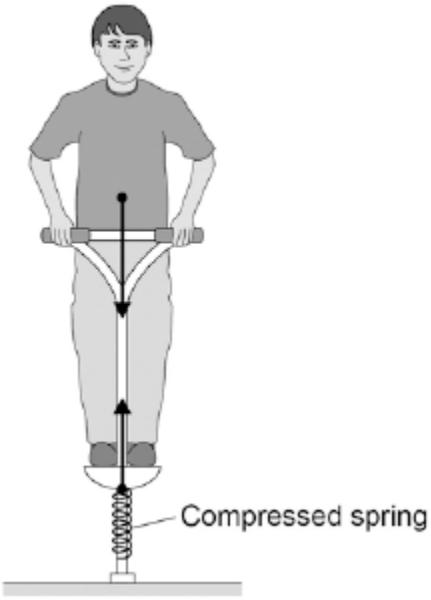
1 The figure below shows the forces acting on a child who is balancing on a pogo stick.

The child and pogo stick are not moving.



(a) The downward force of the child on the spring is equal to the upward force of the spring on the child.

This is an example of which one of Newton's Laws of motion?

Tick **one** box.

First Law ☐

Second Law ☐

Third Law ☐

(1)

(b) Complete the sentence.

Use an answer from the box.

elastic potential	**gravitational potential**	**kinetic**

The compressed spring stores ..... energy.

(1)

(c) The child has a weight of 343 N.

Gravitational field strength = 9.8 N / kg

Write down the equation which links gravitational field strength, mass and weight.

.....

(1)

(d) Calculate the mass of the child.

.....

.....

.....

Mass = ... kg

(3)

(e) The weight of the child causes the spring to compress elastically from a length of 30cm to a new length of 23cm.

Write down the equation which links compression, force and spring constant.

.....

(1)

(f) Calculate the spring constant of the spring.

Give your answer in newtons per metre.

.....

.....

.....

Spring constant = ... N / m

(4)

(Total 11 marks)

2 On 14 October 2012, a skydiver set a world record for the highest free fall from an aircraft.

After falling from the aircraft, he reached a maximum steady velocity of 373 m / s after 632 seconds.

(a) Draw a ring around the correct answer to complete the sentence.

This maximum steady velocity is called the | frictional / initial / terminal | velocity.

(1)

(b) The skydiver wore a chest pack containing monitoring and tracking equipment. The weight of the chest pack was 54 N.

The gravitational field strength is 10 N / kg.

Calculate the mass of the chest pack.

.....

.....

Mass of chest pack = ... kg

(2)

(c) During his fall, the skydiver's acceleration was not uniform.

Immediately after leaving the aircraft, the skydiver's acceleration was 10 m / s ^{2}.

(i) Without any calculation, estimate his acceleration a few seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate .....

Explanation .....

.....

.....

.....

.....

.....

(3)

(ii) Without any calculation, estimate his acceleration 632 seconds after leaving the aircraft.

Explain your value of acceleration in terms of forces.

Estimate .....

Explanation .....

.....

.....

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.....

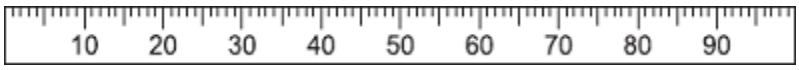
.....

(3)
(Total 9 marks)

3 A student carries out an investigation using a metre rule as a pendulum.

(a) **Diagram 1** shows a metre rule.

Diagram 1



(i) Draw, on **Diagram 1**, an **X** to show the position of the centre of mass of the rule.

(1)

(ii) State what is meant by the 'centre of mass of an object'.

.....

.....

(1)

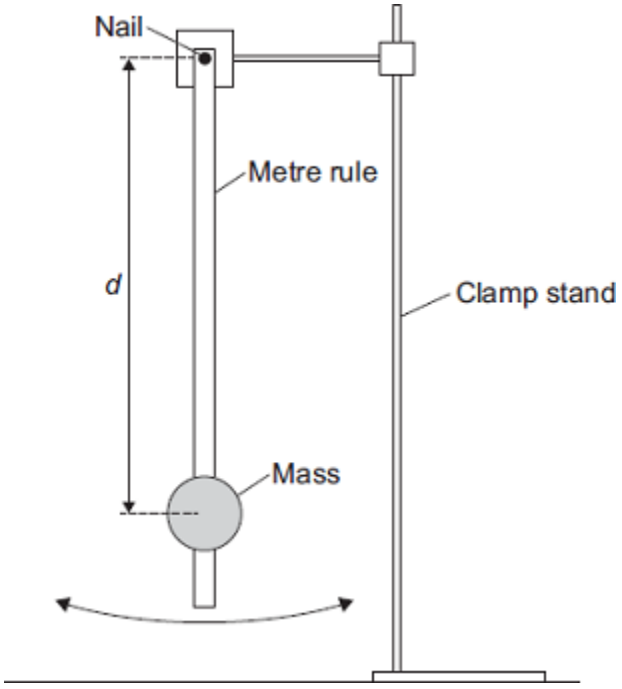
(b) The student taped a 100 g mass to a metre rule.

She set up the apparatus as shown in **Diagram 2**.

She suspended the metre rule from a nail through a hole close to one end, so she could use the metre rule as a pendulum.

The distance d is the distance between the nail and the 100 g mass.

Diagram 2



(i) Draw, on **Diagram 2**, a **Y** to show a possible position of the centre of mass of the pendulum.

(1)

(ii) The student carried out an investigation to find out how the time period of the pendulum varies with *d*.

Some of her results are shown in the table.

	Time for 10 swings in seconds				
***d* in cm**	**First test**	**Second test**	**Third test**	**Mean value**	**Mean time for 1 swing in seconds**
10.0	15.3	15.4	15.5	15.4	1.54
30.0	14.7	14.6	14.7	14.7	1.47
50.0	15.3	15.6	15.4	15.4	1.54
70.0	16.5	16.6	16.5		

Complete the table.

You may use the space below to show your working.

.....

.....

(3)

(iii) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

Describe how the student would carry out the investigation to get the results in the table in part (ii).

You should include:

- any other apparatus required
- how she should use the apparatus
- how she could make it a fair test
- a risk assessment
- how she could make her results as accurate as possible.

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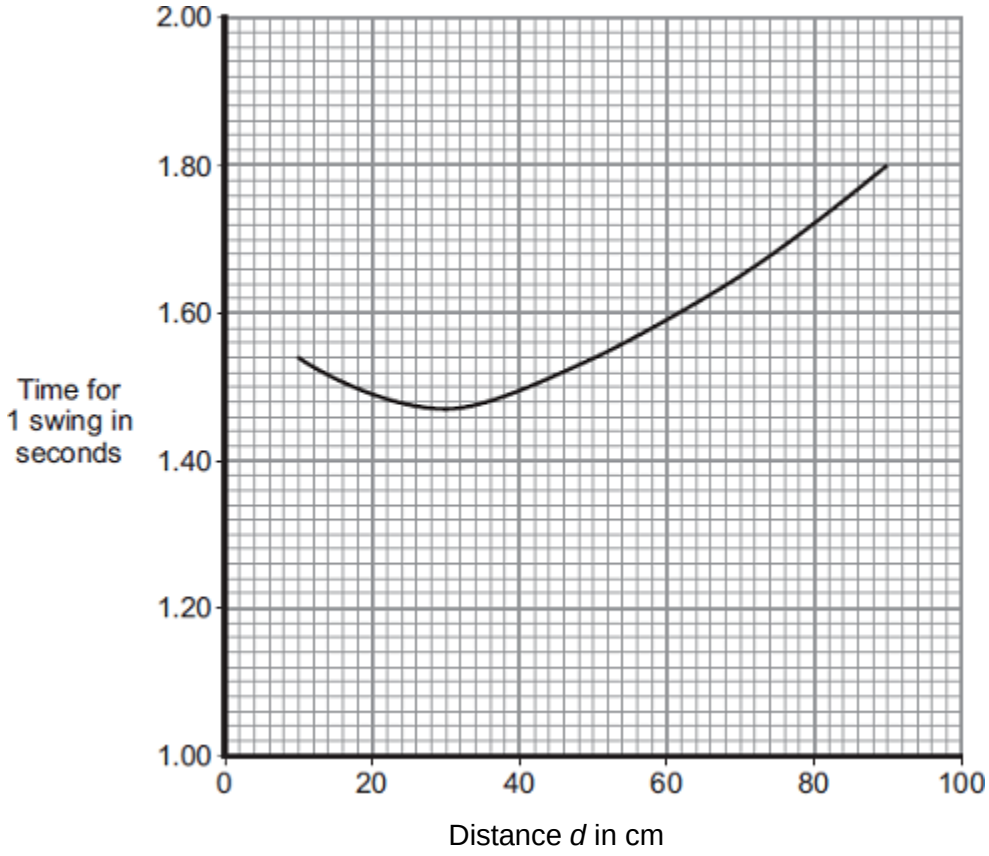
(6)

(c) A graph of the student's results is shown below.



(i) Describe the pattern shown by the graph.

.....

.....

.....

.....

(2)

(ii) The student thinks that the measurements of time for d = 10 cm might be anomalous, so she takes a fourth measurement.

Her four measurements are shown below.

15.3 s **15.4 s** **15.5 s** **15.3 s**

State whether you consider any of these measurements to be anomalous.

Justify your answer.

.....

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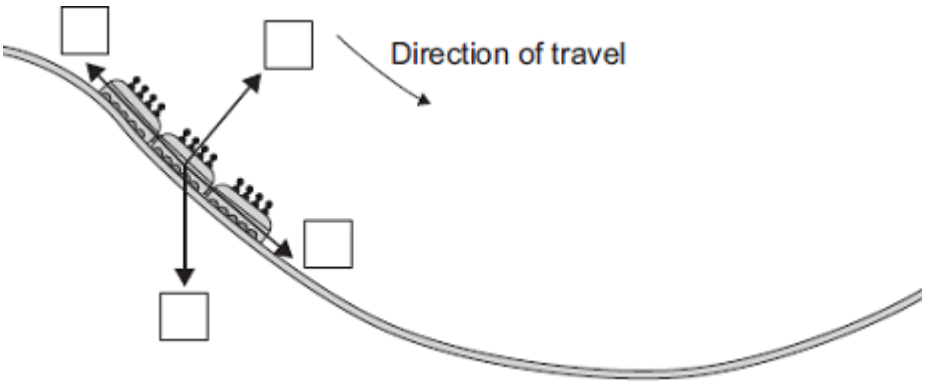
.....

.....

(2)
(Total 16 marks)

4 The diagram shows the passenger train on part of a rollercoaster ride.

(a) Which arrow shows the direction of the resultant force acting on the passenger train? Put a tick (✓) in the box next to your choice.



(1)

(b) For part of the ride, the maximum gravitational field strength acting on the passengers seems 3 times bigger than normal.

Normal gravitational field strength = 10 N/kg

(i) Calculate the maximum gravitational field strength that seems to act on the passengers during the ride.

.....

.....

Maximum gravitational field strength = ... N/kg

(1)

(ii) One of the passengers has a mass of 75 kg.

Calculate the maximum weight this passenger seems to have during the ride.

Show clearly how you work out your answer.

.....

.....

Maximum weight = ... N

(2)

(Total 4 marks)

5 (a) The diagram shows the forces acting on a parachutist in free fall.

The parachutist has a mass of 75 kg.

Calculate the weight of the parachutist.

gravitational field strength = 10 N/kg

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

.....

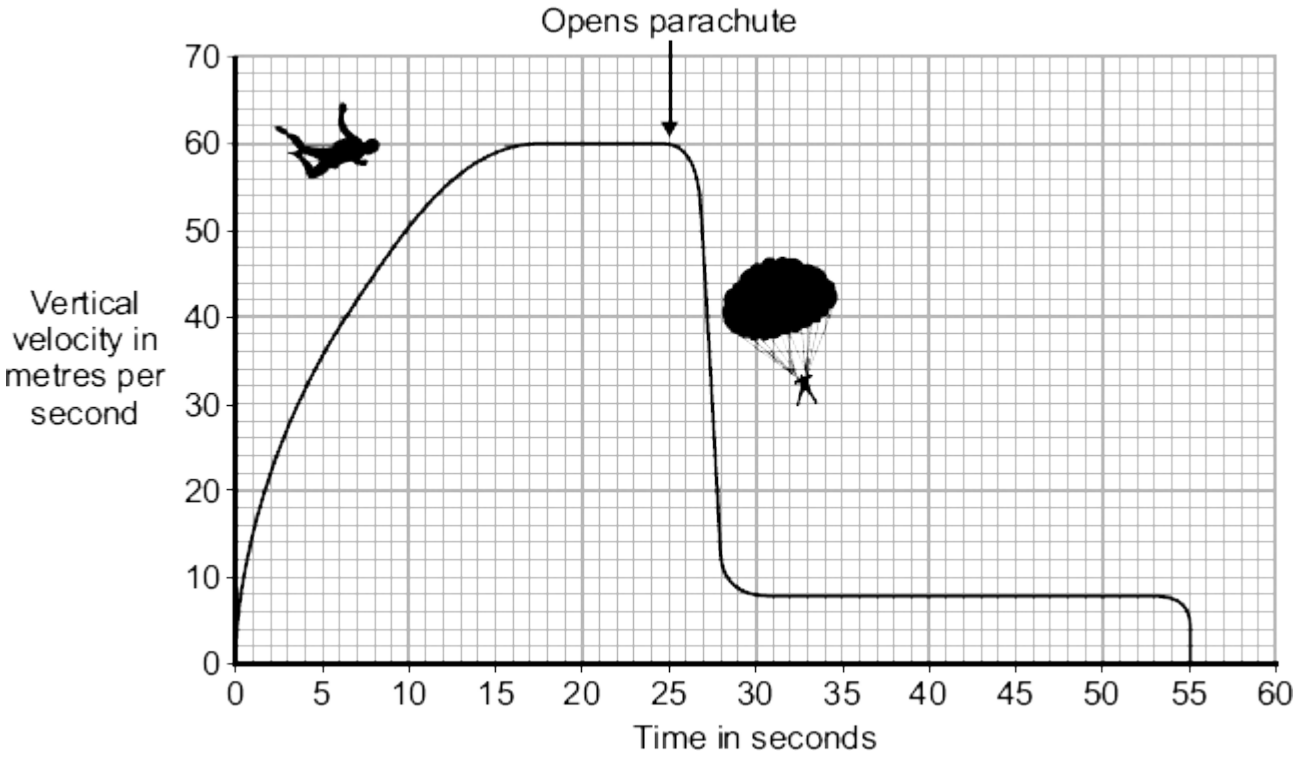
.....

Weight = ...

(3)

(b) *In this question you will be assessed on using good English, organising information clearly and using specialist terms where appropriate.*

The graph shows how the vertical velocity of a parachutist changes from the moment the parachutist jumps from the aircraft until landing on the ground.



Using the idea of forces, explain why the parachutist reaches a terminal velocity and why opening the parachute reduces the terminal velocity.

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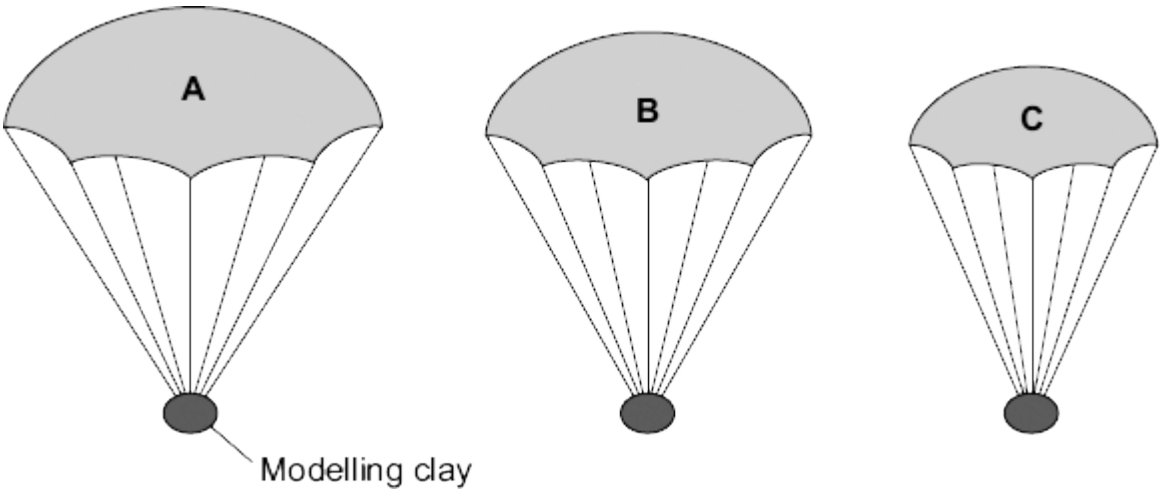
(6)

(c) A student wrote the following hypothesis.

'*The larger the area of a parachute, the slower a parachutist falls.'*

To test this hypothesis the student made three model parachutes, **A**, **B** and **C**, from one large plastic bag. The student dropped each parachute from the same height and timed how long each parachute took to fall to the ground.



(i) The height that the student dropped the parachute from was a control variable.

Name **one** other control variable in this experiment.

.....

(1)

(ii) Use the student's hypothesis to predict which parachute, **A**, **B** or **C**, will hit the ground first.

Write your answer in the box. ☐

Give a reason for your answer.

.....

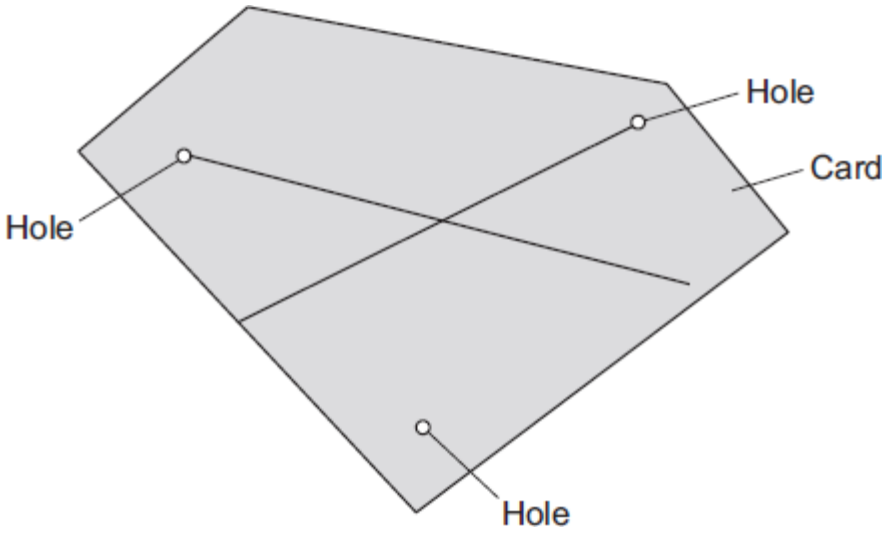
.....

.....

(2)

(Total 12 marks)

6 A student was asked to find the centre of mass of a thin sheet of card. The diagram shows the result of the student's experiment. The student drew two lines onto the card. The centre of mass is where the two lines cross.



(a) Describe how the student found the correct positions to draw the **two** lines.

You may include a labelled diagram in your answer.

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.....

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(3)

(b) Explain how the student can check that the position found for the centre of mass is accurate.

.....

.....

.....

.....

(2)
(Total 5 marks)

7 The drawing shows a plastic toy which can stand on its feet.

(a) (i) Draw an **X** on the diagram so that the centre of the **X** marks the likely position of the centre of mass of the toy.

Photograph supplied by Hemera/Thinkstock

(1)

(ii) Explain the reason for your choice in part (a)(i).

.....

.....

(1)

(b) Suggest **two** ways in which the design of the toy could be altered to make the toy more stable.

1 .....

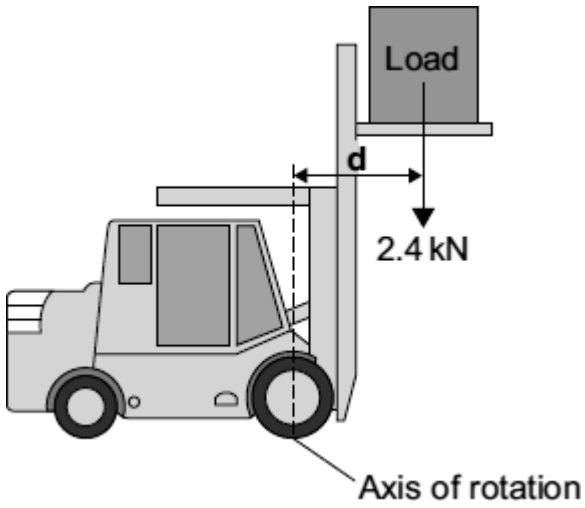
.....

2 .....

.....

(2)
(Total 4 marks)

8 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.

.....

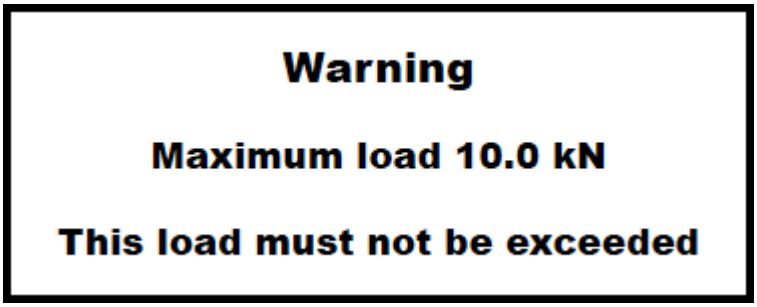
.....

.....

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.

.....

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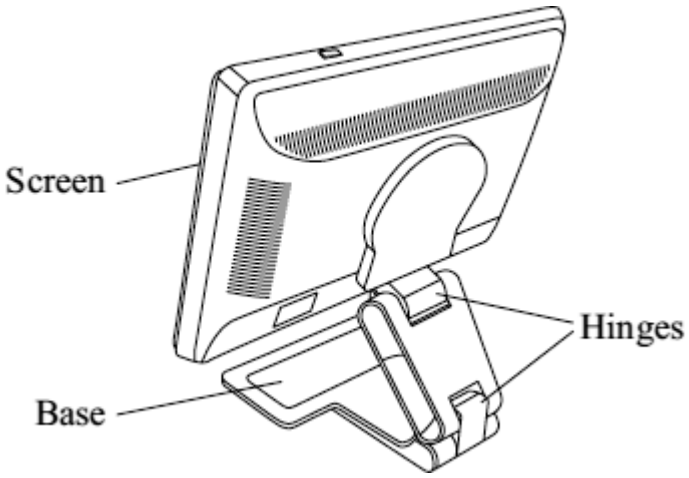
.....

(2)
(Total 5 marks)

9 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.

.....

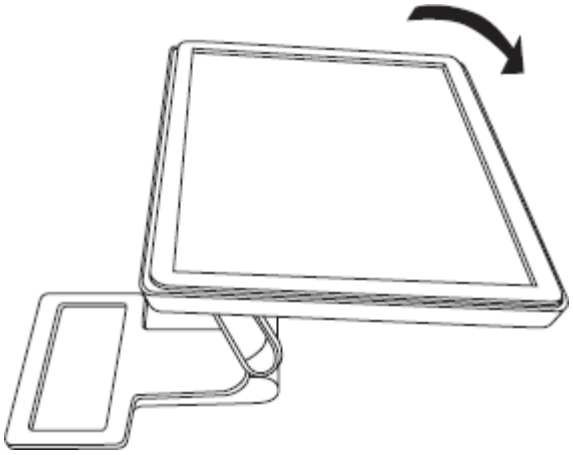
.....

(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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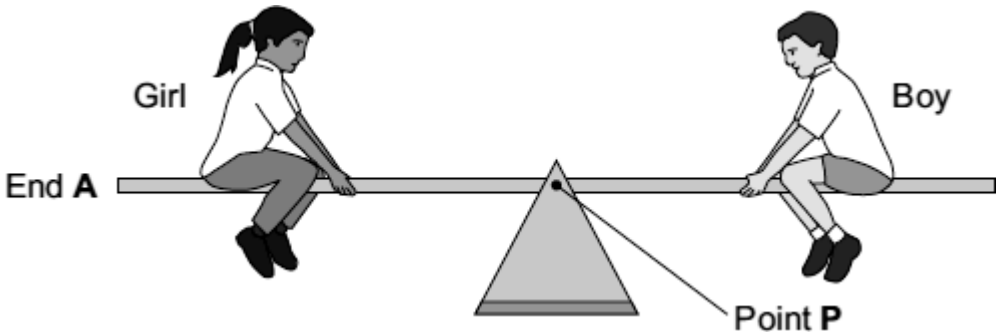
(3)
(Total 6 marks)

10 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)

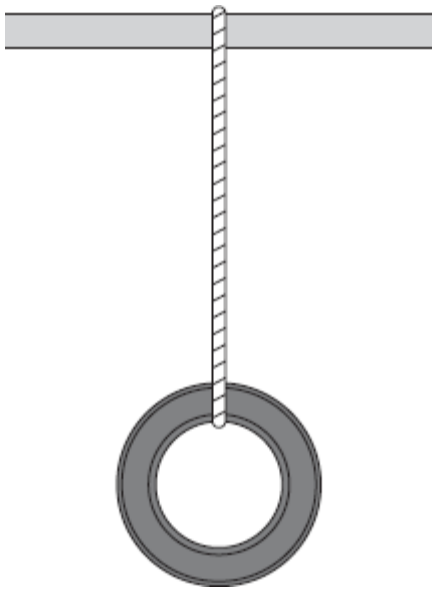
(iii) To make end **A** of the see-saw go up,

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)

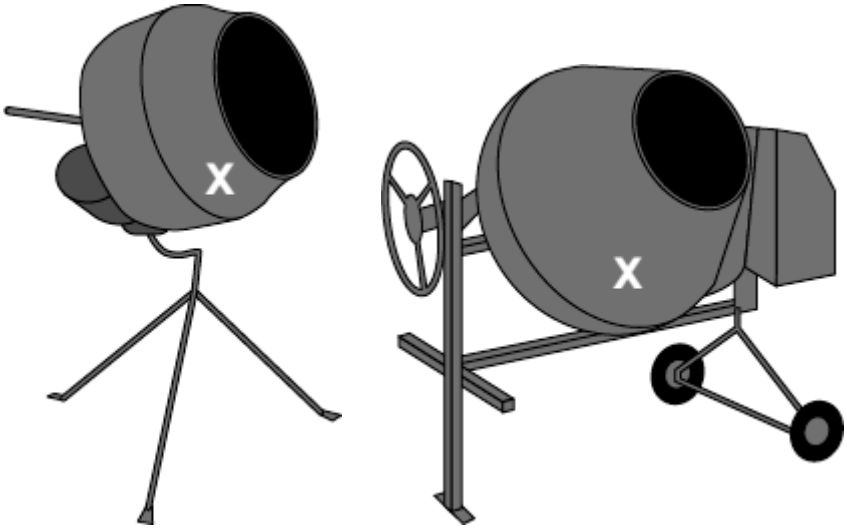
(ii) Complete the sentence by using the correct word or phrase from the box.

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)

11 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.

.....

.....

.....

.....

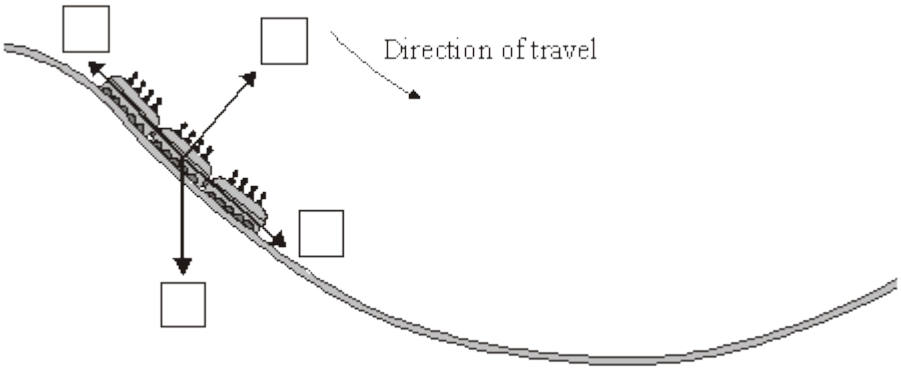
.....

(2)
(Total 5 marks)

12 The diagram shows the passenger train on part of a rollercoaster ride.

(a) Which arrow shows the direction of the resultant force acting on the passenger train?

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



(1)

(b) At the bottom of the slope, the passengers in the train all have the same speed but they each have a different kinetic energy.

Why is the kinetic energy of each passenger different?

.....

.....

(1)

(c) For part of the ride, the maximum gravitational field strength acting on the passengers seems 3 times bigger than normal.

Normal gravitational field strength = 9.8 N/kg

(i) Calculate the maximum gravitational field strength that seems to act on the passengers during the ride.

.....

.....

Maximum gravitational field strength = ... N/kg

(1)

(ii) One of the passengers has a mass of 80 kg.

Calculate the maximum weight this passenger seems to have during the ride.

Show clearly how you work out your answer.

.....

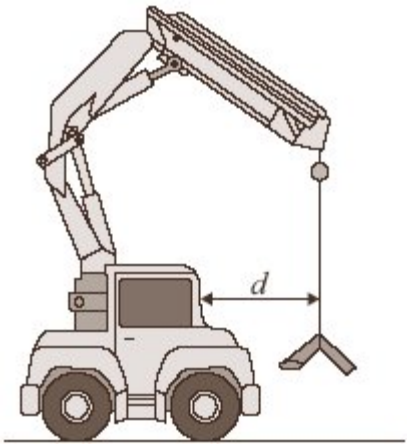
.....

Maximum weight = ... N

(2)

(Total 5 marks)

13 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?

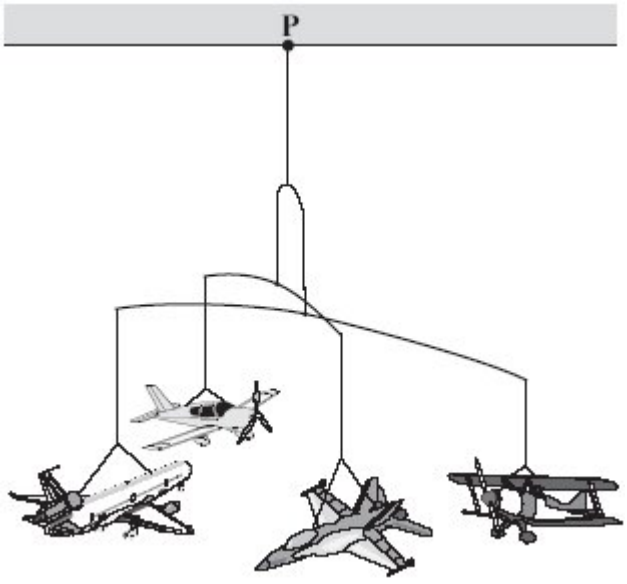
Put a tick (✓) in the box next to your answer.

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)

14 (a) The diagram shows a child's mobile. The mobile hangs from point **P** on the ceiling of the child's bedroom.

(i) Mark the position of the centre of mass of the mobile by drawing a letter **X** on the diagram. Do this so that the centre of the **X** marks the centre of mass of the mobile.



(1)

(ii) Explain why you have chosen this position for your letter **X**.

.....

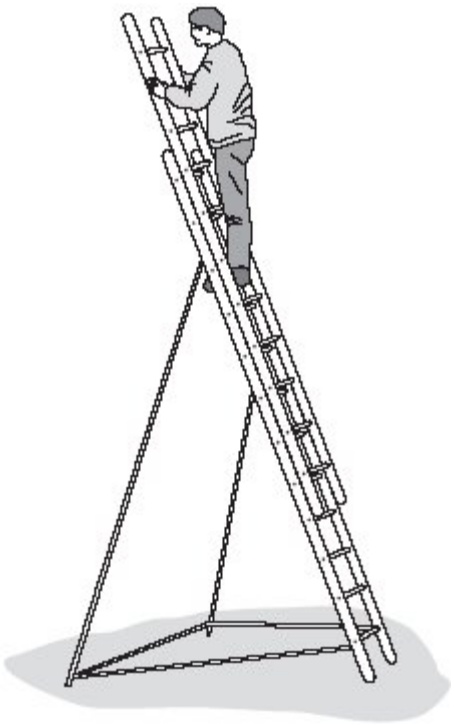
.....

.....

.....

(2)

(b) The diagram shows a device which helps to prevent a ladder from falling over.



Use the term *centre of mass* to explain why the ladder, in the situation shown, is unlikely to topple over.
You may add to the diagram to illustrate your explanation.

.....

.....

.....

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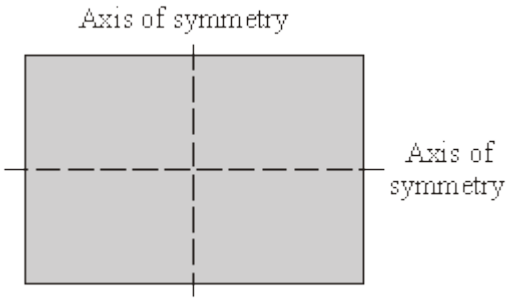
.....

.....

(3)
(Total 6 marks)

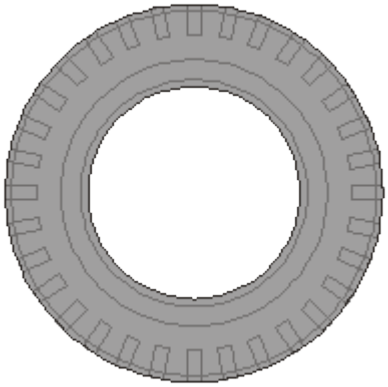
15 (a) The diagram shows a rectangle made out of a sheet of cardboard.



Draw an **X** on the diagram so that the centre of the **X** is at the centre of mass of the rectangle.

(1)

(b) The drawing shows a car tyre.



(i) Where is the centre of mass of the tyre?

.....

(1)

(ii) Explain your answer to (b)(i).

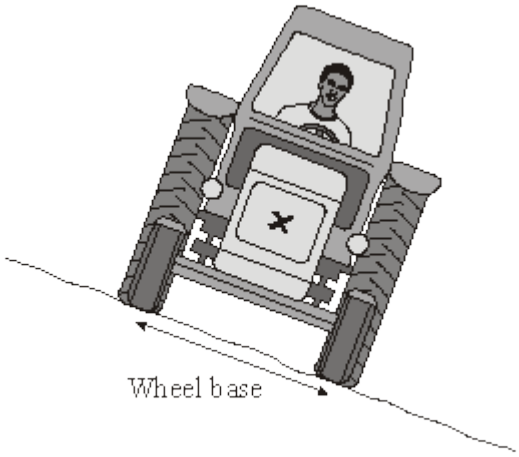
.....

.....

(1)
(Total 3 marks)

16 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 .....

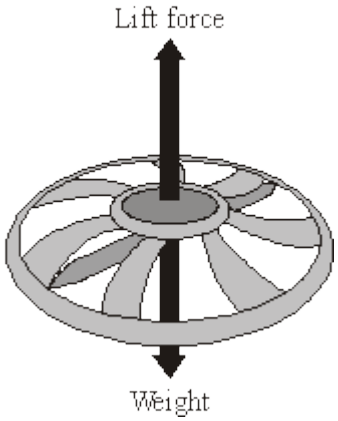
.....

Feature 2 .....

.....

(2)
(Total 5 marks)

17 The diagram shows the forces on a small, radio-controlled, flying toy.



(a) (i) The mass of the toy is 0.06 kg.
Gravitational field strength = 10 N/kg

Calculate the weight of the toy.

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

.....

.....

Weight = ...

(3)

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

When the toy is hovering stationary in mid-air, the lift force is

bigger than
the same as
smaller than

the weight of the toy.

(1)

(b) When the motor inside the toy is switched off, the toy starts to *accelerate* downwards.

(i) What does the word *accelerate* mean?

.....

(1)

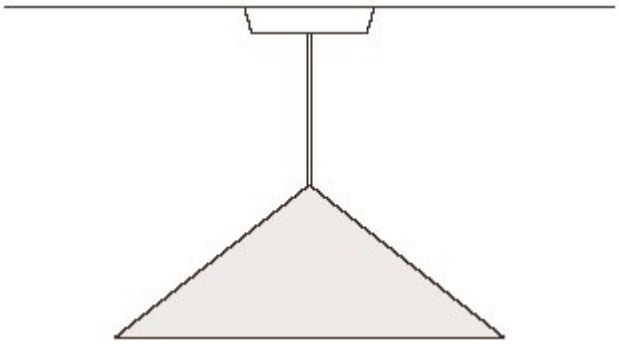
(ii) What is the direction of the resultant force on the falling toy?

.....

(1)

(Total 6 marks)

18 (a) The diagram shows a lampshade hanging from the ceiling. Draw an **X** on the diagram so that the centre of the **X** marks the centre of the mass of the lampshade.



(1)

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

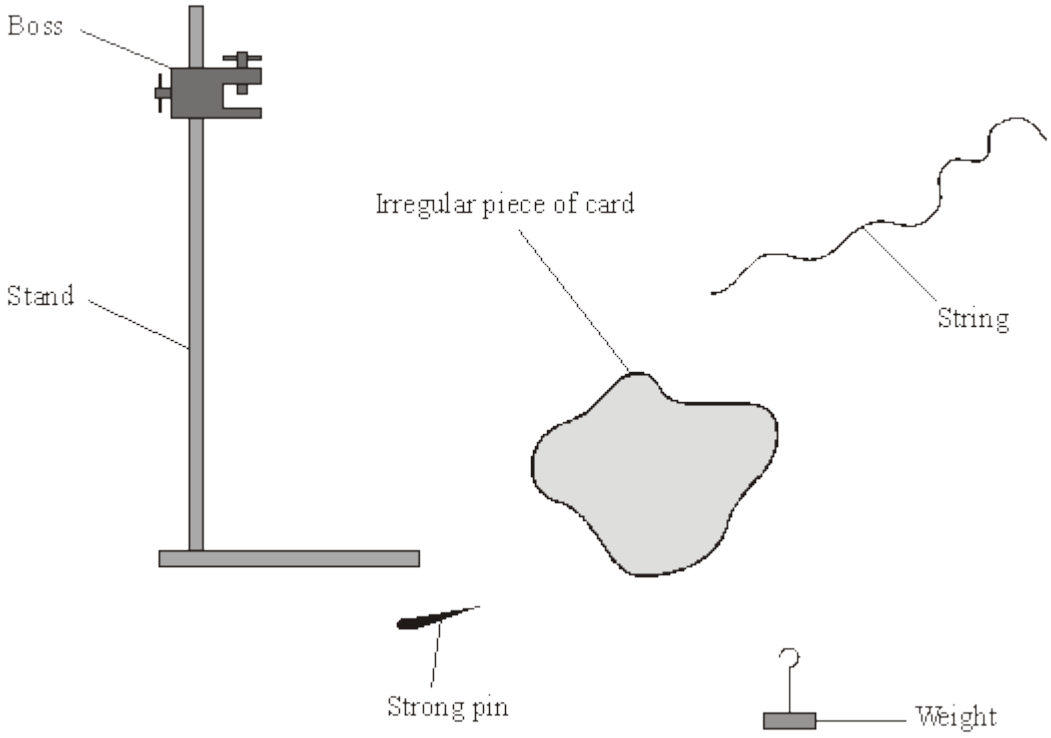
above	**below**	**to the left of**	**to the right of**

A suspended object will come to rest with its centre of mass directly

..... the point of suspension.

(1)

(c) The diagrams show equipment that a student uses to find the centre of mass of a thin sheet of card.



Arrange these sentences in the correct order to describe how the student can find the centre of mass of the card.

The sequence starts with sentence **D** and finishes with sentence **E**.

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

B The pin is put through one of the holes in the card and held in the boss.

C This is repeated using the other hole.

D Two holes are made in the card with each hole near to the edge of the card.

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

F The weight is tied to the string and then the string is hung from the pin.

D					**E**

(3)
(Total 5 marks)

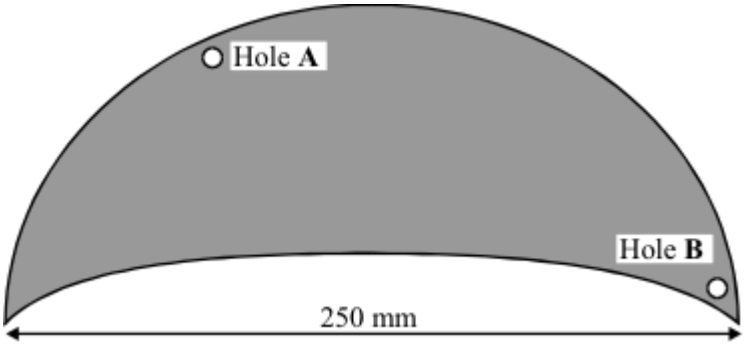
19 (a) Every object has a *centre of mass*. What is meant by the *centre of mass*?

.....

.....

(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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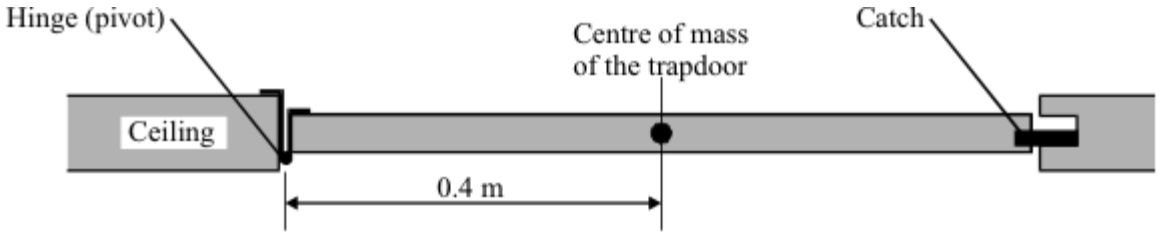
(5)

(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.

.....

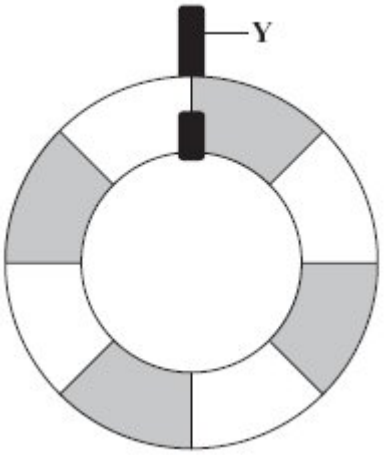
.....

Turning effect = ...

(3)
(Total 10 marks)

20 (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.

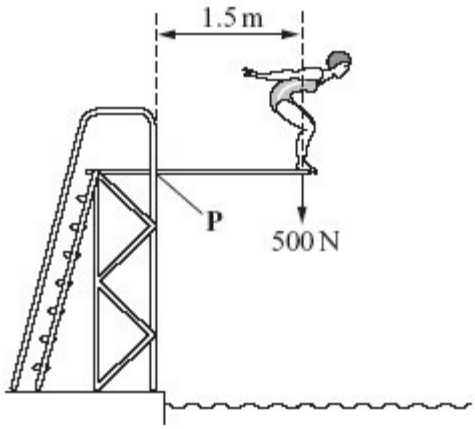
.....

.....

.....

(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.

.....

.....

.....

.....

.....

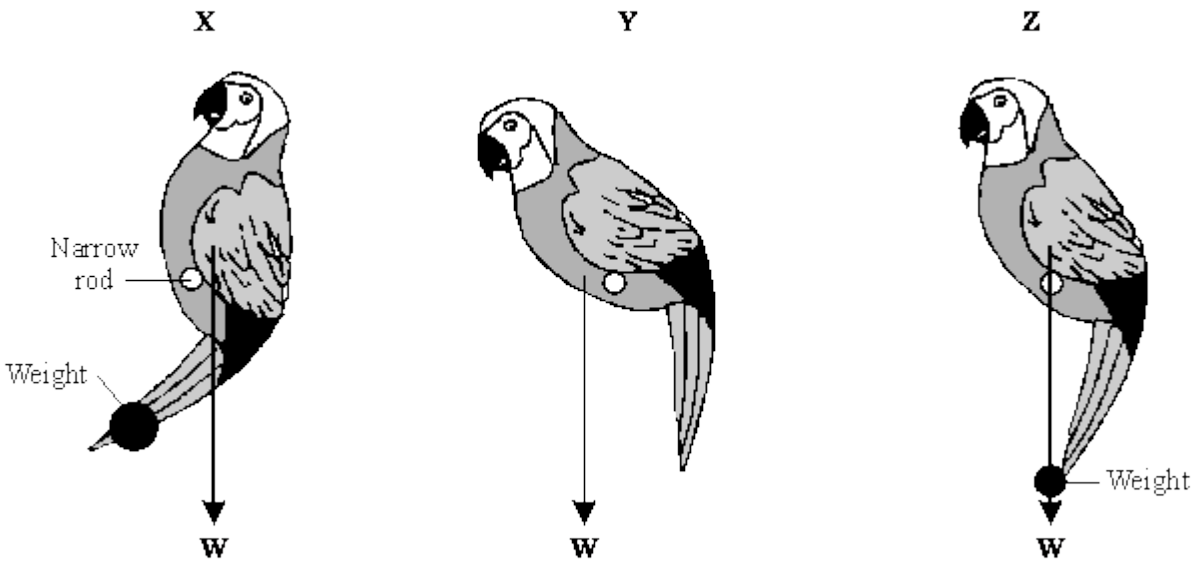
.....

.....

.....

(4)
(Total 10 marks)

21 (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.

.....

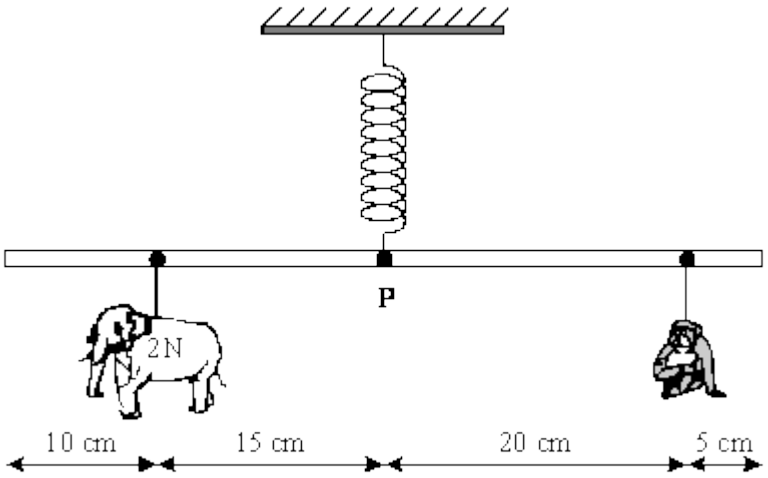
.....

.....

.....

(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

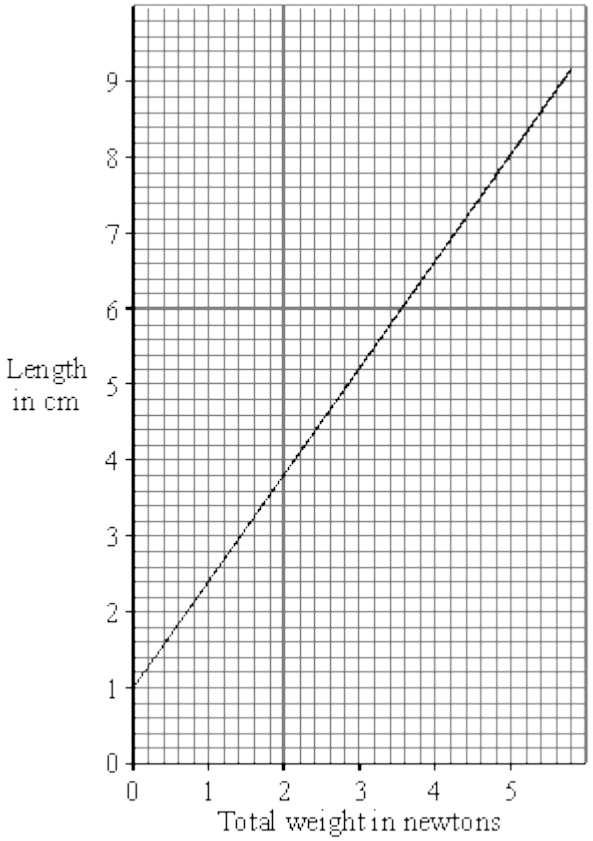
.....

.....

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.

.....

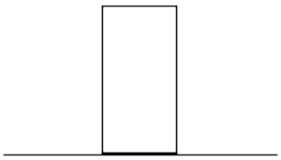
.....

Extension of spring = ... cm

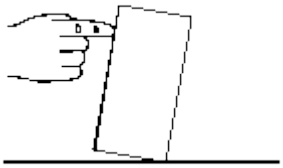
(2)

(Total 10 marks)

22 A child stands a wooden brick on its end as shown in the diagram.



The child then pushes the brick to make it tilt.



How far must the brick be tilted to make it fall over?

Explain your answer.

(You may draw a labelled diagram if you wish.)

.....

.....

.....

(Total 2 marks)

23 Choose words from this list to complete the sentences below.

balanced	electricity	gravity
joules	magnetism	newtons

When you drop something it falls.

This is because it is pulled to the Earth by .....

We measure forces in units called .....

When a falling object reaches the ground, it stops moving.

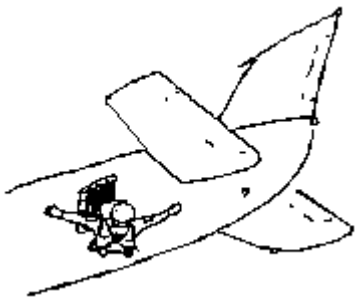
This means that the forces acting on it are now .....

(Total 3 marks)

24 A sky-diver steps out of an aeroplane.

After 10 seconds she is falling at a steady speed of 50m/s.

She then opens her parachute.



After another 5 seconds she is once again falling at a steady speed.

This speed is now only 10m/s.

(a) Calculate the sky-diver's average acceleration during the time from when she opens her parachute until she reaches her slower steady speed. (Show your working.)

.....

.....

.....

(3)

(b) Explain, as fully as you can:

(i) why the sky-diver eventually reaches a steady speed (with or without her parachute).

.....

.....

.....

.....

(3)

(ii) why the sky-diver's steady speed is lower when her parachute is open.

.....

(1)

(c) The sky-diver and her equipment have a total mass of 75kg. Calculate the gravitational force acting on this mass. (Show your working.)

.....

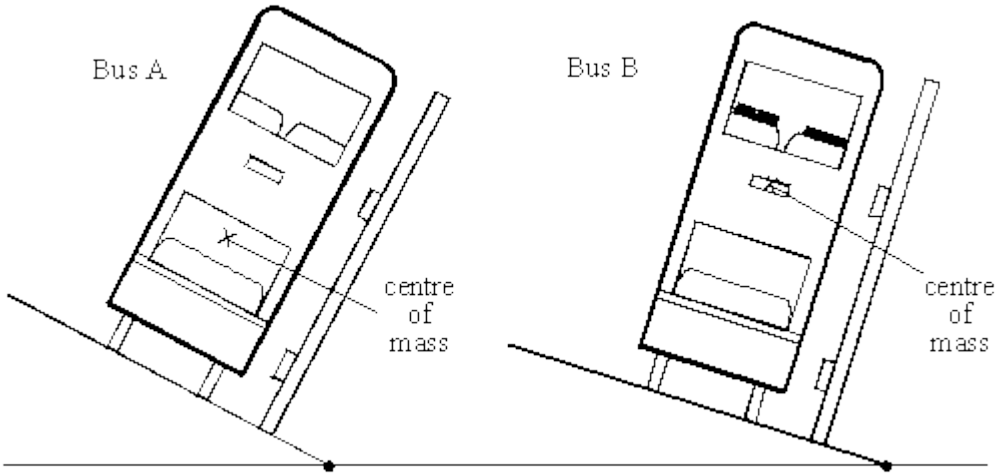
.....

Answer ..... N

(1)
(Total 8 marks)

25 The diagram shows two buses. Bus A is empty. Bus B contains bags of sand upstairs to represent passengers.

Each bus has been tilted as far as it can without falling over.



(a) Each bus will topple over if it is tilted any further.

Explain, in as much detail as you can, why this will happen.

(You can draw on one of the diagrams as part of your answer if you want to.)

.....

.....

.....

(2)

(b) What difference does it make to the stability of the bus when the upper deck is full of "passengers"? Explain your answer as fully as you can.

.....

.....

.....

(3)

(c) Why are the bags of sand in bus B only put upstairs?

.....

.....

(1)
(Total 6 marks)

1

(a) Third Law

1

(b) elastic potential

1

(c) weight = mass × gravitational field strength

accept gravity for gravitational field strength

1

accept W = mg

accept correct rearrangement ie mass = weight / gravitational field strength ***or*** *m = W / g*

(d) 343 = m × 9.8

1

$m = \frac{343}{9.8}$

1

m = 35

1

allow 35 with no working shown for ***3*** *marks*

(e) force = spring constant × compression

accept force = spring constant × extension

accept F = k e

accept correct rearrangement ie constant = force / extension ***or*** *k = F / e*

1

(f) compression = 0.07m

1

343 = k × 0.07

1

k = 343 ÷ 0.07

1

k = 4900

1

allow 4900 with no working shown for ***4*** *marks*

allow 49 with no working shown for ***3*** *marks*

[11]

2

(a) terminal

1

(b) 5.4 (kg)

*correct substitution of 54 = m × 10 gains **1** mark*

2

(c) (i) 0< a <10

1

some upward force

accept some drag / air resistance

1

reduced resultant force

1

(ii) 0

1

upward force = weight (gravity)

1

resultant force zero

1

[9]

3

(a) (i) **X** placed at 50 cm mark

1

(ii) point at which mass of object may be (thought to be) concentrated

1

(b) (i) **Y** placed between the centre of the rule and the upper part of mass

1

(ii) 16.5

*allow for **1** mark*
(16.5 + 16.6 +16.5) / 3

2

1.65

value consistent with mean value given
only penalise significant figures once

1

(iii) Marks awarded for this answer will be determined by the quality of communication as well as the standard of the scientific response. Examiners should apply a 'best-fit' approach to the marking.

0 marks
No relevant content

Level 1 (1 – 2 marks)
A description of a method which would provide results which may not be valid

Level 2 (3 – 4 marks)
A clear description of a method enabling some valid results to be obtained. A safety factor is mentioned

Level 3 (5 – 6 marks)
A clear and detailed description of experiment. A safety factor is mentioned. Uncertainty is mentioned

examples of the physics points made in the response:

additional apparatus

- stopwatch

use of apparatus

- measure from hole to centre of the mass
- pull rule to one side, release
- time for 10 swings and repeat
- divide mean by 10
- change position of mass and repeat

fair test

- keep other factors constant
- time to same point on swing

risk assessment

- injury from sharp nail
- stand topple over
- rule hit someone

accuracy

- take more than 4 values of d
- estimate position of centre of slotted mass
- small amplitudes
- discard anomalous results
- use of fiducial marker

6

(c) (i) initial reduction in T (reaching minimum value) as d increases

1

after 30 cm *T* increases for higher value of *d*

1

(ii) (no)

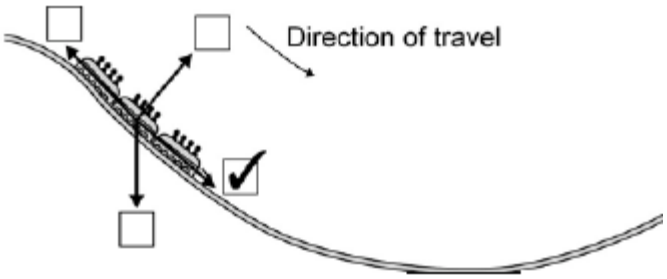
any **two** from:

- fourth reading is close to mean
- range of data 0.2 s / very small
- variation in data is expected

2

[16]

4 (a) correct box ticked



1

(b) (i) 30

ignore added units

1

(ii) 2250 **or** their (b)(i) × 75 correctly calculated

*allow **1** mark for correct substitution ie 75 × 30 **or** their (b)(i) × 75 provided no subsequent step shown*

*an answer of 750 gains **1** mark only if answer to (b)(i) is 10*

2

[4]

5 (a) 750

*allow **1** mark for correct substitution, ie 75 × 10 provided no subsequent step shown*

2

newton(s) / N

*do **not** accept n*

1

(b) Marks awarded for this answer will be determined by the Quality of Written Communication (QWC) as well as the standard of the scientific response.
Examiners should also refer to the Marking Guidance, and apply a 'best-fit' approach to the marking.

0 marks
No relevant content.

Level 1 (1-2 marks)
There is a brief attempt to explain why the velocity / speed of the parachutist changes.
or
the effect of opening the parachute on velocity/speed is given.

Level 2 (3-4 marks)
The change in velocity / speed is clearly explained in terms of force(s)
or
a reasoned argument for the open parachute producing a lower speed.

Level 3 (5-6 marks)
There is a clear and detailed explanation as to why the parachutist reaches terminal velocity
and
a reasoned argument for the open parachute producing a lower speed

examples of the physics points made in the response to explain first terminal velocity

- on leaving the plane the only force acting is weight (downwards)
  accept gravity for weight throughout
- as parachutist falls air resistance acts (upwards)
  accept drag / friction for air resistance
- weight greater than air resistance
  or
  resultant force downwards
- (resultant force downwards) so parachutist accelerates
- as velocity / speed increases so does air resistance
- terminal velocity reached when air resistance = weight
  accept terminal velocity reached when forces are balanced

to explain second lower terminal velocity

- opening parachute increases surface area
- opening parachute increases air resistance
- air resistance is greater than weight

- resultant force acts upwards / opposite direction to motion
- parachutist decelerates / slows down
- the lower velocity means a reduced air resistance

air resistance and weight become equal but at a lower (terminal) velocity

6

(c) (i) any **one** from:

- mass of the (modelling) clay
  accept size/shape of clay size/amount/volume/shape of clay
  accept plasticine for (modelling)clay
- material parachute made from
  accept same (plastic) bag
- number / length of strings

1

(ii) **C**

*reason only scores if **C** is chosen*

1

smallest (area) so falls fastest (so taking least time)

accept quickest/quicker for fastest

*if **A** is chosen with the reason given as 'the largest area so falls slowest' this gains **1** mark*

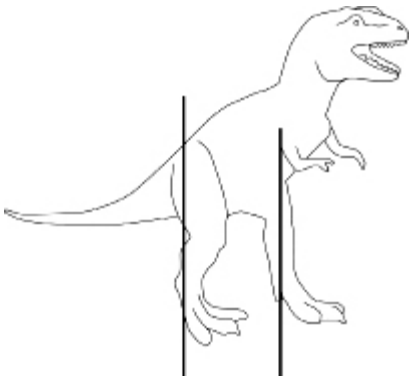
1

[12]

6 *Resource currently unavailable*

7 (a) (i) centre of **X** above the feet and in the body

*a vertical line from their **X** falls between two lines in diagram - judged by eye*



1

(ii) where the mass seems to be concentrated

accept it's above the base (area)

accept because otherwise it would topple

accept line of action (of weight) passes through the base

*do **not** accept where the mass is concentrated*

1

(b) any **two** from:

- make (the area of) feet / base bigger
- make feet wider apart
- makes legs shorter / heavier
- make head smaller / lighter
- make tail touch the ground / make the tail longer

accept 'make centre of mass / gravity lower'

2

[4]

8 (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]

9

(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]

10

(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]

11 (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

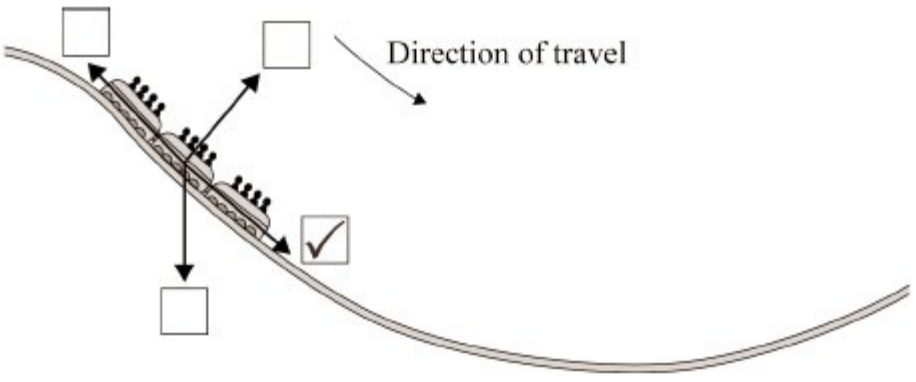
accept resulting moment for resultant moment

*do **not** accept converse argument*

1

[5]

12 (a) correct box ticked



1

(b) each passenger has a different mass

accept weight for mass

ignore other irrelevant factors about the person e.g. mass and height

do not accept a list with incorrect factors e.g. mass and position

accept passengers started with different (gravitational) potential energy

1

(c) (i) 29.4

ignore added units

1

(ii) 2400

accept their (c)(i) × 80 correctly calculated for both marks

allow 1 mark for correct substitution of their (c)(i) and 80

an answer of 800 gains 1 mark only if answer to (c)(i) is not 10

2

[5]

13 (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 over/forward

1

(d) results of experiments on this mobile crane

accept any unambiguous indication

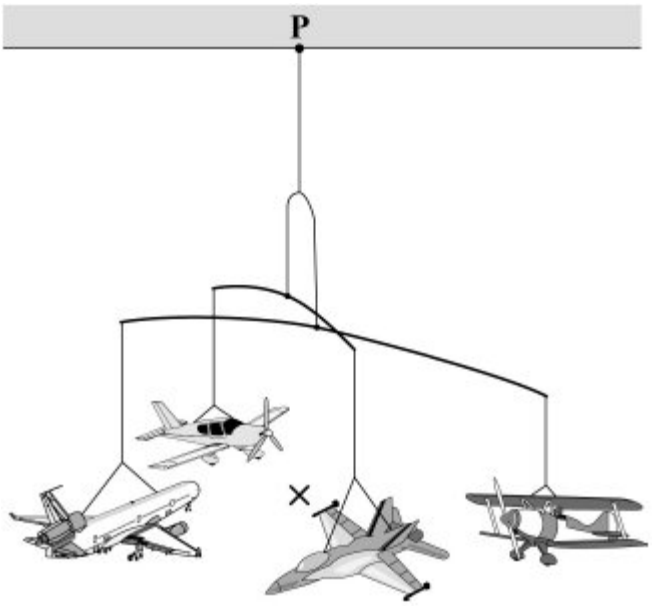
1

[6]

14 (a) (i) centre of **X** directly below **P** and between the model aeroplanes

as judged by eye but between centre of propeller of top aeroplane and canopy of bottom aeroplane

example



1

(ii) the centre of mass is (vertically) below the point of suspension / P

1

the centre of mass is in the middle of the aeroplanes

accept the centre of mass is level with the aeroplanes

1

(b) centre of mass of the worker and the ladder (and device)

1

line of action of the weight is inside the base

accept the centre of mass is above / within / inside the base (of the ladder and device)

1

so there will not be a (resultant) moment

accept so he / it / the ladder will not topple even if he leans over

or it will (only) topple over if the line of action of the weight / the centre of mass is outside the base

*accept each point, either on the diagram or in the written explanation, but do **not** accept the point if there is any contradiction between them*

1

[6]

15 (a) centre of X at the point where the axes cross

to within 1 mm in any direction

1

(b) (i) (at / in the) centre (of the tyre)

***or** unambiguously shown on the diagram*

1

(ii) (this is) where axes of symmetry (of the tyre) cross / intersect / meet

***or** point at which the mass of the tyre seems to be (concentrated)*

1

[3]

16 (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]

17 (a) (i) 0.6

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

2

newtons

accept N
*do **not** accept n*
accept Newtons

1

(ii) the same as

1

(b) (i) changed velocity

accept increased/ decreased for change
accept speed for velocity
accept <u>change</u> direction
accept getting faster/ slower
accept start/ stop moving
accept correct equation in terms of change in speed or change in velocity

1

(ii) down(wards)

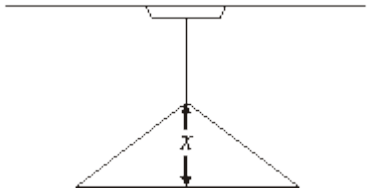
accept towards the ground
accept ↓
*do **not** accept south*

1

[6]

18 (a) centre of **X** should appear to be on the continued line of the flex and in the body of the lamp as judged by eye

example



1

(b) below

1

(c) (D)→B→F→A→C→(E)

*all four correct for **3** marks*

***or** any two correct for **2** marks*

***or** just one correct for **1** mark*

3

[5]

19 (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]

20 (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** centre of mass / gravity will be close(r) to the wheels / axle / ground*

(more) stable

***or** less unstable*

less likely to fall over

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

the turning effect / moment (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]

21 (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]

22 *any evidence of idea that* weight acts through/near centre of mass/gravity/brick

gains 1 mark

but *clear indication that brick topples if*
vertical line through centre of mass is outside base line of brick
or line of action of weight is outside base line of brick

gains 2 marks

[2]

23 gravity
newtons
balanced

each for 1 mark

[3]

24

(a) *evidence of* $\frac{\text{change in speed}}{\text{time taken}}$ or $\frac{40}{5}$

gains 1 mark

(*credit* 50/10 **or** 5 with *1 mark*) NOT 40/10 or 50/5

but 8 [N.B. negative not required]

gains 2 marks

units metres per second per second **or** (metres per second squared or m/s^2)

for 1 mark

3

(b) (i) *idea that*
accelerates at first due to gravity
air/wind resistance
friction/resistance/drag with air increases with speed
eventually gravity and friction cancel balance
or (no net/accelerating force) [NOT terminal velocity]

each for 1 mark

3

(ii) *idea*
a bigger resistance/friction/drag at any given speed (*credit* a bigger drag (factor))

for 1 mark

1

(c) *evidence of* × 10 / × 9.8 / × 9.81 **or** 750/735(75)

for 1 mark

1

[8]

25 (a) *idea*

- line of action of weight/force/gravity
  (if drawn: a vertical line through the centre of mass)
- falls outside the (wheel) base (mark NOT from diagram)

for 1 mark each

2

(b) ideas that

- less stable/topples more easily
- centre of mass at a higher level
- so need small angle to make line of action of weight fall outside (wheel) base

for 1 mark each

3

(c) idea that

this is the most unstable condition (when bus used)
or
this makes c. of m. as high as it is likely to be

for 1 mark

1

[6]