the weight W is moved away from the pivot it can support a heavier load. Why is this?

.....

.....

(2)

(b) (i) The weight W is 100 N. When it is 0.2 m from the pivot it balances the load. Calculate the moment of the weight W about the pivot.

.....

.....

Answer ..... Nm

(2)

(ii) The load is one hundredth of the weight of the lorry and is 0.02 m from the pivot. Calculate the weight of the lorry.

.....

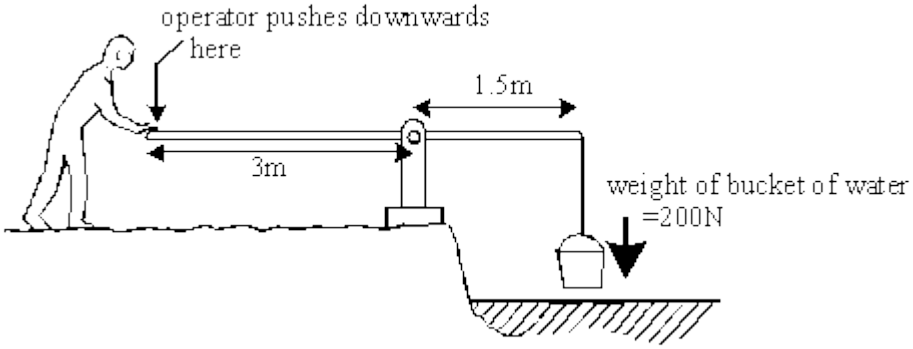
.....

Answer ..... N

(2)

(Total 6 marks)

34 The diagram shows a simple machine for lifting water from a river.



(a) Calculate the turning force (moment) of the bucket of water.

(Show your working.)

.....

.....

.....

Answer ..... Nm (newton metre)

(2)

(b) What can you say about the size of downwards force the operator must use to balance the moment of the bucket of water?

(Explain your answer, using numbers if you can.)

.....

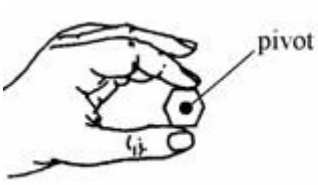
.....

.....

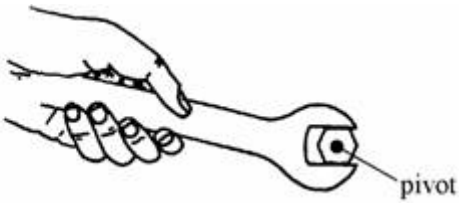
.....

(4)
(Total 6 marks)

35 A spanner makes it a lot easier to loosen a bolt.



You cannot usually loosen a bolt with your fingers.



It is easier with a spanner.

Choose words from this list to complete the sentences below.

lever **piston** **pivot** **pulley** **turning effect**

The spanner is a simple .....

You use it to produce a bigger ..... on the bolt.

A longer spanner works better.

This is because there is a bigger distance between your force and the .....

(Total 3 marks)

Mark schemes

1 (a) moment = 280 × 0.9

1

moment = 252

1

*allow 252 with no working shown for **2** marks*
*allow 25200 with no working shown for **1** mark*

(b) the clockwise moment (of child B) decreases

1

making it is less than the anticlockwise moment (of child A)
accept so moments are no longer balanced

1

so child A moves downwards

or

so child B moves upwards

1

[5]

2 (a) motor effect

1

(b) increase the strength of the magnet

or

increase the current

1

(c) $4.8 \times 10^{-4} = F \times 8 \times 10^{-2}$

1

$F = 6 \times 10^{-3}$ (N)

1

$6 \times 10^{-3} = B \times 1.5 \times 5 \times 10^{-2}$

1

$B = \frac{6 \times 10^{-3}}{7.5 \times 10^{-2}}$

1

$B = 8 \times 10^{-2}$ or 0.08

1

*allow 8×10^{-2} **or** 0.08 with no working shown for **5** marks*

*a correct method with correct calculation using an incorrect value of F gains **3** marks*

Tesla

accept T

1

do not accept t

[8]

3 (a) make the rod longer

1

push down on the rod with a greater force

1

(b) particles are close together

1

so no room for more movement

dependent on 1st marking point

1

(c) (i) downward force produces pressure in liquid

reference to compression of liquid negates this mark

1

this pressure is the same at all points in a liquid
or
this pressure is transmitted equally through the liquid

*and $P = F / A$ **or** $F = P \times A$*

1

area (at load) bigger *(so force bigger)*

1

(ii) the force acting on the car moves less distance than the effort force

1

[9]

4 (a) 3000

*allow **1** mark for correct substitution, ie 600 × 5 provided no subsequent step*

2

(b) anticlockwise moment

must be both words

1

(c) (i) 3400

allow 3.4 kilo (newtons)

1

(ii) as the distance (of the girl from point A) increases, force F increases

allow gets bigger for increases

force is (directly) proportional to distance will negate any correct response

1

[5]

5 (a) 3800

*allow **1** mark for 2000*

*allow **1** mark for 1800*

*if neither of above scored, allow correct substitution for **1** mark (800 × 2.5) + (600 × 3)*

if moments have been calculated incorrectly, allow 1 mark for adding their two moment values correctly

3

newton metres **or** Nm

*do **not** allow nm **or** NM*

1

(b) as the girl increases her distance (from the pivot) the clockwise moment increases

1

(F must increase) as the anticlockwise moment must increase

1

so (the anticlockwise moment) is equalled / balanced by the clockwise moment
or
so resultant / overall moment (on the board) is zero

accept to balance / equal the moments

to balance the board is insufficient

1

[7]

6 (a) (i) turning

accept turning ringed in the box

1

(ii) point at which mass (or weight) may be thought to be concentrated

accept the point from which the weight appears to act

allow focused for concentrated

*do **not** accept most / some of the mass*

*do **not** accept region / area for point*

1

(b) 600 (Nm)

*400 × 1.5 gains **1** mark provided no subsequent steps shown*

2

(c) (i) plank rotates clockwise

accept girl moves downwards

*do **not** accept rotates to the right*

1

(total) CM > (total) ACM

accept moment is larger on the girl's side

1

weight of see-saw provides CM

answer must be in terms of moment

*maximum of **2** marks if there is no reference to the weight of the see-saw*

1

(ii) W = 445 (N)

*W × 1.5 = (270 × 0.25) + (300 × 2.0) gains **2** marks*

*allow for **1** mark:*

total CM = total ACM either stated or implied

or

(270 × 0.25) + (300 × 2.0)

if no other marks given

3

[10]

7 (a) centre of X drawn at centre of pendulum bob

judged by eye

accept dot drawn at centre of circle

1

(b) (i) 2

*allow **1** mark for correct substitution, ie* $\frac{1}{0.5}$ *provided no subsequent step shown*

2

(ii) 30

or

60 ÷ their (b)(i) correctly calculated

allow 1 mark for $\frac{60}{2}$

or $\frac{60}{\text{their (b)(i)}}$

or *0.5 × 60*

provided no subsequent step shown

2

(c) 51.2

*allow **1** mark for correct substitution, ie 64 × 0.8 provided no subsequent step shown*

2

(d) it increases (the moment)

must be comparative

*accept **1** mark for calculation of the moment = 64 (Nm)*

1

[8]

8 (a) 60

*allow **1** mark for correct substitution (with d in metres), ie 36 = F × 0.6*

*an answer of 0.6 **or** 6 gains **1** mark*

2

(b) the line of action of the weight lies outside the base / bottom (of the bag)

accept line of action of the weight acts through the side

accept the weight (of the bag) acts outside the base / bottom (of the bag)

1

a resultant / overall / unbalanced moment acts (on the bag)

accept the bag is not in equilibrium

*do **not** accept the bag is unbalanced*

1

[4]

9 (a) 360

*allow **1** mark for correct substitution ie 300 × 1.2 provided no subsequent step shown*

2

(b) the force is applied further from the axis of rotation

accept pivot / (tree) stump for 'axis of rotation'

1

or

this increases the moment of the force

increases the force on the (tree) stump

1

[4]

10 (a) 38 400

*allow 6.4 × 6000 for **1** mark*

2

Nm **or** newton metres

*do **not** credit 'nm', 'mN' or 'metre newtons'*

1

(b) 16 000 (N) **or** 16 kN

*allow **1** mark for 38 400 ÷ 2.4*

*accept their (a) ÷ 2.4 correctly calculated for **2** marks*

*accept their (a) ÷ 2.4 for **1** mark*

2

[5]

11 (a) (i) 75

*allow **1** mark for correct substitution ie 250 × 0.3*

*do **not** credit if subsequent step shown*

*allow **1** mark for an answer 7500*

2

(ii) Nm

1

(b) force is (applied) further from the nut / pivot / axis of rotation

handle is longer is insufficient

*do **not** accept less force needed*

1

moment (on wrench) is larger

1

[5]

12 (a) 960 (Nm)

1

see-saw is in equilibrium

accept see-saw is balanced

see-saw is stationary is insufficient

1

(total) clockwise moments = anticlockwise moment

accept no resultant moment

forces are balanced is insufficient

*an answer clockwise moments balance the anticlockwise moments gains **2** marks*

1

(b) (i) 600 (Nm)

1

(ii) 375 (N) **or** their (b)(i) ÷ 1.6 correctly calculated

*do **not** credit if (b)(i) is larger than 960*

*allow **1** mark for correct substitution **and** transformation ie*

$\frac{600}{1.6}$ *or* $\frac{\text{their (b)(i)}}{1.6}$

2

[6]

13 (a) 1250

*allow **1** mark for correct substitution*

ie 500 × 2.5 provided there is no subsequent calculation

2

(b) (i) smaller than

1

(ii) force (exerted) further from axis of rotation (than the weight)

accept pivot for axis of rotation

1

(c) increase the force (exerted)

*do **not** accept increase distance of force from axis of rotation*

1

[5]

14 (a) (i) current produces a magnetic field (around XY)

accept current (in XY) is perpendicular to the (permanent) magnetic field

1

(creating) a force (acting) on XY / wire / upwards

reference to Fleming's left hand rule is insufficient

1

(ii) motor (effect)

1

(iii) vibrate / move up and down

1

5 times a second

only scores if first mark point scores

*allow for **1** mark only an answer 'changes direction 5 times a second'*

1

(b) 0.005

*allow **1** mark for calculating moment of the weight as 0.04 (Ncm)*
and
*allow **1** mark for correctly stating principle of moments*
or
*allow **2** marks for correct substitution*
*ie F × 8 = 2 × 0.02 **or** F × 8 = 0.04*

3

[8]

15 (a) **C**

1

(b) moment

accept any unambiguous correct indication

1

(c) bigger than

accept any unambiguous correct indication

1

(d) 120 (Ncm)

*allow **1** mark for correct substitution*
ie 12 × 10

2

[5]

16 (a) 1.2

*allow **1** mark for conversion of 2.4 kN to 2400 N*
or for correct transformation without conversion
ie d = 2880 ÷ 2.4

2

metre(s)/m

1

(b) any **two** from:

- as the load increases the (total) clockwise moment increases
- danger is that the fork lift truck / the load will topple / tip forward
- (this will happen) when the total clockwise moment is equal to (or greater than) the anticlockwise moment

  accept moments will not be balanced
- (load above 10.0 kN) moves line of action (from C of M) outside base (area)

2

[5]

17 (a) (i) turning effect

accept turning force

accept force x distance

(accept symbols only if correctly defined)

*do **not** accept newtons x metres*

1

(ii) stop apparatus falling over

accept holds the stand in place

accept make it safer / stable

references to balanced / equilibrium are insufficient

1

(iii) as *x* increases *y* increases

1

in same proportion / ratios

allow both marks for they are directly proportional

or

a specific example eg doubling y, doubles x

allow both marks for a correct answer giving figures

eg they increase in the ratio of 1 to 7

*allow for **1** mark positive correlation*

1

(iv) the centre of mass of the ruler is at the axis of rotation

1

(b) 108

*allow **1** mark for correct substitution ie 240 x 0.45*

2

newton metres / Nm

symbols must be correct

for full credit the unit must be consistent with the numerical answer

1

[8]

18 (a) (i) will not fall over (1)

accept will not easily fall over (2)

or

centre of mass will remain above the base (1)

(line of action of the) weight will remain above within the base

accept centre of gravity / c of g / c of m / c m

if the monitor is given a small push (1)

depends on mark above

2

(ii) (total) clockwise moment = (total) anticlockwise moment

or *they are equal / balanced*

1

(b) the position of the centre of mass has changed (1)
the line of action of the weight is outside the base (1)
producing a (resultant) moment (1)

points may be expressed in any order

3

[6]

19 (a) (i) moment

1

(ii) rotation

1

(iii) the girl moves nearer to point **P**

1

(b) (i) **X** drawn in the centre of the space enclosed by the tyre

judge by eye

1

(ii) below

1

[5]

20 (a) the point at which the (total) mass seems to act / appears to be concentrated

accept 'weight' for 'mass'

accept the point at which gravity seems to act

*do **not** accept a definitive statement eg where (all) the mass is*

1

(b) wider / larger base

marks are for a correct comparison

1

lower centre of mass

accept lower centre of gravity / c of g

1

(c) line of action (of the weight) lies / falls inside the base

in each case the underlined term must be used correctly to gain the mark

1

the resultant moment returns mixer to its original position

accept there is no resultant moment / resultant moment is zero

accept resulting moment for resultant moment

*do **not** accept converse argument*

1

[5]

21 (a) 38 400

*allow 6.4 × 6000 for **1** mark*

2

Nm **or** newton metres

*do **not** credit 'nm', 'mN' or 'metre newtons'*

1

(b) 16 000 (N) **or** 16 kN

*allow **1** mark for 38 400 ÷ 2.4*

*accept their (a) ÷ 2.4 correctly calculated for **2** marks*

*accept their (a) ÷ 2.4 for **1** mark*

2

[5]

22 (a) any **two** from:

- inversely proportional
- as the load gets biggerthe (maximum safe) distance gets less

  allow 'as the mass increases the distance decreases'
  accept an unspecified response e.g. 'big load at a short distance' for (1)
- load × distance = 60 (kNm)

2

(b) yes, because 30 × 2 = 60 (2)

accept for (1) a correct but insufficiently explained response e.g. 'yes because it's safe'

accept for (2) a correct response which is sufficiently explained

e.g. 'yes, because 60 (kNm) at 1 metre is safe and 30 (kNm) is half the load at twice the distance

*do **not** accept 'no' and do not accept just 'yes'*

*do **not** accept 'yes, because 30 is between 24 and 40 and 2 is between 2.5 and 1.5'*

*do **not** accept 'the crane/ cable may break' or other dangers*

2

(c) the crane may/will topple over/fall <u>over/forward</u>

1

(d) results of experiments on this mobile crane

accept any unambiguous indication

1

[6]

23 (a) centre of **X** at the centre of the concentric circles

judge by eye that the intention is correct

1

(b) drawn from any corner to the diagonally opposite corner

judge by eye that the intention is correct

or from the mid-point of any side to the mid-point of the opposite side

if more than one axis of symmetry has been drawn, accept only if both / all are correct

1

(c) a turning

accept any unambiguous indication

1

[3]

24 (a) moment

or *torque do* ***not*** *credit 'leverage'*

1

(b) 4 (2)

either *0.20 × 20 (1)* ***or*** *allow '400' (1)*

2

(c) use a longer spanner

or *increases the perpendicular distance / length*

or 'fit a pipe over the (end of the) spanner (to lengthen it)'

note 'lever' refers to 'spanner'
note change the . . . (0)
ignore references to wider / larger nut

1

use a greater force / pull

either order

1

[5]

25 (a) (line of action of) its weight

1

falls inside its wheel base

accept 'falls between the wheels'

the first ***two*** *points may be credited by adding a vertical line from the centre of the X on the diagram (1)*
and labelling it weight / force / with a downwards arrow (1)
provided there is no contradiction between what is added to the diagram and anything which may be written

1

(so there is) no (resultant / clockwise) moment / turning effect

1

(b) centre of mass should be lower

accept '… centre of gravity'
accept 'weight / mass low down'
***not** just 'lower the roof'*

1

wheel base should be wider

accept 'long axle(s)' for 'wide wheel base'
allow bigger / larger wheel base
*do **not** credit '<u>long</u> wheel base'*
responses in either order

1

[5]

26 (a) 810 000

*allow 45 000 × 18 for **1** mark*

2

newton-metres / Nm

1

(b) any **three** from:

ignore references to force throughout

- their weight / mass can be altered / adjusted
- so that the crane remains stable

  allow does not topple
- so that the (total) clockwise moment equals the (total) anticlockwise moment

  *do **not** allow just 'moments are equal'*
- because not all containers are the same weight / mass

  *do **not** allow 'not all containers are the same size / volume'*
- because not all containers will be / need to move the same distance (from the crane)
- to keep the centre of mass (of the upper crane and container) in/ above the base of the tower
- so that the crane remains in equilibrium/balanced

3

[6]

27 (a) point at which its mass (seems to) act **or** point at which gravity (seems to) act

accept ... its weight acts

accept correct statements if the intent is clear e.g.. .. if suspended, the centre of gravity will be directly under the point of suspension

*e.g.... (if the object is symmetrical), the centre of gravity is on the **or** an axis (of symmetry)*

*do **not** credit just 'it is a point'*

1

(b) *The answer to this question requires good English in a sensible order with correct use of scientific terms. Quality of written communication should be considered in crediting points in the mark scheme*

*maximum of **4** marks if ideas not well expressed*

any **five** from:

clamp (steel) rod (horizontally)

***no** marks if method quite unworkable*

hang plastic / sheet by rod through (one) hole

hang plumb line from rod

mark ends of plumb line on the sheet and
use the ruler to draw a straight line

repeat with other hole

centre of mass is where the lines cross

check by balancing at this point

*maximum of **3** marks if no 'repeat with other hole'*

5

(c) (i) (turning) effect **or** moment
force
distance

all three correct
accept weight
accept length

1

(ii) 17.6

*allow 44 x 0.4 **or** 0.4 x 44 for **1** mark*

2

Nm **or** newton metre(s)

*do **not** accept N/m **or** N/cm*

*1760 Ncm gains all **3** marks*

1

[10]

28 (a) (i) **X** at the centre of the lifebelt

*measuring from the centre of **X**, allow 2 mm tolerance in any direction*

1

(ii) any **two** from:

if X is on vertical line below the hanger (but not at centre) can gain the first point only

below the point of suspension

*accept '(vertically) below **Y**'*

at the centre (of the lifebelt)

accept 'in the middle'

(because) the lifebelt / it is symmetrical

***or** (because) the mass / weight is evenly distributed*

2

(b) Nm **or** newton metre(s)

accept Newton metre(s)

*do **not** accept any ambiguity in the symbol ie NM, nM or nm*

1

750

(moment) = force × (perpendicular) distance (between line of action and pivot)

***or** (moment) = 500 × 1.5 gains **1** mark*

2

(c) Quality of written communication:

*for **2** of the underlined terms used in the correct context*

1

any **three** connected points from:

low(er) centre of mass / gravity

or *<u>centre of mass / gravity</u> will be close(r) to the wheels / axle / ground*

(more) <u>stable</u>

or *less <u>unstable</u>*

less likely to fall over

accept 'less likely to overturn'
*do **not** accept 'will not fall over'*

the <u>turning effect / moment</u> (of the weight of case) is less

or *so less effort is needed to hold the case*
ignore references to pulling the case

so the pull on her arm is less

3

[10]

29 (a) A

must be correct for reason to score

moment (due to weight) of sail is the largest

1

or

(perpendicular) distance from pivot to rope the smallest

*do **not** accept sail is low **or** sail is too heavy*

1

(b) (i) no resultant turning moment **or** in a state of balance **or** balanced

allow clockwise moments = anticlockwise moments
allow no resultant force
allow (forces are) balanced
allow no acceleration
*do **not** allow forces are equal*

1

(ii) moment = 420

*allow **1** mark for moment = 700 × 0.6*

or

700 × a distance from diagram (1.5, 2.1, 0.9)

2

(iii) force = 280

420 = F × 1.5

or

$F = \frac{\text{their (b)(ii)}}{1.5}$ ***1** mark only*

if (b)(ii) obtained by a correct method (1470, 630, 1050)

2

(c) (as wind speed increases) the force on the sail increases

accept pressure

1

aniticlockwise moment increases **or** moment on sail increases

1

so clockwise moment (**or** opposite moment) needs to increase (by increasing the distance from the pivot)

1

[10]

30 300

*allow **1** mark for rearranging equation **or** correct substitution*

[2]

31 (i) C

1

(ii) 48

*an answer of 4 800 gains **1** mark*

*if answer (b)(i) is given as A then 42 scores **1** mark*

*4200 scores **0** marks substitution of correct* figures = **1** *mark*

2

[3]

32 (a) **Z**

1

weight **or** mass acts through pivot

*accept rod **or** base for pivot*

accept centre of gravity in line with pivot

1

no (resultant) (turning) moment

accept clockwise moment equals anticlockwise moment

*do **not** accept same weight on each side of rod*

1

(b) (i) 30

*allow **1** mark for 2 × 15*

***or** 2 × 0.15*

2

N cm

or

for full credit the unit must be consistent with the numerical answer

0.3

Nm

*do **not** accept joules*

1

(ii) 1.5 (N)

*allow **1** mark for correct transformation*

*allow **2** marks ecf their part (b)(i)/20 (ecf only if correct physics)*

2

(c) 5 (cm)

*allow **1** mark for 6.0 (cm)*

*allow **1** mark for a subtraction of 1 from a value clearly obtained from the graph*

*allow **2** marks for correct ecf using an incorrect value for (b)(i) ± 0.2cm*

*allow **1** mark for clearly showing correct use of graph using an incorrect value for (b)(ii)*

2

[10]

33 (a) moment/torque increases as moves away

gains 2 marks

leverage/force increases as moves away

gains 1 mark

2

(b) (i) 20

gains 2 marks

else working

gains 1 mark

2

(ii) 100 000 ecf

gains 2 marks

else working

gains 1 mark

2

[6]

34 (a) *evidence of* moment = force × distance
or 200 × 1.5

gains 1 mark

but 300

gains 2 marks

2

(b) *ideas that* smaller than load

gains 1 mark

but 100 N **or** half the load

gains 2 marks

because applied further from pivot

gains 1 mark

but applied 2 × distance from pivot **or** evidence of balancing moments

gains 2 marks
(working for (b) shown in (a) gains credit – transfer mark)

4

[6]

35 lever

turning effect

pivot

for 1 mark each

[3]