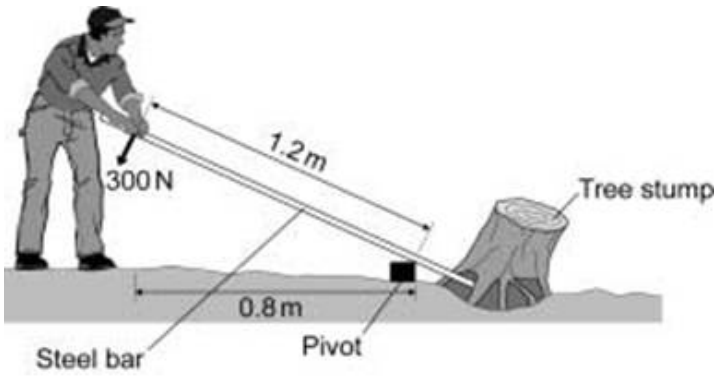
Motion

147 minutes

145 marks

Q1. (a) The diagram shows a gardener using a steel bar to lever a tree stump out of the ground.



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

Calculate the moment produced by the gardener on the steel bar.

Write down the equation you use, and then show clearly how you work out your answer and give the unit.

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Moment = ...

(4)

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

Explain why.

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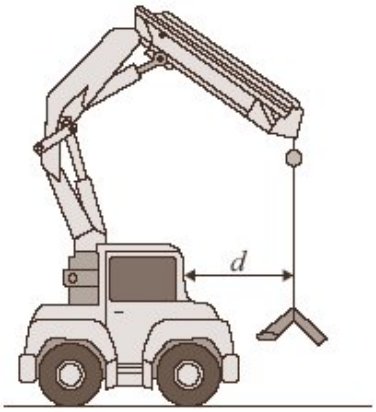
(3)

(Total 7 marks)

Q2. 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.

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.....

(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)

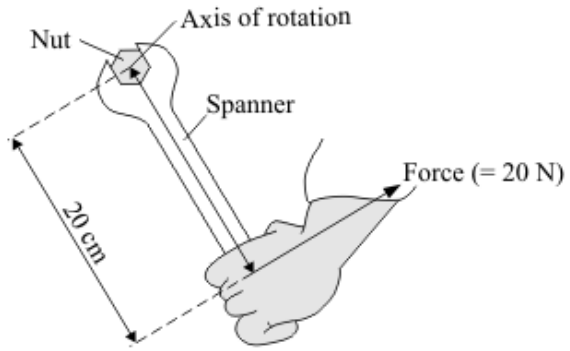
Q3. A spanner gives a turning effect to undo a nut.

(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.



Use the equation in the box to calculate the spanner's turning effect in newton metres.

turning effect = perpendicular distance from the line of action of the force to the axis of rotation

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.

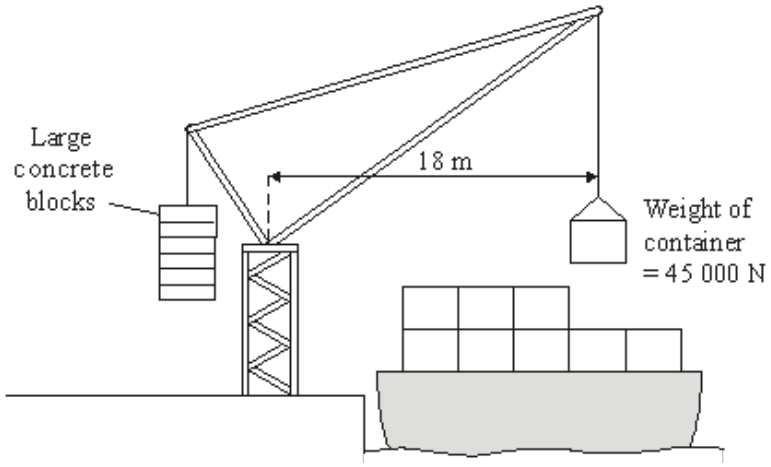
1 .....

2 .....

(2)

(Total 5 marks)

Q4. The diagram shows a crane which is loading containers onto a ship.



(a) Use the equation in the box to calculate the moment of the container which is being loaded.

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 of the container = ...

(3)

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

.....

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.....

.....

.....

(3)
(Total 6 marks)

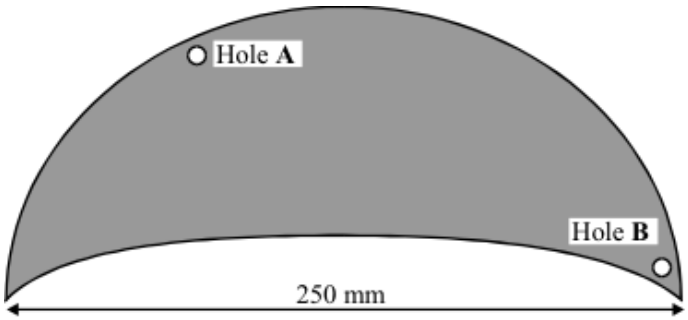
Q5. (a) Every object has a *centre of mass*. What is meant by the *centre of mass*?

.....

.....

(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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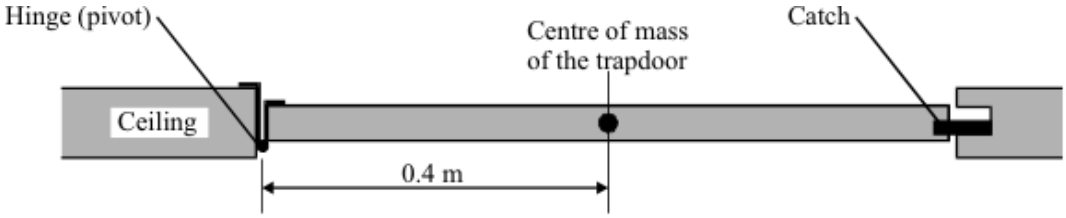
(5)

(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 ..... and 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 = ...

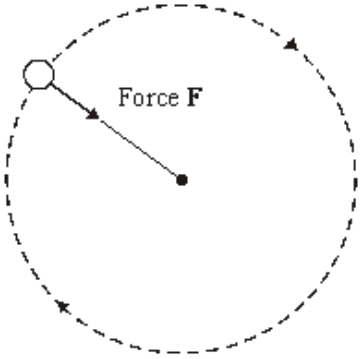
(3)

(Total 10 marks)

Q6. (a) A student has fastened a ball to a piece of string and is swinging it round in a horizontal circle.

(i) The diagram below shows an overhead view of the movement of the ball.

Add an arrow, from the centre of the ball, to show the direction in which the ball would move if the string broke at this instant.



(1)

(ii) Complete the table to show how force **F** changes if the student changes what he is doing. In each case, all the other factors stay the same.

If the student	Force F needs to
uses a ball with a greater mass	.....
swings the ball at a greater speed	.....
swings the ball with a shorter piece of string	.....

(3)

(b) The Moon orbits the Earth in a circular path. Use words from the box to complete the **three** spaces in the sentence.

direction	**resistance**	**speed**	**velocity**

You may use each word once, more than once or not at all.

The Moon's ..... is constant but its ..... changes

because its ..... changes.

(2)

(c) When any object moves in a circular, or nearly circular, path a force must act towards the centre of the circle.

(i) What word is used to describe this force?

.....

(1)

(ii) The Moon orbits the Earth. What provides the force towards the Earth?

.....

(1)

(iii) In an atom, name the particles which are moving in circular paths around the nucleus.

.....

(1)

(iv) In the case of an atom, what word describes the forces which keep these particles moving in circular paths around the nucleus?

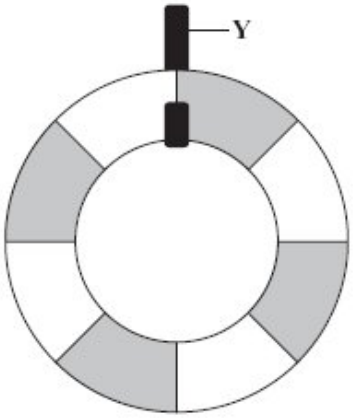
.....

(1)

(Total 10 marks)

Q7. (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.

.....

.....

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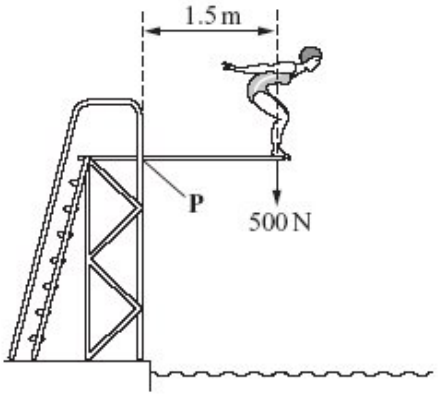
(2)

(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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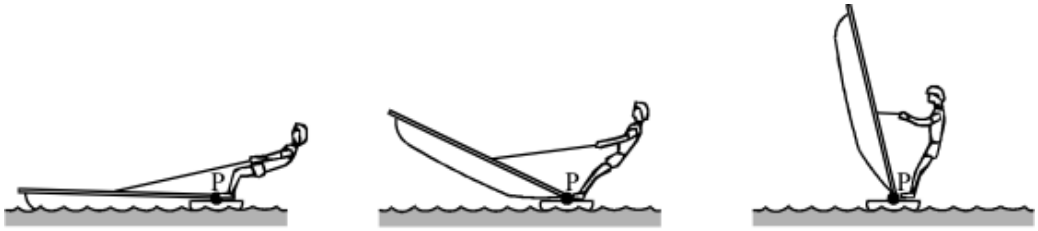
(4)

(Total 10 marks)

Q8. (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.

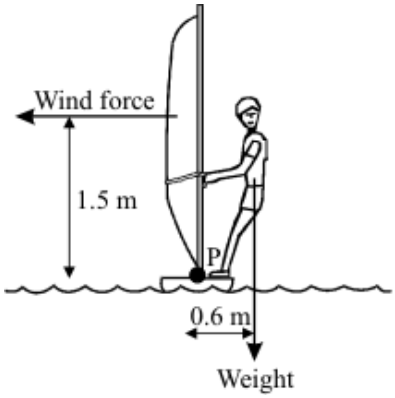
.....

.....

.....

(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. Use the equation below to calculate the moment exerted by the windsurfer on the sailboard. Show clearly how you work out your answer.

moment = force × perpendicular distance from pivot

.....

.....

Moment = ... Nm

(2)

(iii) Use the relationship below to calculate the horizontal force of the wind on the sail. Show clearly how you work out your answer.

total clockwise moment = total anticlockwise moment

.....

.....

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.

.....

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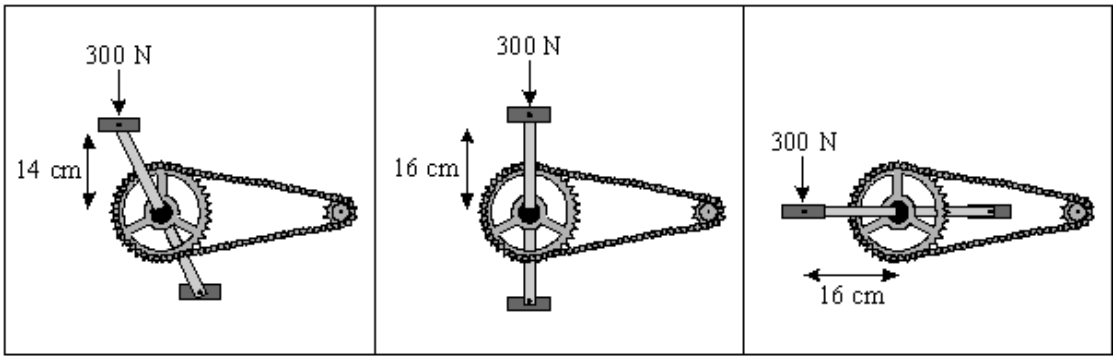
.....

.....

(3)

(Total 10 marks)

Q9. 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) Use the following equation to calculate, in Newton metres, the size of the largest moment on the pedal.

moment = force × perpendicular distance from pivot

.....

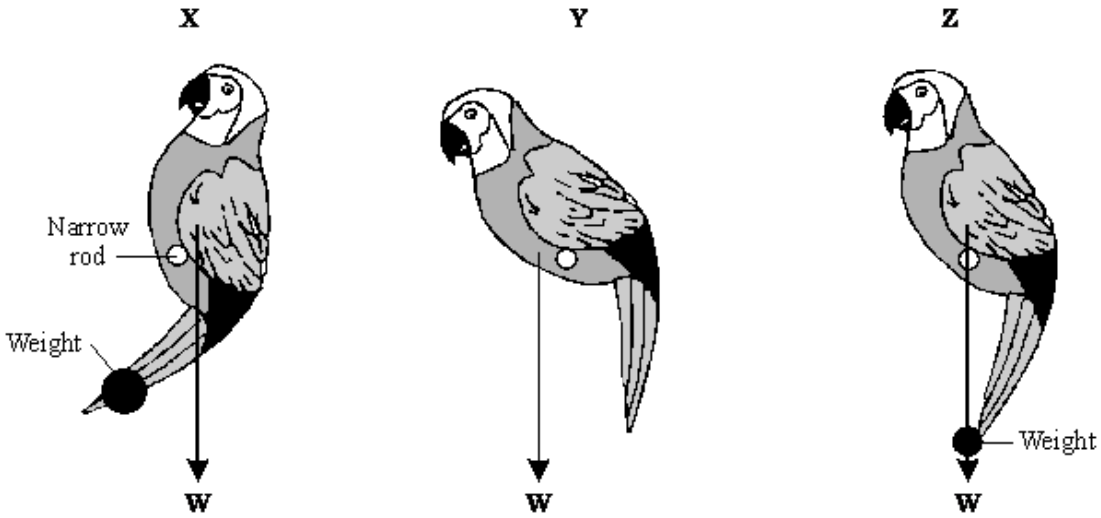
.....

Moment = ... Nm

(2)

(Total 3 marks)

Q10. (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.

.....

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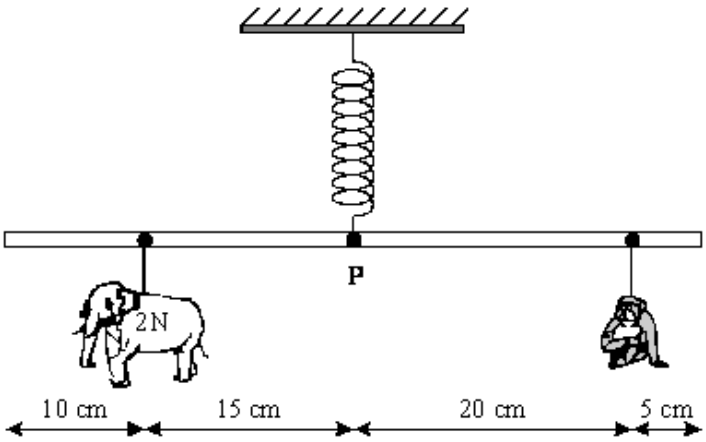
.....

(3)

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



(i) Use the following equation to 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 = force × perpendicular distance from pivot

.....

.....

Moment = ...

(3)

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

total clockwise moment = total anticlockwise moment

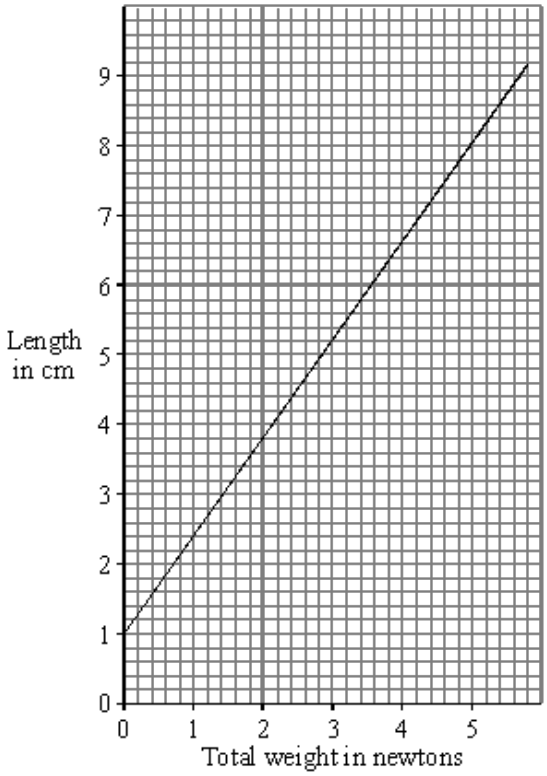
.....

.....

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.

.....

.....

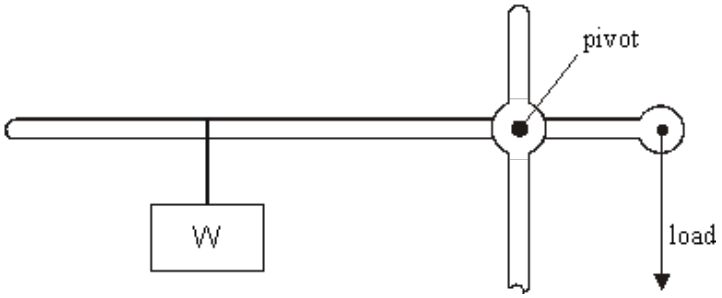
Extension of spring = ... cm

(2)

(Total 10 marks)

Q11. 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.

.....

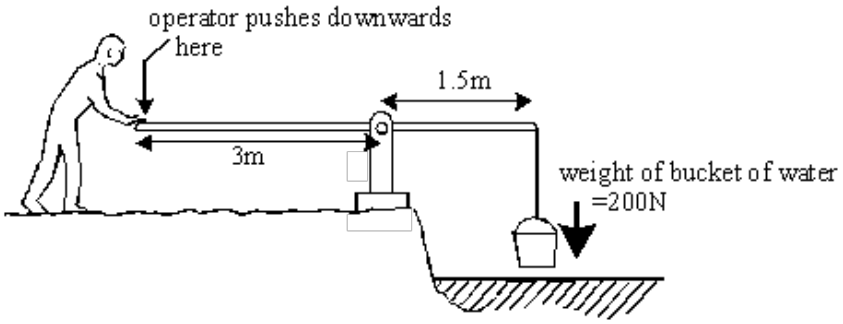
.....

Answer ..... N

(2)

(Total 6 marks)

Q12. 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.)

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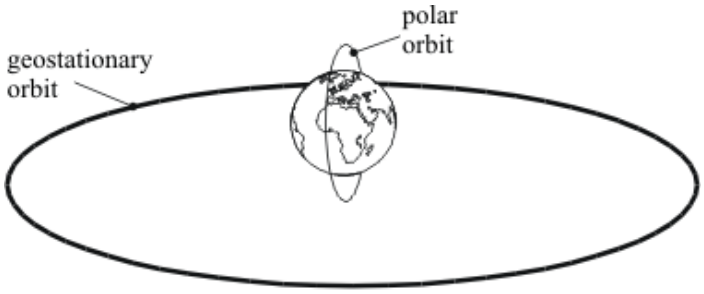
(4)
(Total 6 marks)

Q13. The diagram below shows the orbits for two types of satellite, a polar orbit and a geostationary orbit.



A satellite in stable Earth orbit moves at a constant speed in a circular orbit because there is a single force acting on it.

(i) What is the direction of this force?

.....

(1)

(ii) What is the cause of this force?

.....

(1)

(iii) What is the effect of this force on the **velocity** of the satellite?

.....

(1)

(iv) In which of the orbits shown above would this force be bigger?
Explain the reason for your answer.

.....

.....

(2)

(v) Explain why the kinetic energy of the satellite remains constant.

.....

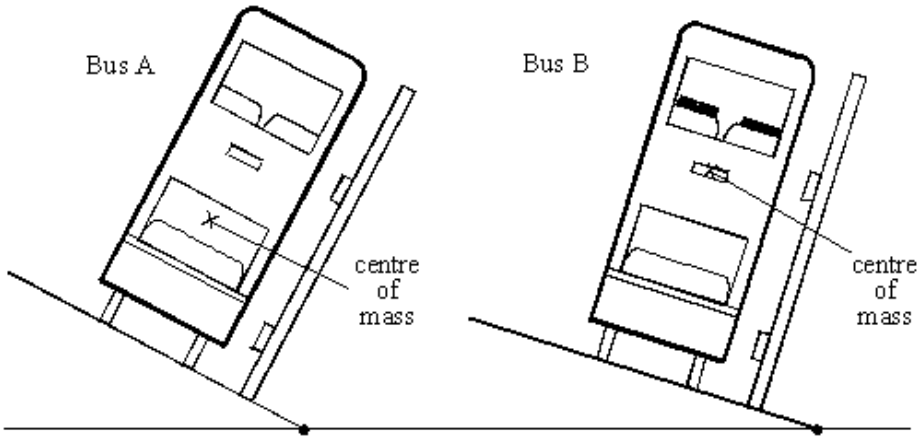
.....

.....

(2)
(Total 7 marks)

Q14. 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?

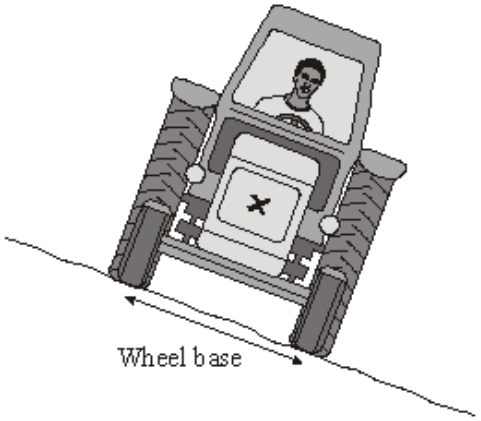
.....

.....

(1)
(Total 6 marks)

Q15. 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 .....

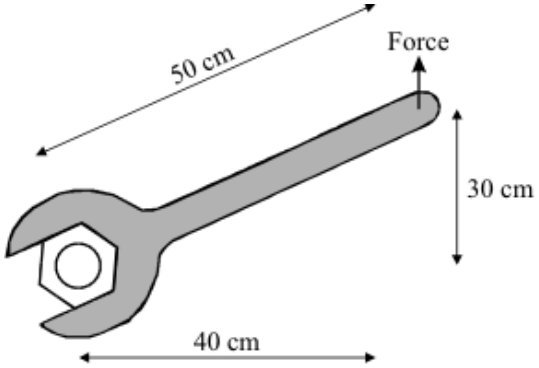
.....

Feature 2 .....

.....

(2)
(Total 5 marks)

Q16. The diagram shows a spanner being used to undo a tight nut.



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

Use the following equation to calculate the force needed to undo the nut. Show clearly how you work out your answer.

moment = force × perpendicular distance from pivot

.....

.....

Force = ... N

(Total 2 marks)

Q17. The London Eye is the largest observation wheel in the world.

The passengers ride in capsules. Each capsule moves in a circular path and accelerates.

(a) Explain how the wheel can move at a steady speed and the capsules accelerate at the same time.

.....

.....

.....

(2)

(b) In which direction does each capsule accelerate?

.....

(1)

(c) What is the name of the resultant force that causes the capsules to accelerate?

.....

(1)

(d) The designers of the London Eye had to consider **three** factors which affect the resultant force described in part (c).

Two factors that increase the resultant force are

- an increase in the speed of rotation
- an increase in the total mass of the wheel, the capsules and the passengers.

Name the other factor that affects the resultant force and state what effect it has on the resultant force.

.....

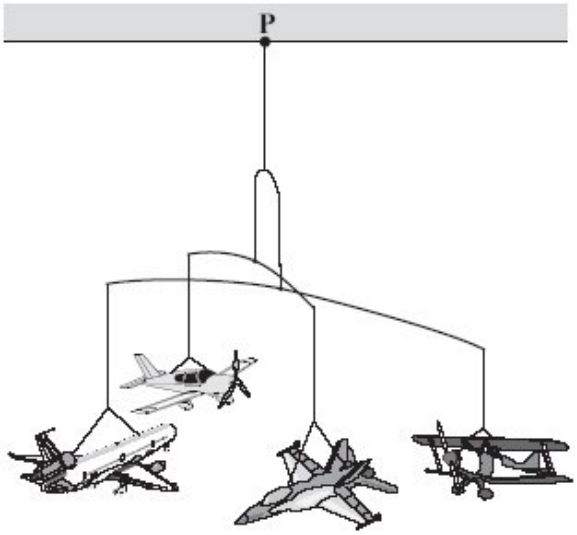
.....

(1)

(Total 5 marks)

Q18. (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**.

.....

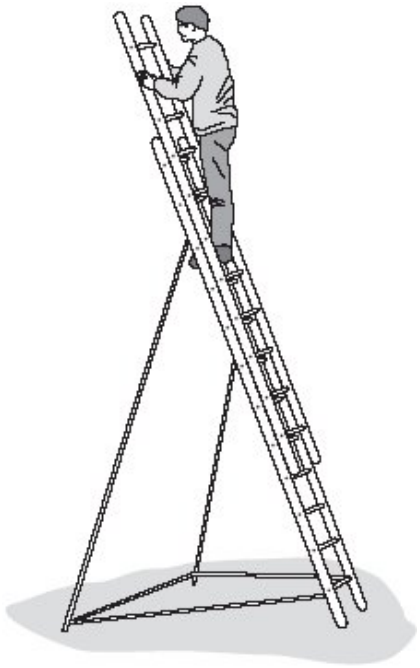
.....

.....

.....

(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.

.....

.....

.....

.....

.....

.....

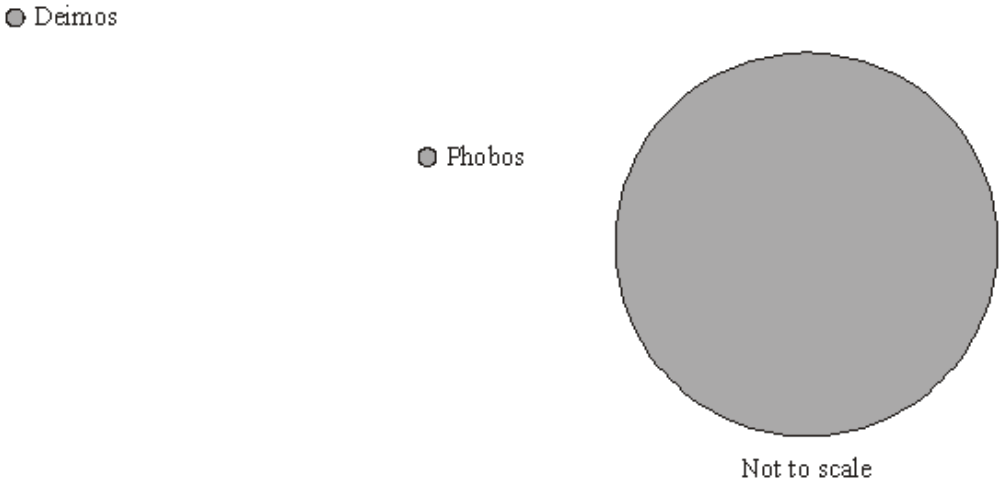
(3)
(Total 6 marks)

Q19. This page is from a science magazine.

The Red Planet

The two natural satellites, or moons, of Mars are Phobos (fear) and Deimos (terror). They are named after the horses which pulled the chariot of Mars, the god of war in the mythology of Ancient Greece.

Phobos takes less than eight hours to orbit Mars and gets slightly closer every time it does so. Scientists predict that in about 100 million years time it will either be ripped apart by the gravitational force or will crash onto the surface of Mars.



(a) Suggest how scientists have arrived at their prediction of about 100 million years.

.....

.....

(2)

(b) The centripetal force on Phobos is gradually changing as it orbits Mars.

Is the force increasing or decreasing?

.....

Explain your answer.

.....

.....

.....

(2)

(c) Scientists expect that the mass of Mars and the mass of Phobos will not increase.

Explain what will happen to the gravitational force on Phobos as it orbits Mars.

.....

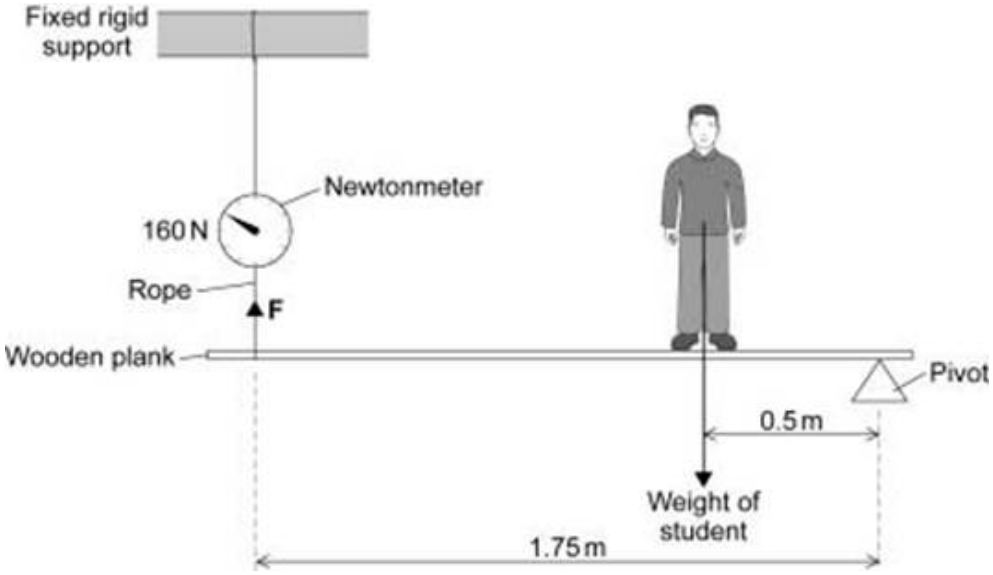
.....

.....

.....

(2)
(Total 6 marks)

Q20. A student wants to weigh himself but the only balance available is a newtonmeter that measures up to 200 newtons.
The diagram shows how the student solved the problem using moments.



(a) Use the information in the diagram to calculate the weight of the student given by this method.

Write down the equation you use, and then show clearly how you work out your answer and give the unit.

.....

.....

.....

.....

.....

.....

.....

.....

Weight = ...

(5)

(c) Even though all the measurements are accurate the student's weight obtained by this method is inaccurate.

Explain why.

.....

.....

.....

.....

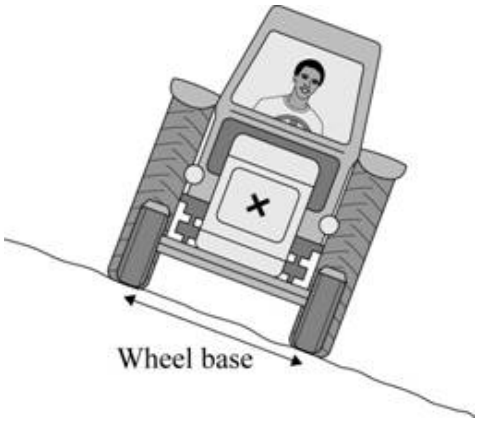
.....

(2)

(Total 7 marks)

Q21. 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) What is meant by the term *centre of mass*?

.....

.....

(1)

(b) Explain how the design of the tractor could be changed in order to increase the tractor's stability.

.....

.....

.....

.....

(2)

(c) Explain why the tractor does not topple over. You may add to the diagram to help your explanation.

.....

.....

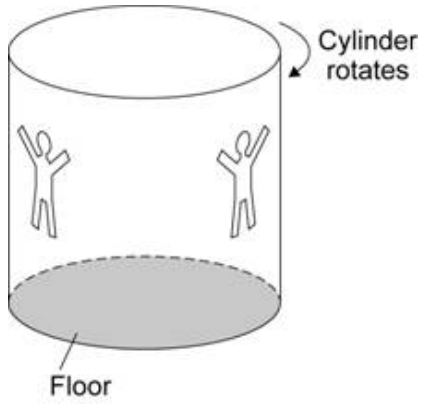
.....

.....

.....

(3)
(Total 6 marks)

Q22. The fairground ride called 'The Rotor' is a large cylinder which rotates. When the cylinder reaches its maximum speed the floor drops away and the riders inside the cylinder are left against the cylinder wall.



(a) Explain how the cylinder is rotating at a constant speed but at the same time the riders inside the cylinder are accelerating.

.....

.....

.....

.....

.....

.....

(3)

(b) In which direction do the riders accelerate?

.....

(1)

(c) What name is given to the resultant force that causes the riders to accelerate?

.....

(1)

(d) At the end of the ride the floor goes back into place and the cylinder slows down and stops.

How does the resultant force on the riders change as the cylinder slows down?

.....

.....

(1)
(Total 6 marks)

M1. (a) (i) 360

*allow **1** mark for correct length used ie 1.2 m*
*allow **2** marks for substitution into correct equation - ie 300 × 1.2*
*allow **1** mark only for an answer 240*

3

(ii) Newton-metre or Nm

1

(b) the force is applied further from the pivot

1

which causes an increased moment to act on the steel bar

1

and therefore an increased force acts on the tree stump

1

[7]

M2. (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]

M3. (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 <u>change</u> the . . . (0)
ignore references to wider / larger nut

1

use a greater force / pull

either order

1

[5]

M4. (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]

M5. (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]

M6. (a) (i) arrow from centre of the ball **and** at right angles to the string **and** in the correct direction

arrow should point to the student's belt
accept free-hand 'straight' line
*do **not** accept curved line*

1

(ii) increase

accept 'be stronger / bigger'

1

increase

accept 'be stronger / bigger'

1

increase

accept 'be stronger / bigger'

1

(b) speed
velocity
direction

*all **three** correct*
*any two correct for **1** mark*
*otherwise **0** marks*

2

(c) (i) centripetal

accept 'centripedal' and other minor misspellings
*do **not** accept anything which could be 'centrifugal'*

1

(ii) gravity

accept 'weight'
accept 'force of attraction due to mass(es) (of the Moon and the Earth)'

1

(iii) electron(s)

1

(iv) electrostatic

accept 'electrical'
*do **not** accept just 'centripetal'*

1

[10]

M7. (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]

M8. (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]

M9. (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]

M10. (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]

M11. (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]

M12. (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]

M13. (i) towards Earth

for 1 mark

1

(ii) gravity

for 1 mark

1

(iii) changes direction

for 1 mark

1

(iv) polar orbit;
closer

for 1 mark each

2

(v) speed constant (1)
mass constant (1)
for 1 mark each

2

[7]

M14. (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]

M15. (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 'long wheel base'*
responses in either order

1

[5]

M16. 300

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

[2]

M17. (a) any **two** ideas:

- (acceleration occurs when) the direction (of each capsule) changes
- velocity has direction
- acceleration is (rate of) change of velocity

2

(b) to(wards) the centre (of the wheel)

1

(c) centripetal

*allow minor misspellings but do **not** credit a response which could be 'centrifugal'*

1

(d) the greater the radius / diameter / circumference (of the wheel)
the smaller the (resultant) force (required)

accept 'the size'
both parts required for the mark
accept converse

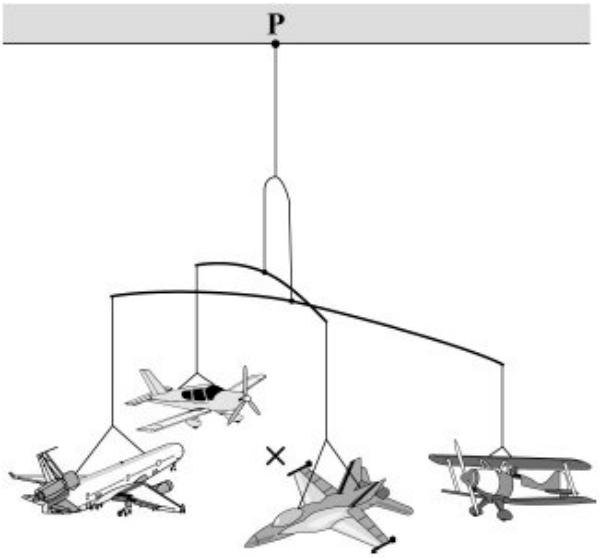
1

[5]

M18. (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]

M19. (a) (from present/recent) data/evidence/observations of (the rate of change in) Phobos'/the moon's orbit (1)

or appropriate example of data (1)

and its correct use (1)

(and) continued/extended/extrapolated (the pattern/trend for the next 100 million years) (1)

example (present) distance from Phobos to Mars (1)
÷ (average) rate of approach (1)

2

(b) (it is) increasing (1)

Phobos/the moon will be nearer (to Mars) (1)

or the radius/circumference/diameter of the orbit of Phobos/the moon will decrease/be less

only credit 2nd mark if the first mark is correct

2

(c) it will increase/be more (1)

(because) Phobos/the moon will get/be closer to Mars/the planet (1)

only credit 2nd mark if the first mark is correct

note part(s) of this response may be included as the answer to part (b)

read both before marks are awarded

2

[6]

M20. (a) 560

*allow **1** mark for*

clockwise (moments) = anticlockwise (moments)

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

ie 160 × 1.75 = W × 0.5

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

ie $\frac{160 \times 1.75 = W}{0.5}$

4

newtons, N

1

(c) the weight of plank which has been ignored

1

causes an anticlockwise moment which has not been considered / included in the calculation

1

[7]

M21. (a) where the mass of the object can be thought to be concentrated

1

(b) lower the C of M

1

and make the wheelbase wider

1

accept a practical description of how these changes could be achieved

(c) the line of action of its weight

*accept a vertical arrow drawn from **X***

2

falls inside its wheel base

accept falls between the wheels

therefore there is no resultant / clockwise moment

1

[6]

M22. (a) the direction of the riders is constantly changing

1

therefore the velocity of the riders is changing

1

and because acceleration is the rate of change of velocity
the acceleration is changing

1

(b) to(wards) the centre (of the cylinder / rotor)

1

(b) centripetal

1

(b) it is reduced

1

[6]