AQA GCSE Physics | 8463

SPECIFICATION POINT 4.5.4

Moments, levers and gears (physics only)

Past-paper questions

Tier	**Higher**
Question groups	**33**
Available paper years	**2003–2025**

Using this booklet

1. Answer the questions in order and show your working.
2. Original question numbers and marks are retained.
3. Print at actual size (100%) for measuring questions.
4. Use the companion answer booklet to check your work.

Name: _____ **Date:** _____

Whole questions are retained for context, so some parts assess other specification points. Current and legacy sources are labelled. Continue on extra paper if needed.

4.5.4 Moments, levers and gears (physics only)

Question 01

June 2003 | 3451H | Original Q6 | Legacy

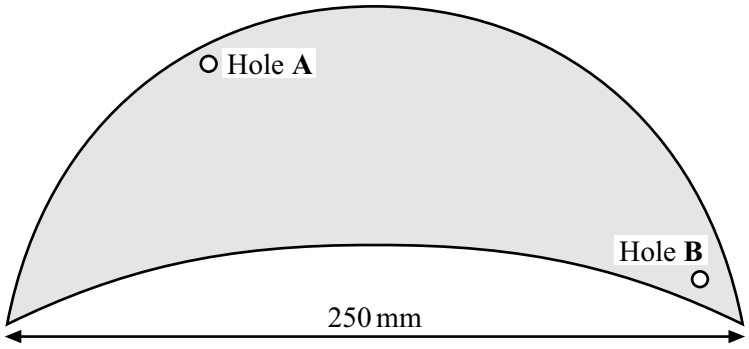
6 (a) Every object has a *centre of mass*. What is meant by the *centre of mass*?

.....

.....

(1 mark)

(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 1 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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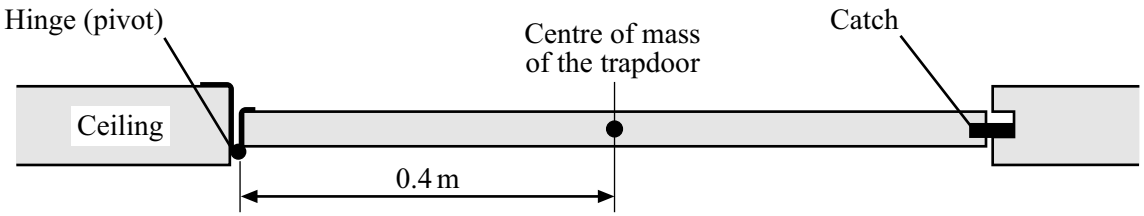
(5 marks)

4.5.4 Moments, levers and gears (physics only)

Question 01 · continued

MARGIN
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(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 mark)

(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.

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Turning effect = ...

(3 marks)

10

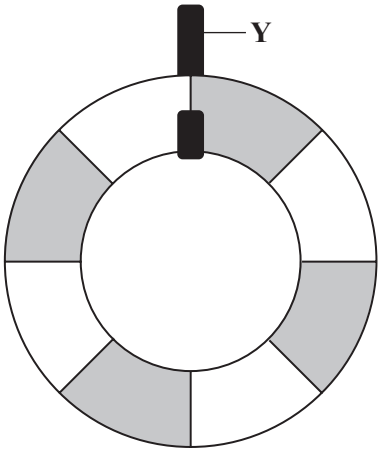
4.5.4 Moments, levers and gears (physics only)

Question 02

June 2005 | 3451 | Original Q6 | Legacy

6 (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 mark)

(ii) Explain why you have chosen this point.

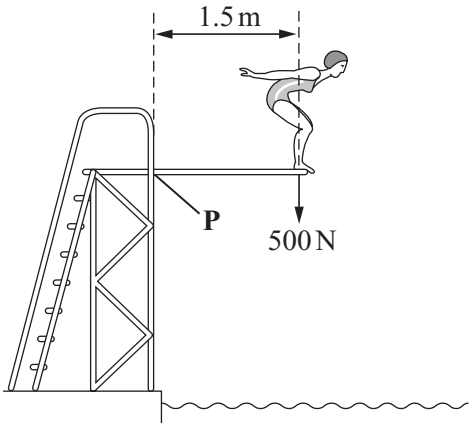
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(2 marks)

(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** = ...

4.5.4 Moments, levers and gears (physics only)

Question 02 · continued

MARGIN BLANK

(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 marks)

10

TURN OVER FOR THE NEXT QUESTION

4.5.4 Moments, levers and gears (physics only)

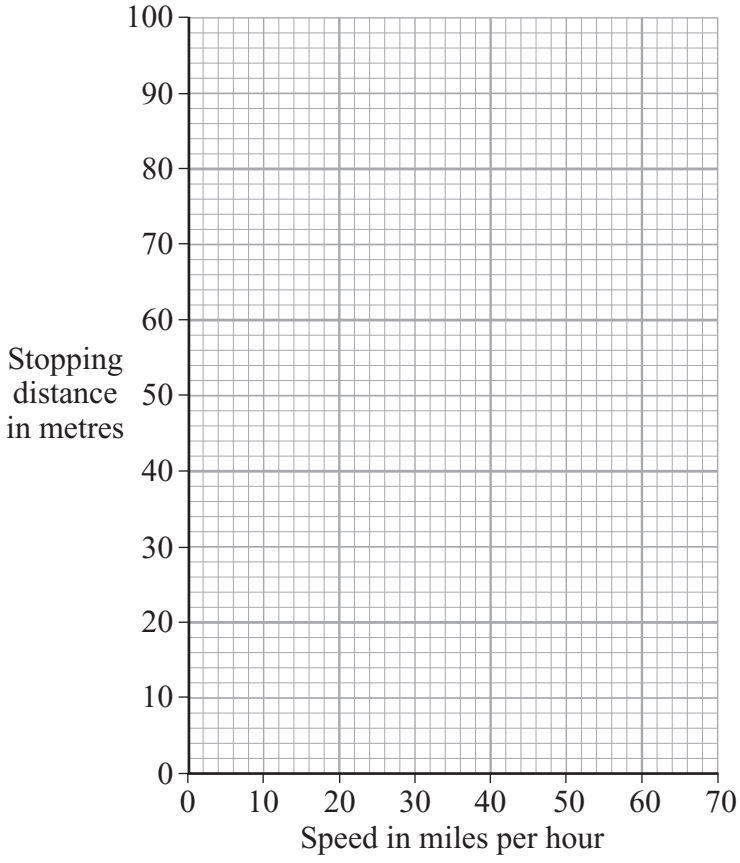
Question 03

June 2006 | 3451 | Original Q4 | Legacy

4 (a) The table shows how the stopping distance of a car, in metres (m), depends on the speed of the car, in miles per hour (mph).

Speed (mph)	20	30	40	50	60	70
Stopping distance (m)	12	23	36	53	73	96

(i) Draw a graph of stopping distance against speed.



(3 marks)

(ii) The speed limit outside a school is 20 mph.

Use the graph to estimate **how much further** a car will travel before it stops when driven at 25 mph instead of 20 mph.

Show clearly how you work out your answer.

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(2 marks)

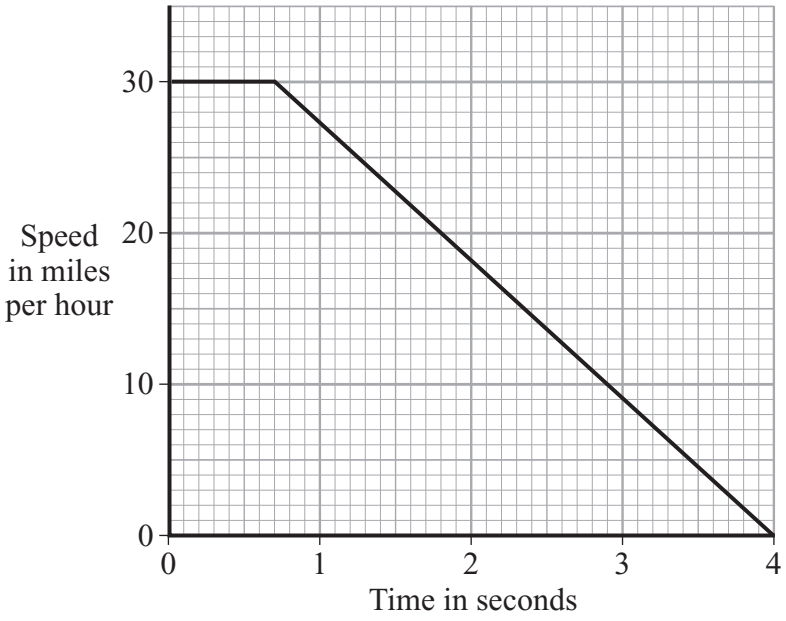
Question 4 continues on the next page

Question 03 · continued

June 2006 | 3451 | Original Q4 | Legacy

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(b) A child ran out in front of a car causing the driver to make an emergency stop. The graph shows how the speed of the car changed from the moment the driver saw the child.



(i) What was the driver's reaction time?

.....

(1 mark)

(ii) Describe the motion of the car during the first 0.5 seconds.

.....

(1 mark)

(iii) How long did it take the car to stop once the brakes were applied?

.....

(1 mark)

(iv) The drug cannabis makes the reactions of a person slower.

Explain how the stopping distance of the car would change if the driver had been smoking cannabis.

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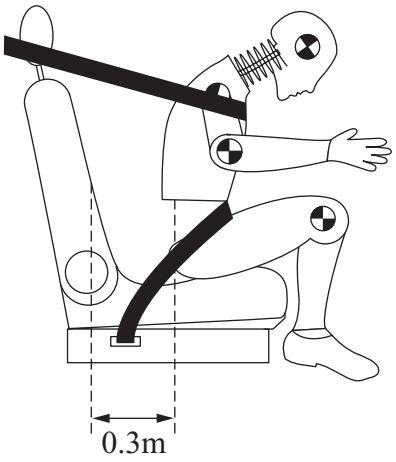
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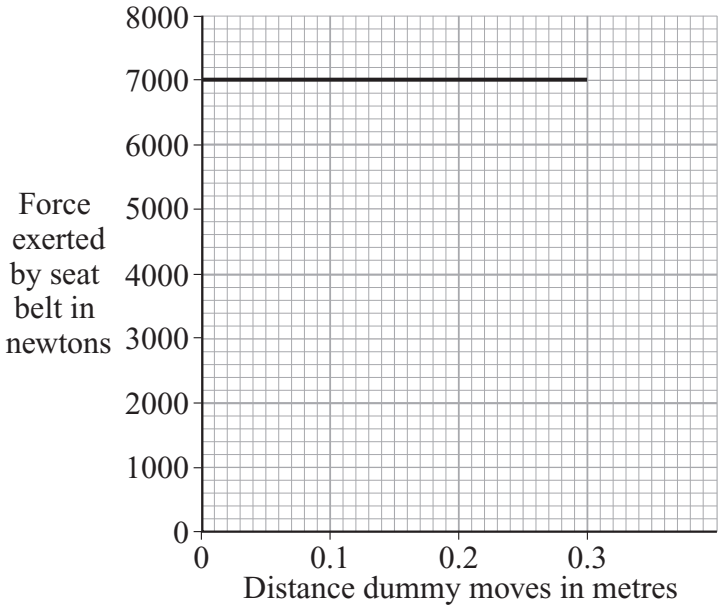
(2 marks)

Question 03 · continued

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(c) The diagram shows how far a dummy in a car crash test moves before it is stopped by the seat belt. The graph shows the force exerted by the seat belt on the dummy during the crash.





(i) Write down the equation that links distance moved, force applied and work done.

.....

(1 mark)

(ii) Calculate the work done to stop the dummy.

Show clearly how you work out your answer.

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Work done = ... joules

(2 marks)

(iii) How much energy is transferred from the dummy during the crash?

.....

(1 mark)

14

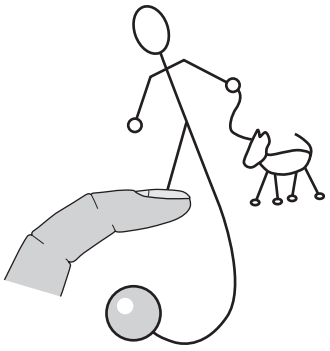
4.5.4 Moments, levers and gears (physics only)

Question 04

June 2006 | 3451 | Original Q16 | Legacy

16 (a) The drawing shows a toy balanced on the end of someone's finger. The toy is made of wire with a metal ball at the bottom end.

(i) On the drawing, mark with an **X**, the point where you think the toy's centre of mass is.



(1 mark)

(ii) Explain why you have chosen this point.

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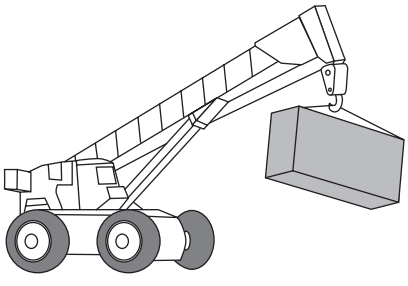
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(2 marks)

(b) The drawing shows a mobile crane and its heavy load.

(i) On the drawing, mark with an **X**, the point where you think the centre of mass of the crane **and** its heavy load is.



(1 mark)

(ii) Explain why you have chosen this point.

.....

.....

.....

(2 marks)

4.5.4 Moments, levers and gears (physics only)

Question 04 · continued

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(c) (i) Write down the equation that is used to calculate the turning effect, or moment, of a force.

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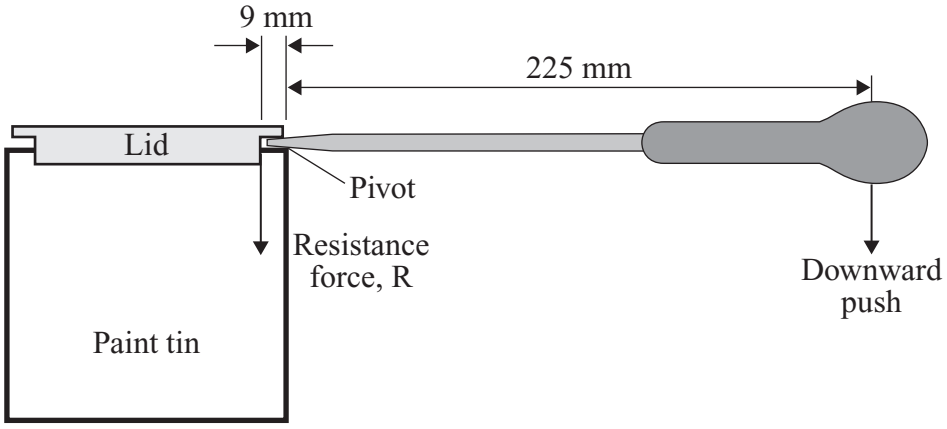
.....

(1 mark)

(ii) State a unit of moment. .....

(1 mark)

(iii) The diagram shows a screwdriver being used to lever off the lid of a paint tin.



The resistance force, R, of the lid is 500 N.

Calculate the minimum downward push which is needed to lever off the lid.

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

.....

.....

Minimum downward push = ...

(4 marks)

(d) Complete the sentence.

If an object is **not** turning then the total moments of forces trying to turn it in a ..... direction must be equal to the total moments of forces trying to turn it in an ..... direction.

(1 mark)

13

4.5.4 Moments, levers and gears (physics only)

Question 05

June 2006 | 3451 | Original Q17 | Legacy

17 (a) A golf ball is driven forward when it is hit with a golf club.



(i) Write down the equation that connects change in momentum, force and time.

.....

(1 mark)

(ii) Calculate the change in momentum of a golf club which exerts an average force on a golf ball of 45 N for 0.9 seconds.

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

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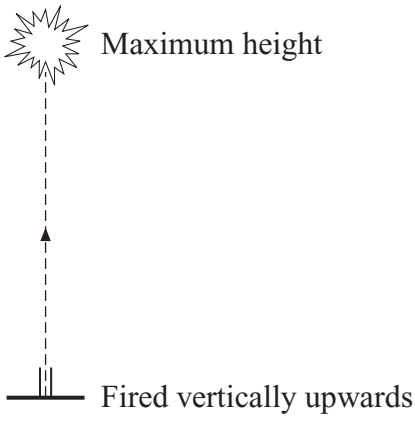
Change in momentum = ...

(3 marks)

Question 05 · continued

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A firework fires a small explosive package into the air. The mass of the package is 50 g. When the package is at its maximum height it explodes.



(b) Just after take off, the momentum of the package is 1.5 kg m/s vertically upwards.

What is the velocity of the package?

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

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Velocity, vertically upwards = ...

(5 marks)

(c) At the moment when it reaches its maximum height the velocity of the package is zero. At the same moment the package explodes into a cloud of dust and gas.

(i) What is the total momentum of this 'cloud' immediately after the explosion?

.....

(1 mark)

(ii) What assumption did you make in order to give your answer to part (c)(i)?

.....

.....

(1 mark)

(iii) What will be the direction of the total momentum of the 'cloud' a few seconds after the explosion?

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(1 mark)

12

4.5.4 Moments, levers and gears (physics only)

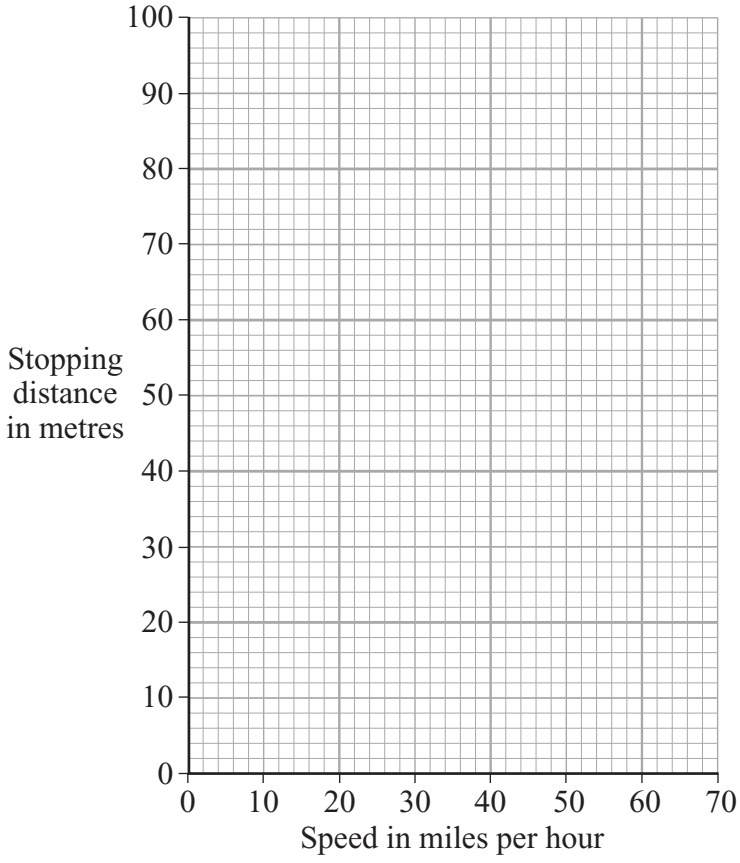
Question 06

June 2006 | 3462 | Original Q4 | Legacy

4 (a) The table shows how the stopping distance of a car, in metres (m), depends on the speed of the car, in miles per hour (mph).

Speed (mph)	20	30	40	50	60	70
Stopping distance (m)	12	23	36	53	73	96

(i) Draw a graph of stopping distance against speed.



(3 marks)

(ii) The speed limit outside a school is 20 mph.

Use the graph to estimate **how much further** a car will travel before it stops when driven at 25 mph instead of 20 mph.

Show clearly how you work out your answer.

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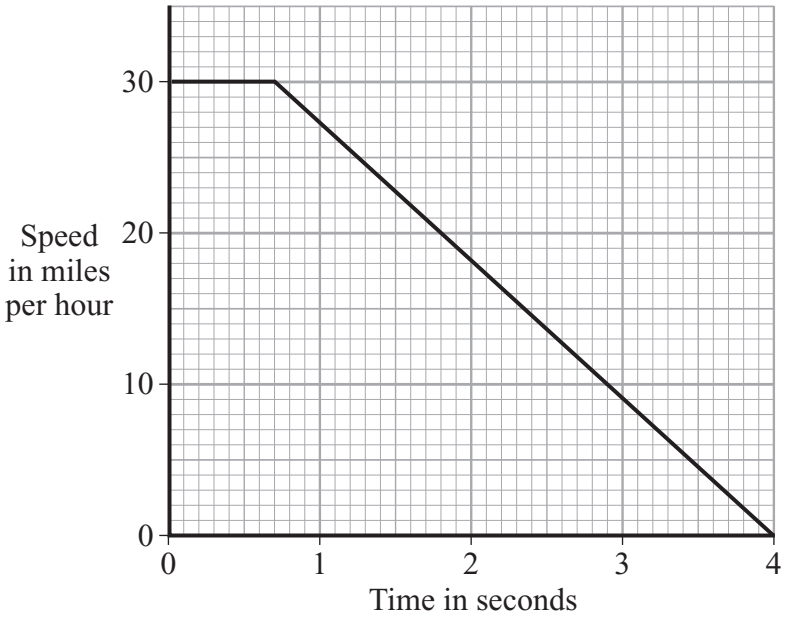
(2 marks)

Question 4 continues on the next page

Question 06 · continued

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(b) A child ran out in front of a car causing the driver to make an emergency stop. The graph shows how the speed of the car changed from the moment the driver saw the child.



(i) What was the driver's reaction time?

.....

(1 mark)

(ii) Describe the motion of the car during the first 0.5 seconds.

.....

(1 mark)

(iii) How long did it take the car to stop once the brakes were applied?

.....

(1 mark)

(iv) The drug cannabis makes the reactions of a person slower.

Explain how the stopping distance of the car would change if the driver had been smoking cannabis.

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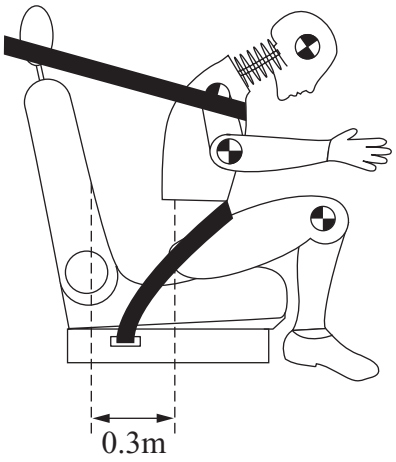
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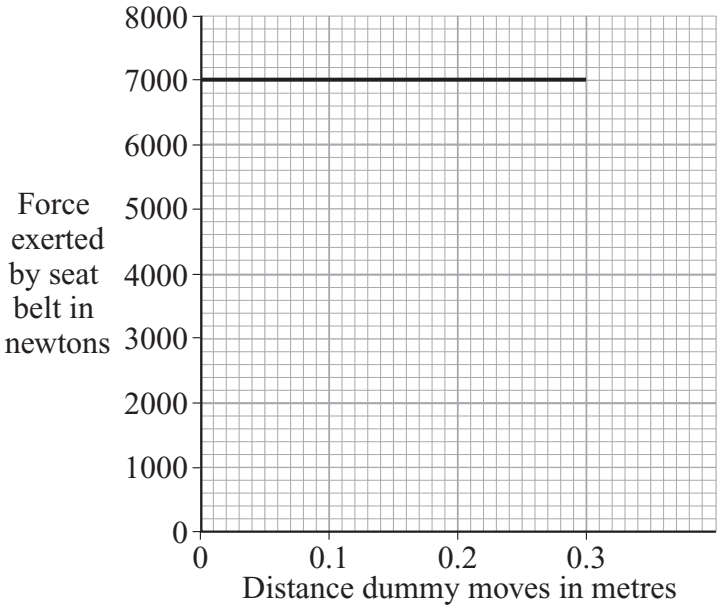
(2 marks)

Question 06 · continued

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(c) The diagram shows how far a dummy in a car crash test moves before it is stopped by the seat belt. The graph shows the force exerted by the seat belt on the dummy during the crash.





(i) Write down the equation that links distance moved, force applied and work done.

.....

(1 mark)

(ii) Calculate the work done to stop the dummy.

Show clearly how you work out your answer.

.....

.....

.....

Work done = ... joules

(2 marks)

(iii) How much energy is transferred from the dummy during the crash?

.....

(1 mark)

14

4.5.4 Moments, levers and gears (physics only)

Question 07

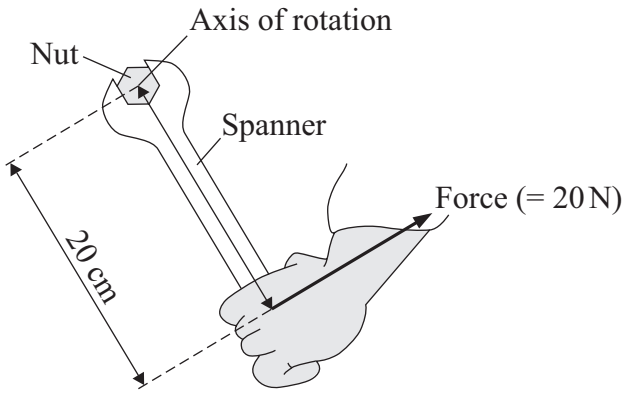
January 2008 | PHY3H | Original Q1 | Legacy

1 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 mark)

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

Show clearly how you work out your answer.

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Turning effect = ... Nm
(2 marks)

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

1 .....

2 .....
(2 marks)

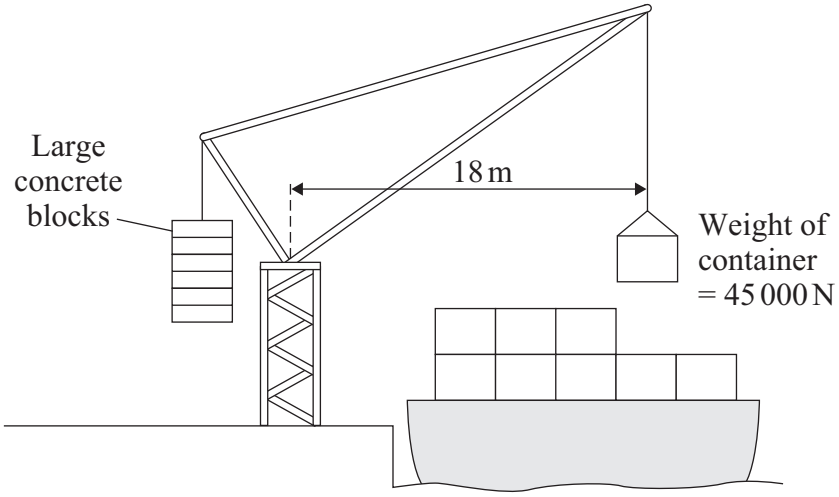
5

4.5.4 Moments, levers and gears (physics only)

Question 08

June 2008 | PHY3H | Original Q3 | Legacy

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



3 (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.

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Moment of the container = ...

(3 marks)

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

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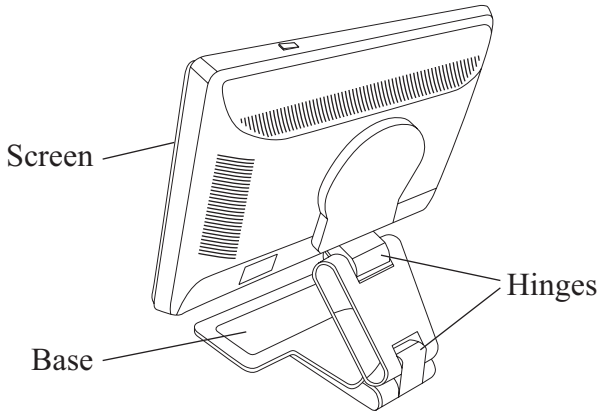
(3 marks)

6

4.5.4 Moments, levers and gears (physics only)

Question 09

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



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

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

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(2 marks)

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

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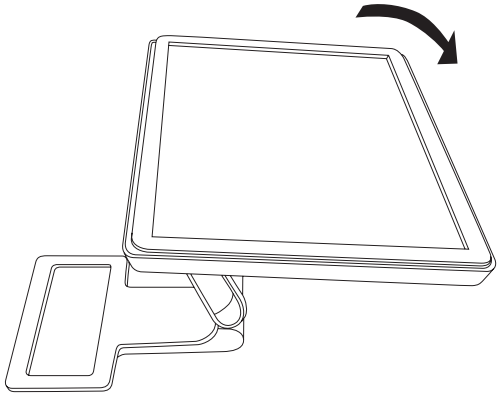
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(1 mark)

for mark

4 (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 marks)

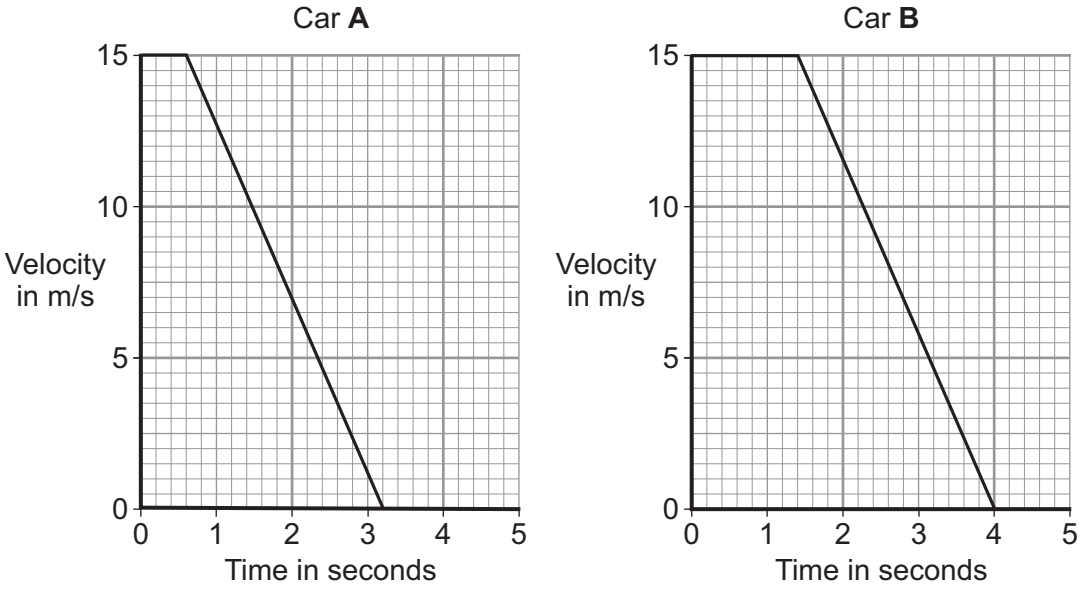
6

4.5.4 Moments, levers and gears (physics only)

Question 10

June 2010 | PHY2H | Original Q5 | Legacy

5 (a) The graphs show how the velocity of two cars, **A** and **B**, change from the moment the car drivers see an obstacle blocking the road.



One of the car drivers has been drinking alcohol. The other driver is wide awake and alert.

5 (a) (i) How does a comparison of the two graphs suggest that the driver of car **B** is the one who has been drinking alcohol?

.....

.....

(1 mark)

5 (a) (ii) How do the graphs show that the two cars have the same deceleration?

.....

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(1 mark)

5 (a) (iii) Use the graphs to calculate how much further car **B** travels before stopping compared to car **A**.

Show clearly how you work out your answer.

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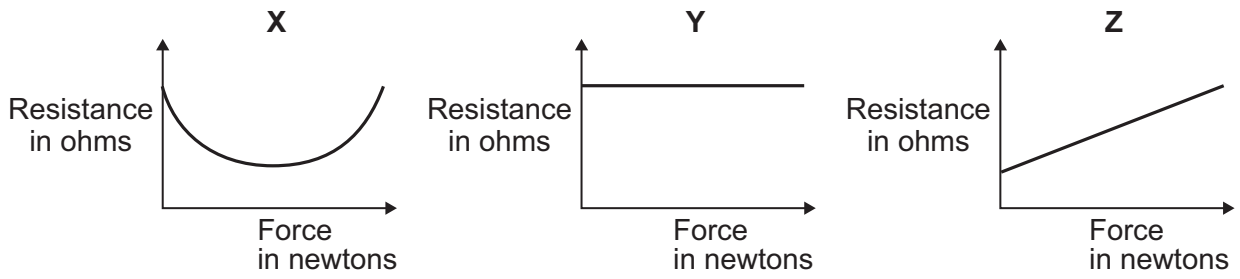
Additional stopping distance = ... m

(3 marks)

4.5.4 Moments, levers and gears (physics only)

Question 10 · continued

5 (b) In a crash test laboratory, scientists use sensors to measure the forces exerted in collisions. The graphs show how the electrical resistance of 3 experimental types of sensor, **X**, **Y** and **Z**, change with the force applied to the sensor.



Which of the sensors, **X**, **Y** or **Z**, would be the best one to use as a force sensor?

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Give a reason for your answer.

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(2 marks)

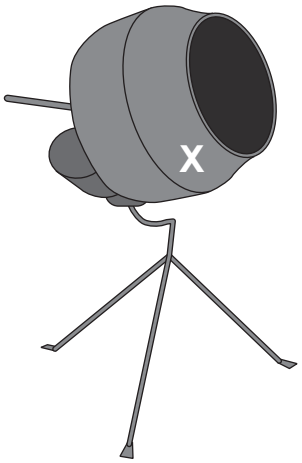
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4.5.4 Moments, levers and gears (physics only)

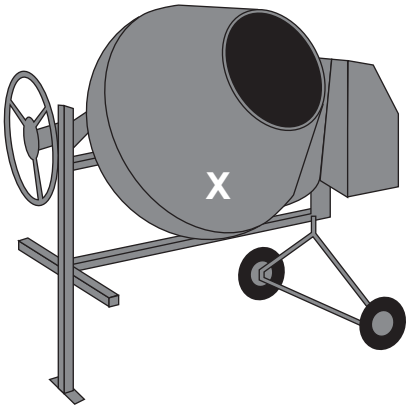
Question 11

June 2010 | PHY3H | Original Q4 | Legacy

4 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.

4 (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 mark)

4 (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 .....

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(2 marks)

Question 11 · continued

4 (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.

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(2 marks)

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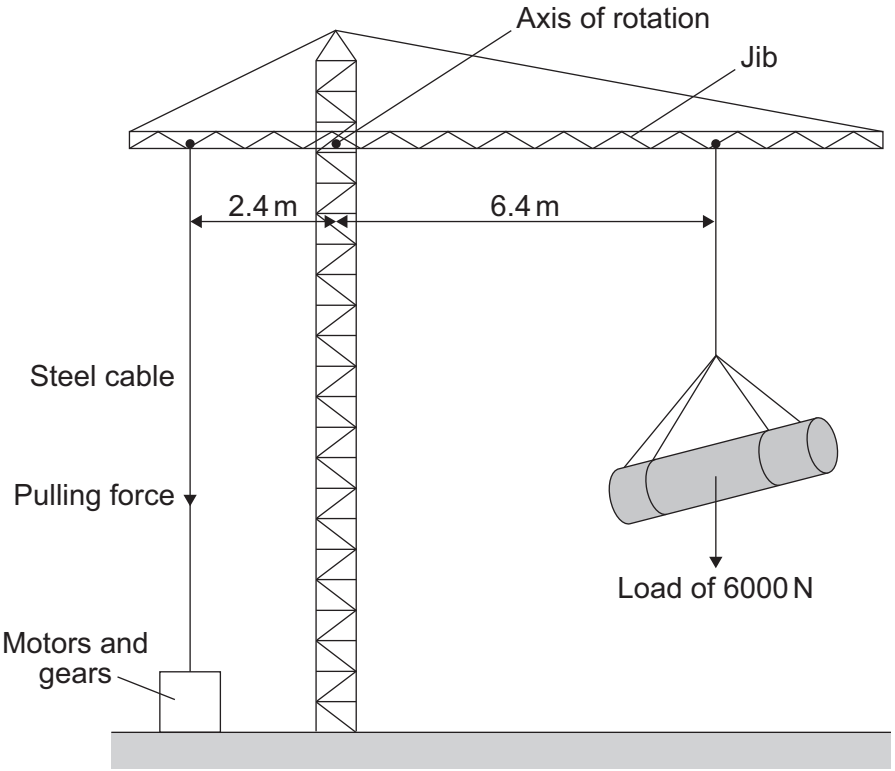
Turn over for the next question

4.5.4 Moments, levers and gears (physics only)

Question 12

June 2010 | PHY3H | Original Q6 | Legacy

6 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.

Use the equation in the box to answer questions (**a**) and (**b**).

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

6 (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 marks)

4.5.4 Moments, levers and gears (physics only)

Question 12 · continued

6 (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 marks)

5

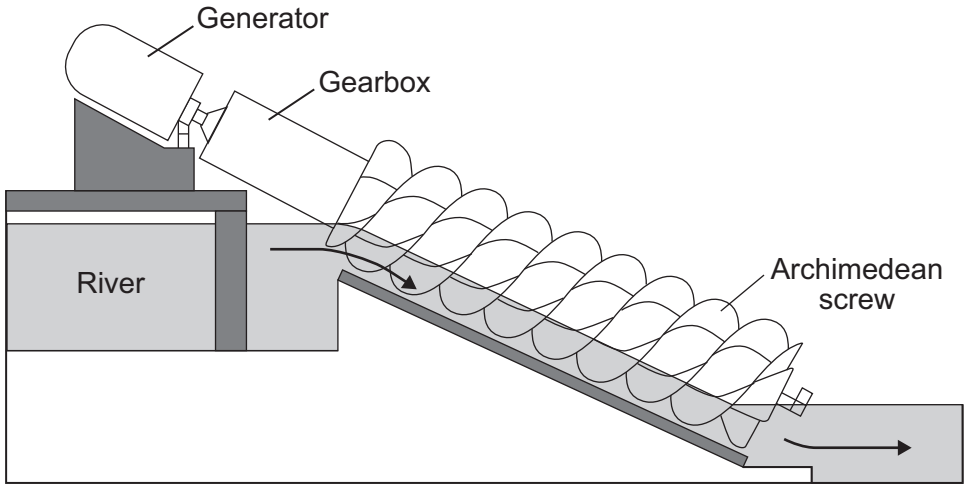
Turn over for the next question

4.5.4 Moments, levers and gears (physics only)

Question 13

January 2011 | PHY1H | Original Q4 | Legacy

4 The diagram shows a small-scale, *micro-hydroelectricity* generator which uses the energy of falling river water to generate electricity. The water causes a device, called an Archimedean screw, to rotate.
The Archimedean screw is linked to the generator by a gearbox.



4 (a) Each second, the *micro-hydroelectricity* generator transforms 80 000 joules of gravitational potential energy into 60 000 joules of electrical energy.

4 (a) (i) Fill in the missing word to complete the energy transformation diagram.

Gravitational potential energy of the falling water	→	..... energy of the Archimedean screw	→	Electrical energy generated

(1 mark)

4 (a) (ii) Use the equation in the box to calculate the efficiency of the *micro-hydroelectricity* generator.

$$\text{efficiency} = \frac{\text{useful energy transferred by the device}}{\text{total energy supplied to the device}}$$

Show clearly how you work out your answer.

.....

.....

Efficiency = ...

(2 marks)

4.5.4 Moments, levers and gears (physics only)

Question 13 · continued

4 (b) The power output from a conventional large-scale hydroelectric power station is 100 000 times more than the power output from a micro-hydroelectric system.

Give **one** disadvantage of a conventional large-scale hydroelectric power station compared to the micro-hydroelectric system.

.....

.....

(1 mark)

4 (c) The electricity generated by a micro-hydroelectric system is transferred via a transformer directly to local homes. The electricity generated by a conventional large-scale hydroelectric power station is transferred to the National Grid, which distributes the electricity to homes anywhere in the country.

4 (c) (i) What is the National Grid?

.....

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(1 mark)

4 (c) (ii) Explain why transferring the electricity directly to local homes is more efficient than using the National Grid to distribute the electricity.

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(2 marks)

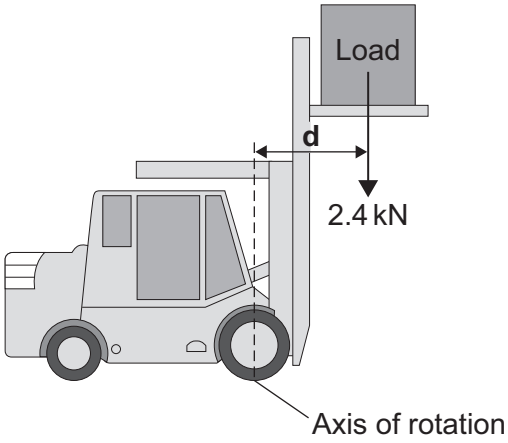
7

4.5.4 Moments, levers and gears (physics only)

Question 14

January 2011 | PHY3H | Original Q5 | Legacy

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



5 (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 marks)

4.5.4 Moments, levers and gears (physics only)

Question 14 · continued

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

Warning

Maximum load 10.0 kN

This load must not be exceeded

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

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(2 marks)

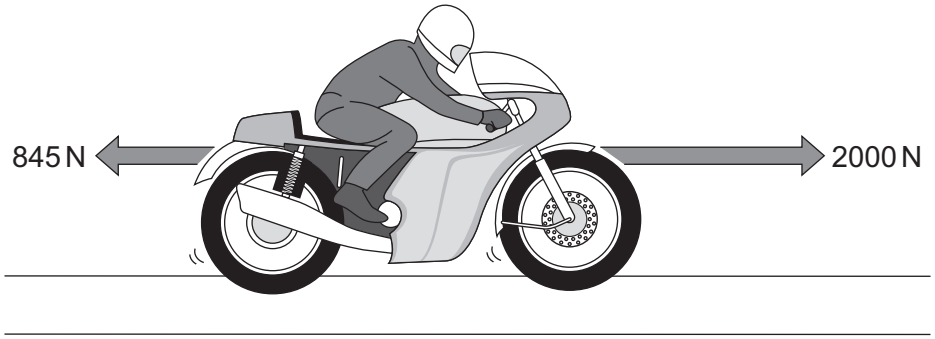
5

4.5.4 Moments, levers and gears (physics only)

Question 15

June 2011 | PHY2H | Original Q7 | Legacy

7 The arrows in the diagram represent the horizontal forces acting on a motorbike at one moment in time.



7 (a) The mass of the motorbike and rider is 275 kg.

Use the equation in the box to calculate the acceleration of the motorbike at this moment in time.

resultant force = mass × acceleration

Show clearly how you work out your answer.

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.....

Acceleration = ... m/s ^{2}

(3 marks)

7 (b) A road safety organisation has investigated the causes of motorbike accidents.

The main aim of the investigation was to find out whether there was any evidence that young, inexperienced riders were more likely to be involved in an accident than older, experienced riders.

Data obtained by the organisation from a sample of 1800 police files involving motorbike accidents, is summarised in the table.

Size of motorbike engine	Percentage of all motorbikes sold	Total number in the sample of 1800 accident files
up to 125 cc	36	774
126 to 350 cc	7	126
351 to 500 cc	7	162
over 500 cc	50	738

Most of the motorbikes with engines up to 125 cc were ridden by young people. The motorbikes with engines over 500 cc were ridden by older, more experienced riders.

7 (b) (i) In terms of the main aim of the investigation, is this data valid?

Draw a ring around your answer. **NO** **YES**

Explain the reason for your answer.

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.....

(2 marks)

Question 7 continues on the next page

Question 15 · continued

7 (b) (ii) The organisation concluded that:

"Young, inexperienced riders are more likely to be involved in a motorbike accident than older, experienced riders".

Explain how the data supports this conclusion.

.....

.....

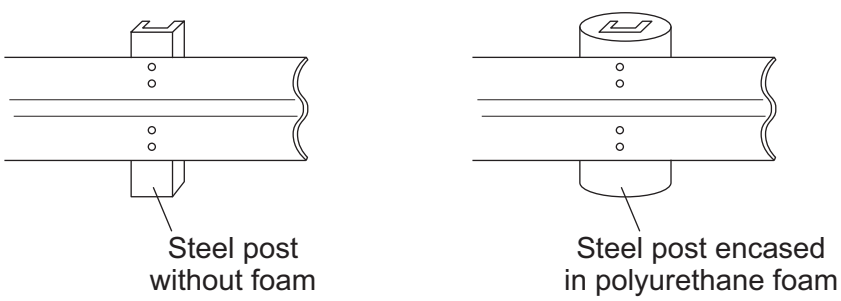
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(2 marks)

7 (c) Of particular concern to motorbike riders is the design of steel crash barriers. Riders falling off and sliding at high speed into a steel support post are often seriously injured.

One way to reduce the risk of serious injury is to cover the post in a thick layer of high impact polyurethane foam.



7 (c) (i) Use the ideas of momentum to explain how the layer of foam reduces the risk of serious injury to a motorbike rider sliding at high speed into the support post.

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(3 marks)

4.5.4 Moments, levers and gears (physics only)

Question 15 · continued

7 (c) (ii) Crash barrier tests use dummies that collide at 17 m/s with the barrier. Each test costs about £12 000. New safety devices for crash barriers are tested many times to make sure that they will improve safety.

Do you think that the cost of developing the new safety devices is justified?

Draw a ring around your answer. **NO** **YES**

Give a reason for your answer.

.....

.....

(1 mark)

11

4.5.4 Moments, levers and gears (physics only)

Question 16

June 2011 | PHY3H | Original Q2 | Legacy

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

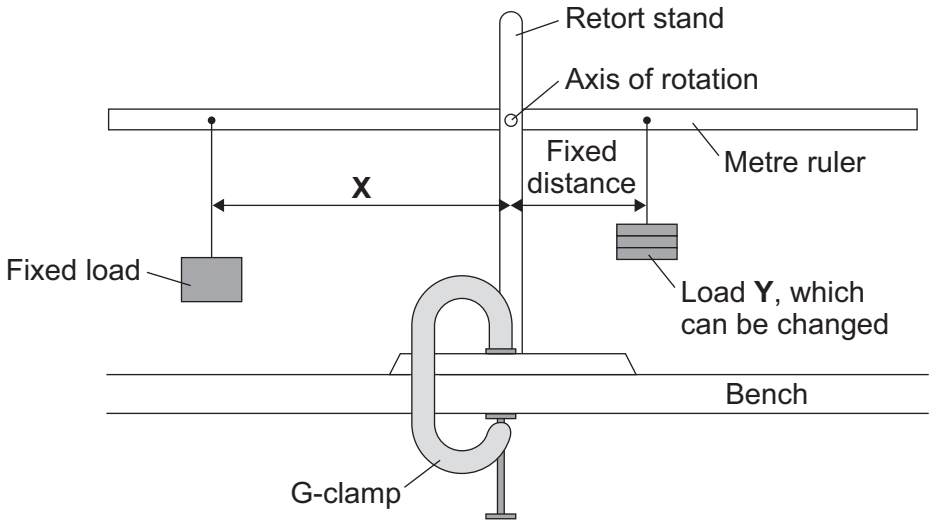
2 (a) (i) What does the word *moment* mean in this sentence?

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.....

(1 mark)

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



Suggest the purpose of the G-clamp.

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.....

(1 mark)

Question 16 · continued

2 (a) (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**.

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(2 marks)

2 (a) (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. ☐

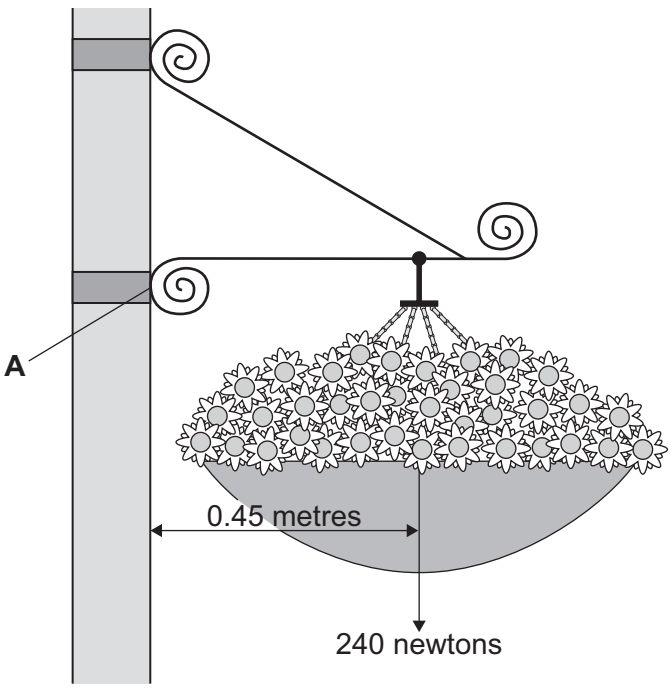
The centre of mass of the ruler is at the axis of rotation. ☐

The ruler is a symmetrical object. ☐

(1 mark)

Question 2 continues on the next page

2 (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.

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Moment =.....

(3 marks)

8

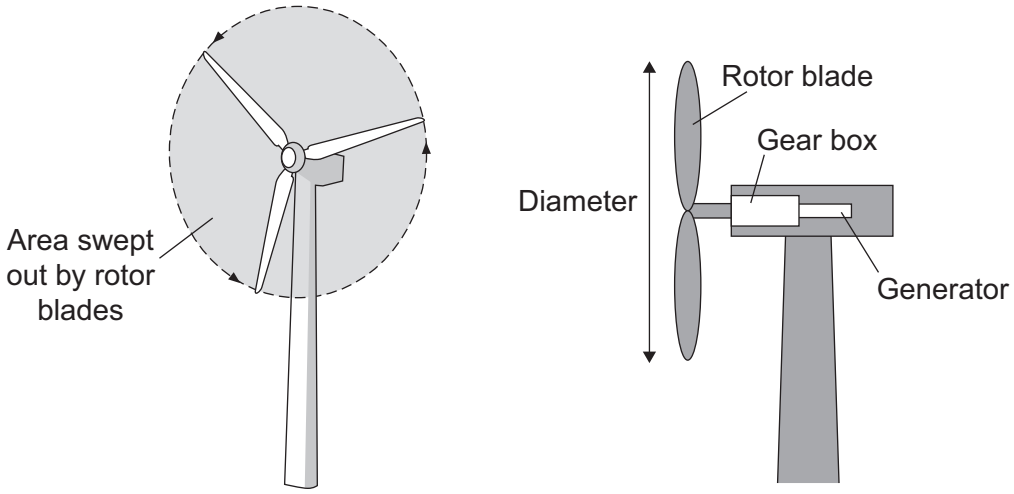
4.5.4 Moments, levers and gears (physics only)

Question 17

November 2011 | PHY1AP | Original Q8 | Legacy

QUESTION EIGHT

A wind turbine is an electrical generator. The rotor blades are connected to the generator through a gear box.



8A Which is the correct energy transformation for the wind turbine generator?

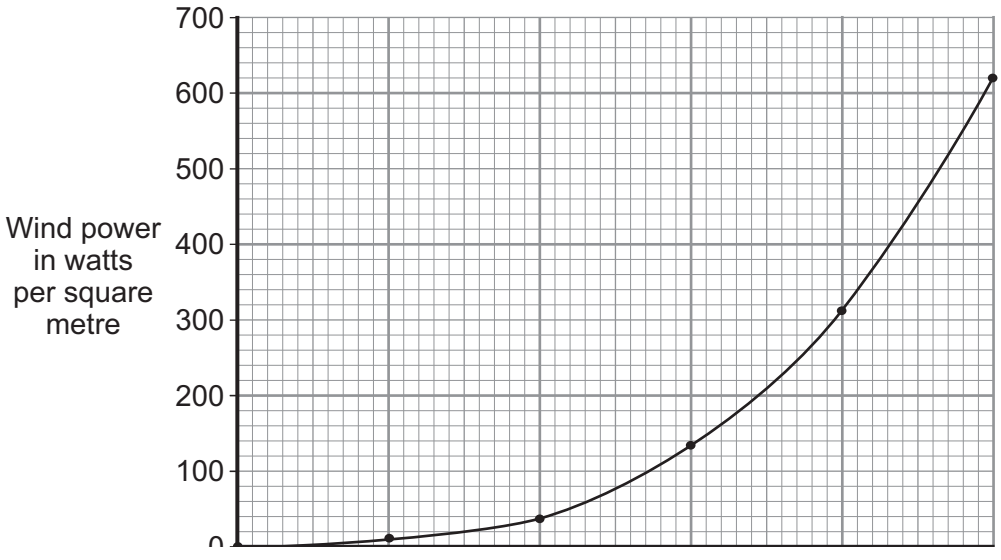
1 potential → electrical, thermal and sound

2 potential → kinetic, electrical and thermal

3 kinetic → electrical, thermal and sound

4 kinetic → chemical, electrical and thermal

8B The graph shows the power developed by the wind at different wind speeds. The power is measured in watts per square metre of area swept out by the rotor blades.



Question 17 · continued

What wind power is developed by a wind speed of 5.5 metres per second when the rotor blades sweep out an area of 5 square metres?

1 20 W

2 27.5 W

3 100 W

4 500 W

8C The table shows how the power output of a wind turbine changes with the diameter of the rotor blade.

Rotor blade diameter in metres (m)	Power output in kilowatts (kW)
1	0.4
2	1.6
3	3.6
4	6.4
6	14.4
8	25.6
10	40.0

Which of the following statements is correct?

1 decrease the rotor blade diameter and the power output increases

2 double the rotor blade diameter and the power output doubles

3 double the rotor blade diameter and the power output trebles

4 double the rotor blade diameter and the power output quadruples

8D A small wind turbine on the roof of a house has an average power output of 1 kW. The average demand for a household is 10 kW.

Large wind farms can produce an average power output of 5 MW.

One of the **disadvantages** of using wind farms to provide all the electricity for a large city is that . . .

1 wind farms develop far too much power for a large city.

2 large numbers of turbines are needed, taking up a lot of land.

3 large numbers of turbines will produce a lot of carbon dioxide.

4 wind farms produce a lot of noise that is very harmful to birds.

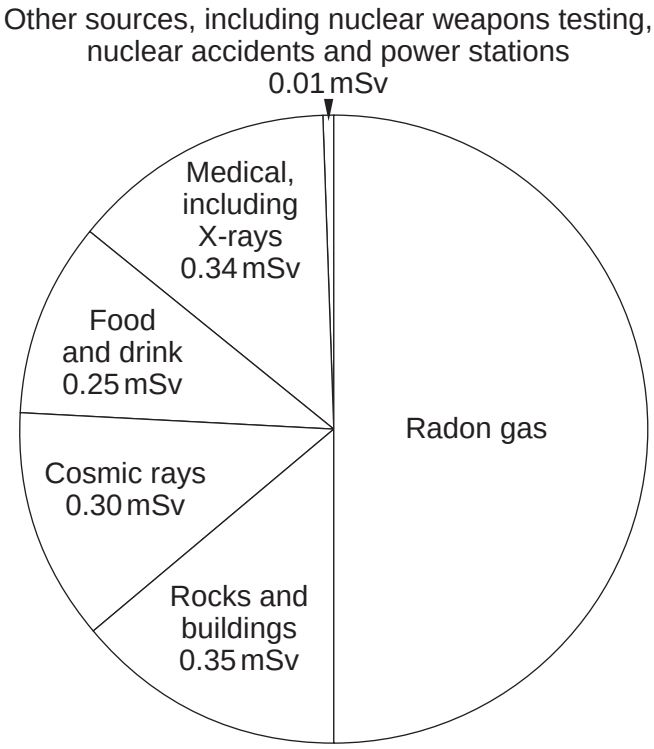
4.5.4 Moments, levers and gears (physics only)

Question 18

June 2012 | PH2HP | Original Q2 | Legacy

2 The pie chart shows the sources of the background radiation and the radiation doses that the average person in the UK is exposed to in one year.

Radiation dose is measured in millisieverts (mSv).



2 (a) (i) What is the radiation dose that the average person in the UK receives from radon gas?

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Radiation dose from radon gas = ... mSv

(1 mark)

2 (a) (ii) A person may receive a higher than average dose of radiation from background sources.

Suggest **two** reasons why.

1 .....

.....

2 .....

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(2 marks)

2 (b) Exposure to radon gas can cause lung cancer.
A recent study has compared the risk of getting lung cancer, by the age of 75 years, for cigarette smokers and non-smokers.
The people in the study had been exposed throughout their lives to different levels of radon gas.
A summary of the data produced from the study is given in the table.

Exposure to radon gas	Risk of lung cancer by age of 75	
	Non-smoker	Smoker
No exposure	0.4%	10%
Moderate exposure	1.0%	14%
Very high exposure	1.5%	32%

2 (b) (i) Why were people that have had **no exposure** to radon gas included in the study?

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(1 mark)

2 (b) (ii) Using information from the table, what conclusions can be made about exposure to radon gas and the risk of getting lung cancer?

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(2 marks)

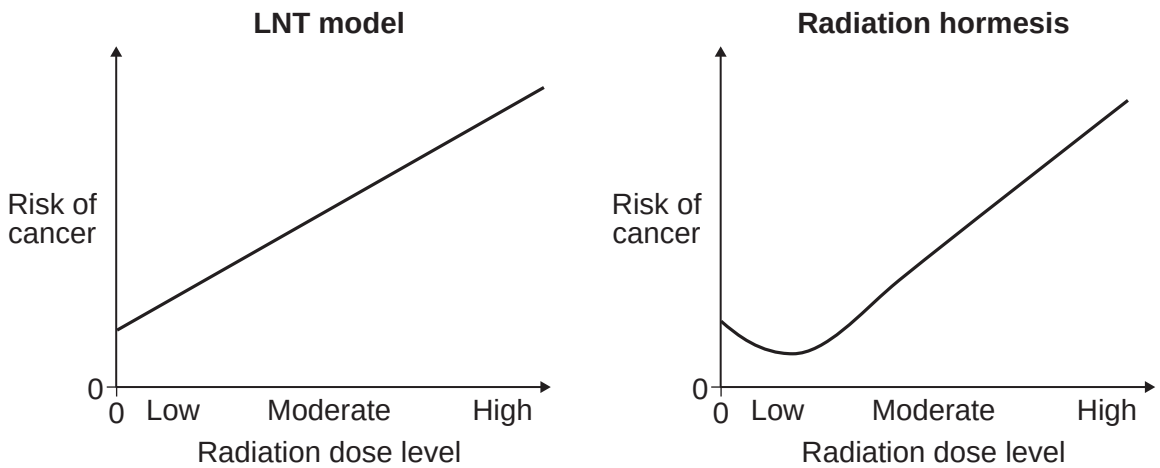
Question 2 continues on the next page

4.5.4 Moments, levers and gears (physics only)

Question 18 · continued

2 (c) At the moment, the regulations designed to protect people from over-exposure to radiation are based on a model called the 'linear no-threshold' (LNT) model.
Some scientists believe that the LNT model is too simple. These scientists believe that at low radiation levels a process called 'radiation hormesis' happens.

The graphs show that each model suggests a link between the risk of developing a cancer and exposure to low levels of radiation.



The link between the risk of developing cancer and exposure to low levels of radiation suggested by each of the models is different.

Describe how.

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(2 marks)

Question 18 · continued

2 (d) Scientists have conducted experiments in which mice have been exposed to different levels of radiation. The number of mice developing a cancer has then been measured.

Discuss whether it is ethical to use animals in scientific experiments.

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(2 marks)

10

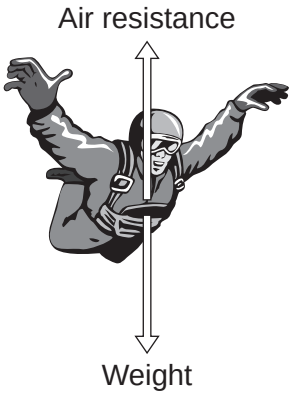
Turn over for the next question

4.5.4 Moments, levers and gears (physics only)

Question 19

June 2012 | PH2HP | Original Q3 | Legacy

3 (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

Use the correct equation from the Physics Equations Sheet.

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

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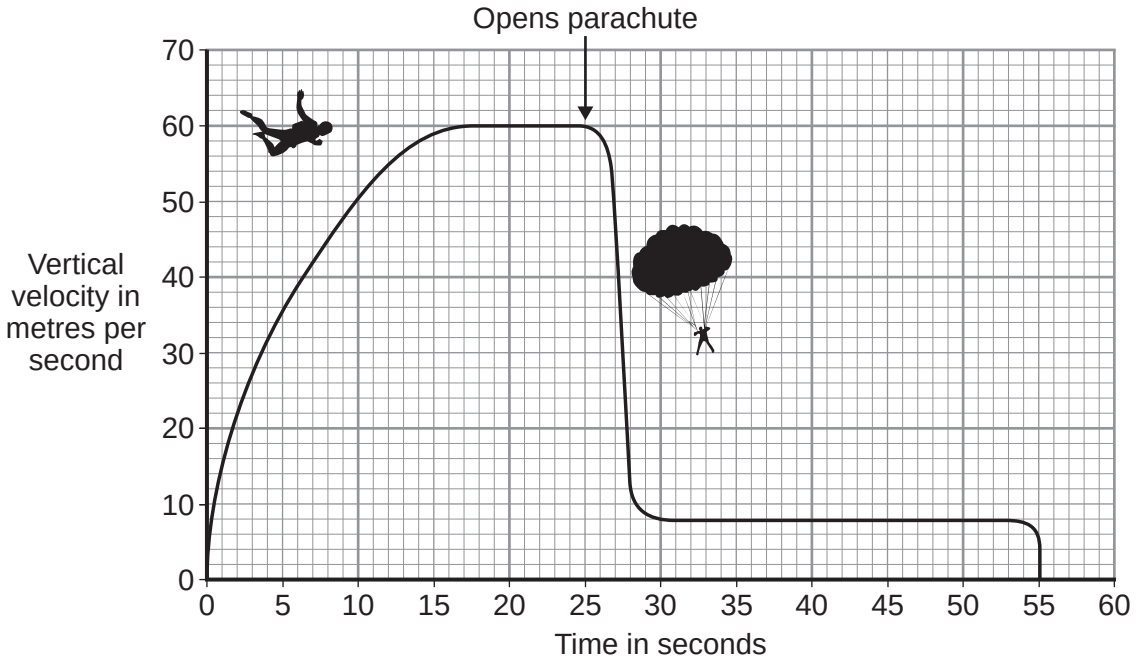
Weight = ...

(3 marks)

Question 19 · continued

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 marks)

Question 3 continues on the next page

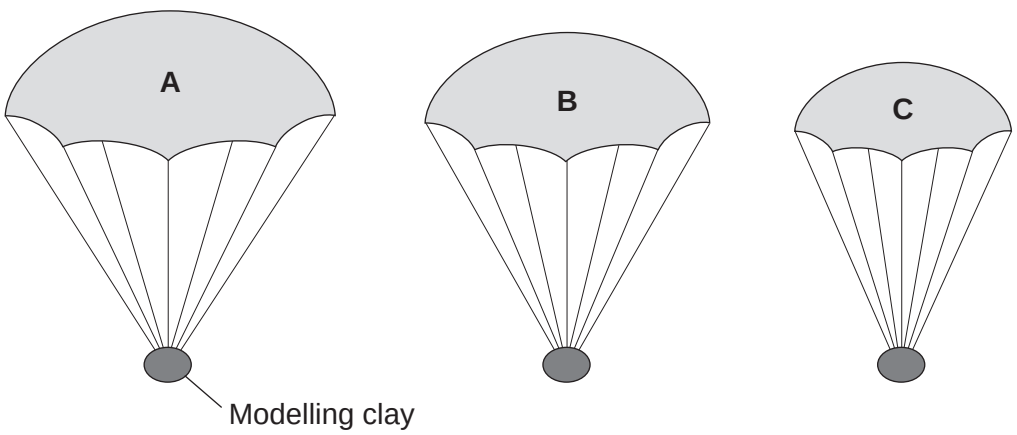
4.5.4 Moments, levers and gears (physics only)

Question 19 · continued

3 (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.



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

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

.....

(1 mark)

3 (c) (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.

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(2 marks)

12

4.5.4 Moments, levers and gears (physics only)

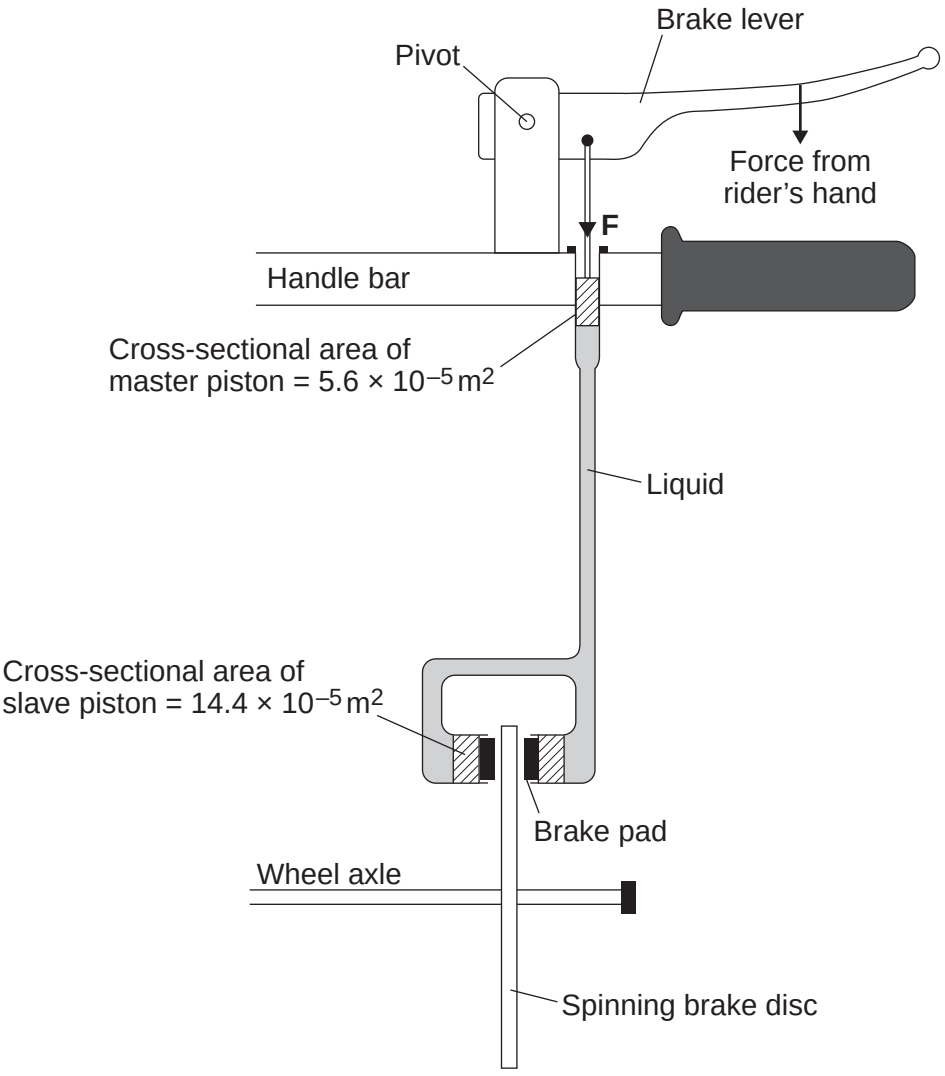
Question 20

June 2013 | PH3HP | Original Q4 | Legacy

4 Mountain bike riders use brakes to slow down.



Some mountain bikes have hydraulic brakes.



4.5.4 Moments, levers and gears (physics only)

Question 20 · continued

4 (a) What property of a liquid enables a hydraulic brake system to work?

.....

(1 mark)

4 (b) When the rider's hand pulls on the brake lever, the master piston applies a pressure of 1.5×10^6 pascals to the liquid.

Using information from the diagram, calculate the force **F** exerted on the liquid by the master piston.

Use the correct equation from the Physics Equations Sheet.

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Force **F** = ... N

(2 marks)

4 (c) The pressure in the liquid applies a force to move each slave piston.

How does the size of this force compare to the force **F** applied by the master piston?

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Give a reason for your answer.

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(2 marks)

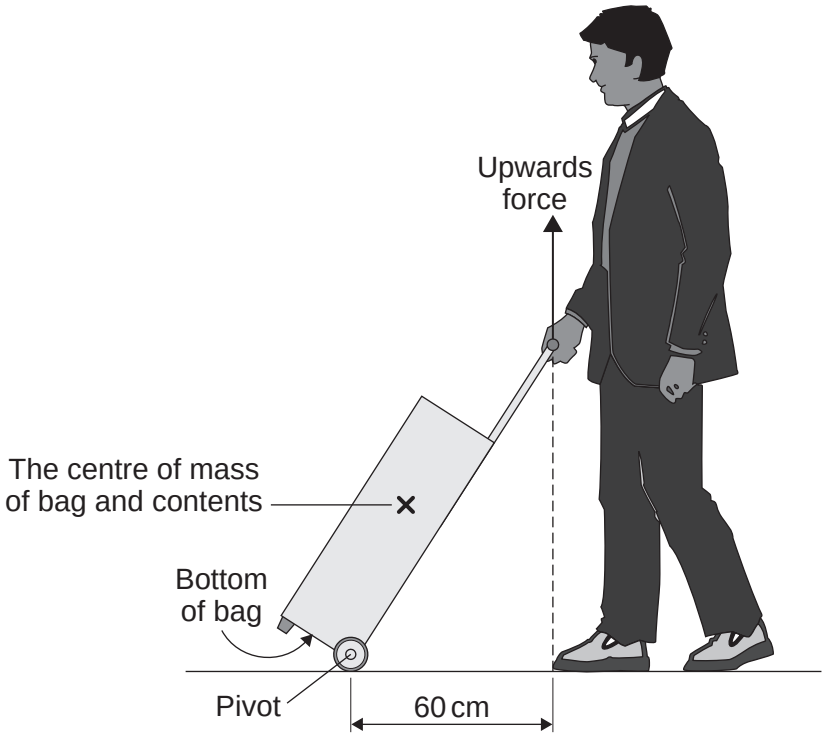
5

4.5.4 Moments, levers and gears (physics only)

Question 21

June 2013 | PH3HP | Original Q6 | Legacy

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



6 (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.

Use the correct equation from the Physics Equations Sheet.

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Force = ... N

(2 marks)

4.5.4 Moments, levers and gears (physics only)

Question 21 · continued

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

Explain why.

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(2 marks)

6 (c) During his holiday the man visits the Foucault Pendulum in Paris, France.
The pendulum makes 10 complete swings every 160 seconds.

Calculate the frequency of the pendulum and give the unit.

Use the correct equation from the Physics Equations Sheet.

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Frequency = ...

(3 marks)

7

4.5.4 Moments, levers and gears (physics only)

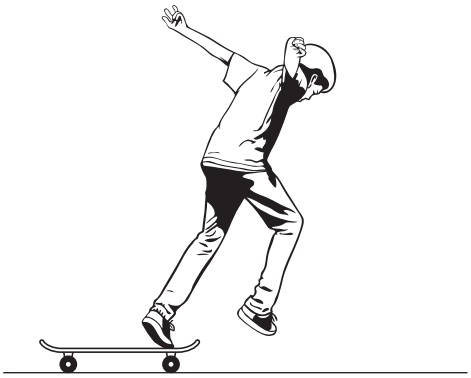
Question 22

June 2014 | PH2HP | Original Q5 | Legacy

5 **Figure 6** shows a skateboarder jumping forwards off his skateboard.

The skateboard is stationary at the moment the skateboarder jumps.

Figure 6



5 (a) The skateboard moves backwards as the skateboarder jumps forwards.

Explain, using the idea of momentum, why the skateboard moves backwards.

[3 marks]

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4.5.4 Moments, levers and gears (physics only)

Question 22 · continued

5 (b) The mass of the skateboard is 1.8 kg and the mass of the skateboarder is 42 kg.

Calculate the velocity at which the skateboard moves backwards if the skateboarder jumps forwards at a velocity of 0.3 m/s.

Use the correct equation from the Physics Equations Sheet.

[3 marks]

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Velocity of skateboard = ... m/s

6

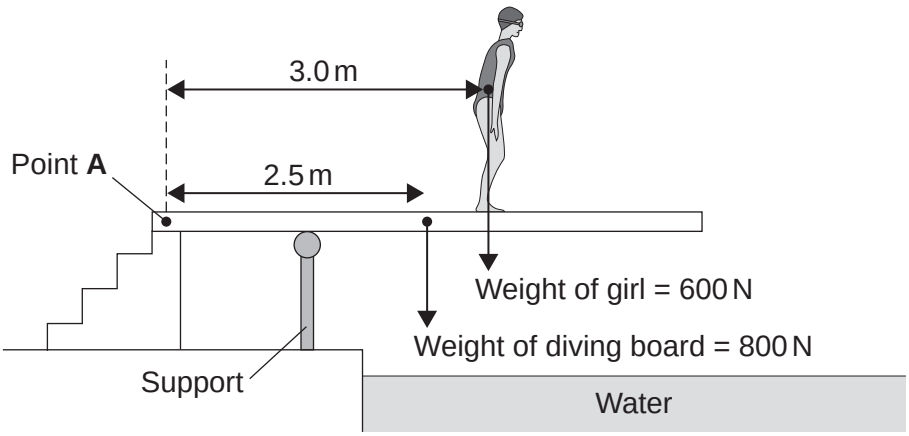
4.5.4 Moments, levers and gears (physics only)

Question 23

June 2014 | PH3HP | Original Q4 | Legacy

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

Figure 5



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

Use the correct equation from the Physics Equations Sheet.

[4 marks]

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

Question 4 continues on the next page

4.5.4 Moments, levers and gears (physics only)

Question 23 · continued

4 (b) **Figure 6** 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 6

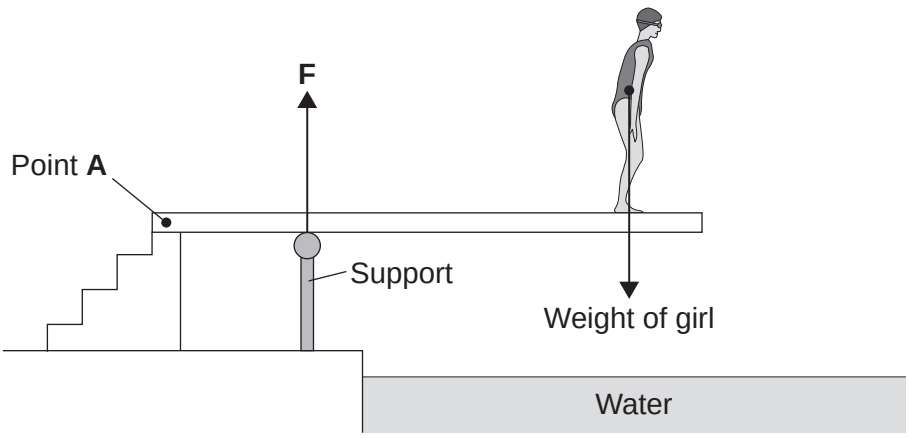
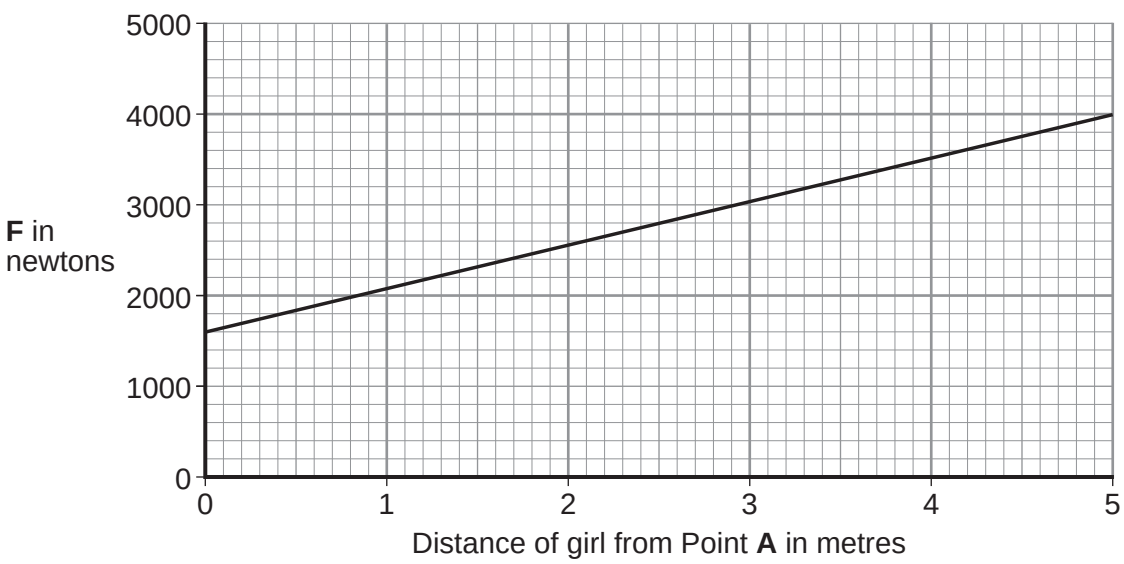


Figure 7 shows how the upward force **F** varies with the distance of the girl from Point **A**.

Figure 7



4.5.4 Moments, levers and gears (physics only)

Question 23 · continued

Explain, in terms of clockwise and anticlockwise moments, why the upward force **F** increases as shown in **Figure 7**.

[3 marks]

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7

Turn over for the next question

4.5.4 Moments, levers and gears (physics only)

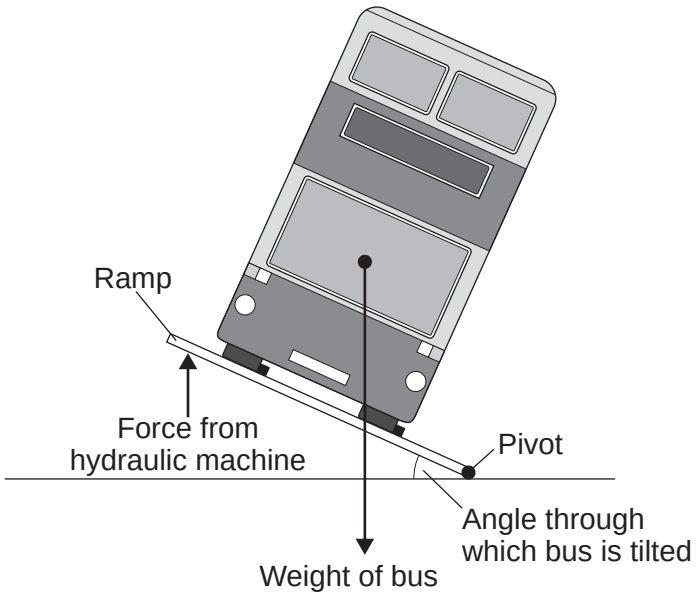
Question 24

June 2015 | PH3HP | Original Q7 | Legacy

7 Before a new bus can be used on the roads, it must pass a stability test.
Figure 13 shows how the bus is tested.

Figure 13

Front view



7 (a) (i) The bus will topple over if the ramp is tilted at too great an angle.

Explain why.

[2 marks]

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7 (a) (ii) The bus is tested to angles of tilt far greater than it would experience in normal use.

Suggest **two** reasons why.

[2 marks]

1 .....

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2 .....

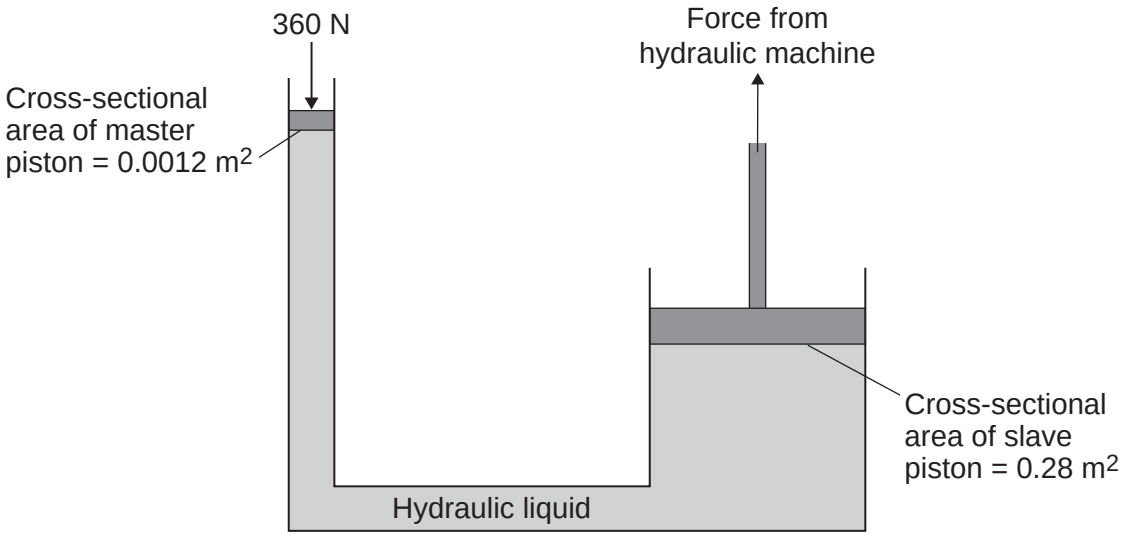
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4.5.4 Moments, levers and gears (physics only)

Question 24 · continued

7 (b) **Figure 14** shows the hydraulic machine that is used to make the ramp tilt.

Figure 14



The pressure applied to the hydraulic liquid at the master piston is the same as the pressure applied by the hydraulic liquid to the slave piston.

7 (b) (i) State the property of the liquid that keeps the pressure at both pistons the same.

[1 mark]

.....

7 (b) (ii) A 360 N force acts on the master piston.

Use information from **Figure 14** to calculate the force applied by the hydraulic liquid to the slave piston.

Use the correct equation from the Physics Equations Sheet.

[3 marks]

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Force = ... N

8

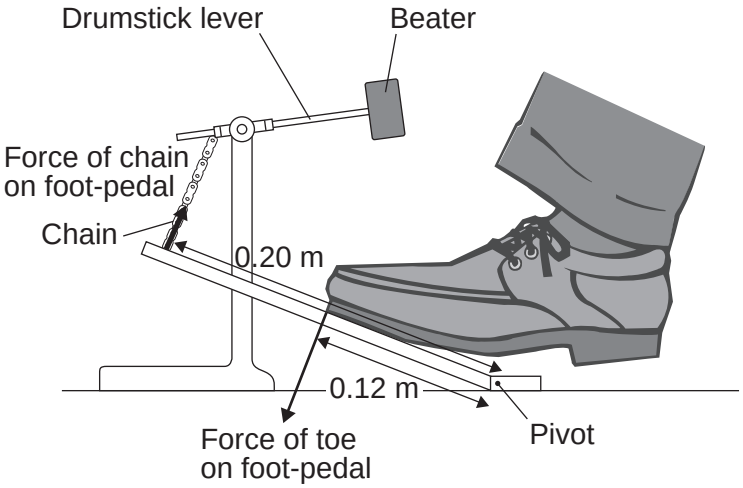
4.5.4 Moments, levers and gears (physics only)

Question 25

June 2016 | PH3HP | Original Q5 | Legacy

5 A drum is hit by a beater attached to a drumstick lever. The drumstick lever is attached to a foot-pedal by a chain, as shown in **Figure 9**.

Figure 9



5 (a) When the toe is pushed down the force creates a moment on the foot-pedal.

5 (a) (i) State what is meant by the moment of a force.

[1 mark]

5 (a) (ii) The foot-pedal is pushed halfway down and held stationary. The toe and the chain both exert a force on the foot-pedal.

Compare the sizes and directions of the moments caused by the force of the toe and the force of the chain on the foot-pedal.

[1 mark]

Question 25 · continued

5 (a) (iii) The drummer's toe pushes with a 1.5 N force on the foot-pedal.
The perpendicular distance from the pivot to the force is 0.12 m.
The perpendicular distance from the pivot to the chain is 0.20 m.

Calculate the force of the chain acting on the foot-pedal.

Use the correct equation from the Physics Equations Sheet.

[3 marks]

Force = _____ N

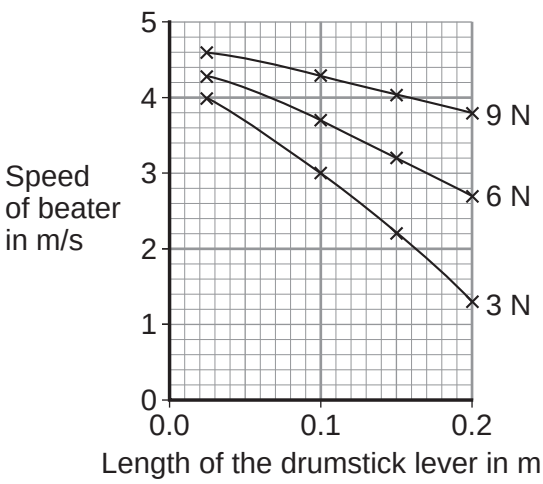
Question 5 continues on the next page

5 (b) The foot-pedal is pushed with different forces to make the beater move at different speeds.

The higher the speed at which the beater hits the drum, the louder the sound the drum makes.

Figure 10 shows how the length of the drumstick lever affects the speed of the beater for three different forces.

Figure 10



The drummer needs to be able to sometimes play the drum quietly and sometimes loudly.

How does the **length** of the drumstick lever affect the variation in loudness of the sound from the drum when applying:

[2 marks]

a force of 3 N? _____

_____

a range of forces from 3 N to 9 N? _____

_____

7

4.5.4 Moments, levers and gears (physics only)

Question 26

June 2016 | PH3HP | Original Q6 | Legacy

6 In a balancing game, wooden blocks are used to build a tower. The shape of the tower at the start of the game is shown in **Figure 11**. During the game, some of the blocks are taken out and put on top of the tower as shown in **Figure 12**. This causes the centre of mass of the tower to change.

Figure 11

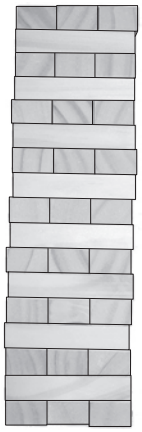
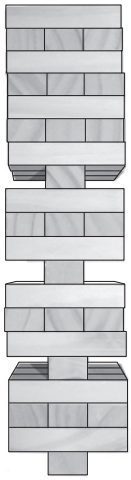


Figure 12



6 (a) (i) State what is meant by the term 'centre of mass'.

[1 mark]

6 (a) (ii) Give **two** reasons why the tower in **Figure 12** is less stable than the tower in **Figure 11**.

[2 marks]

1 _____

_____

2 _____

_____

4.5.4 Moments, levers and gears (physics only)

Question 26 · continued

6 (b) **Figure 13** shows a different arrangement for the wooden blocks.

Figure 13



A block was placed in position **A** and an identical block was placed in position **B** at the same time.

Explain why the tower did not fall over. You should include reference to moments in your answer.

[2 marks]

5

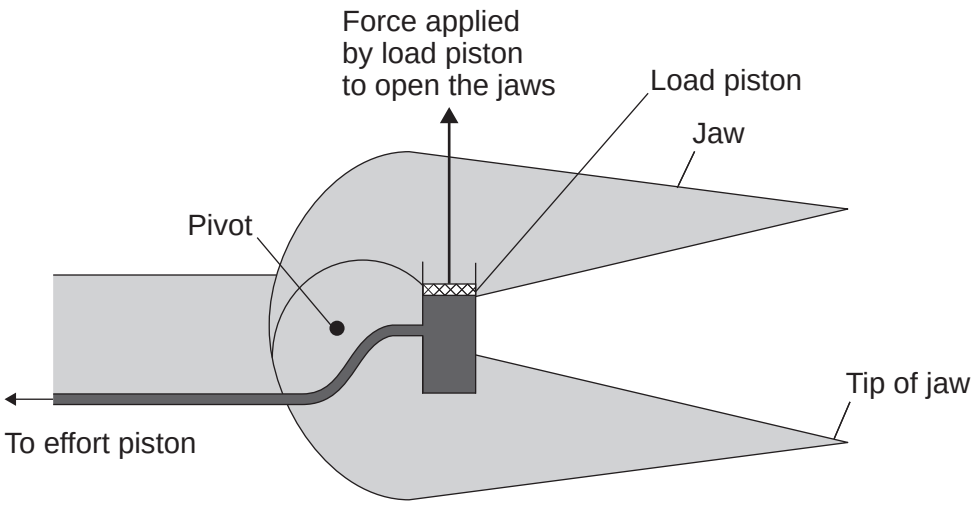
4.5.4 Moments, levers and gears (physics only)

Question 27

June 2017 | PH3HP | Original Q5 | Legacy

5 **Figure 4** shows some jaws used by the fire service. The jaws are opened and closed by a hydraulic system.

Figure 4



5 (a) The force applied at the effort piston is transmitted throughout the hydraulic system.

State the property of the liquid in the hydraulic system that allows this to happen.

[1 mark]

_____

5 (b) The pressure in the liquid in the hydraulic system in the jaws is 5.2×10^8 Pa
The cross-sectional area of the load piston in the jaws is 4.1×10^{-4} m^2

Calculate the force at the load piston.

Use the correct equation from the Physics Equations Sheet.

Give your answer to two significant figures.

[3 marks]

_____

_____

_____

_____

Force = _____ newtons

4.5.4 Moments, levers and gears (physics only)

Question 27 · continued

5 (c) How does the maximum force that the tip of the jaws can apply compare to the maximum force the load piston can apply?

Give a reason for your answer.

[2 marks]

5 (d) In **Figure 4** the moments of the forces on the jaws are in equilibrium.

Explain what is meant by the statement 'the moments of the forces on the jaws are in equilibrium'.

[2 marks]

8

4.5.4 Moments, levers and gears (physics only)

Question 28

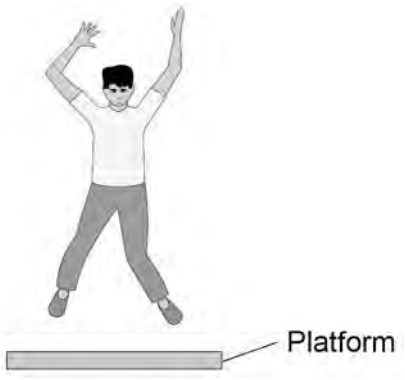
June 2019 | 8463/1H | Original Q3

0 3 A scientist investigated how the maximum muscle power of humans varies with age and gender.

The scientist asked volunteers to stand on a platform and to jump as high as they could.

Figure 4 shows a volunteer taking part in the experiment.

Figure 4



An electronic timer measured the time that the volunteer was in the air.

0 3 . 1 The muscle power in watts per kg is calculated using the following equation:

$$\text{muscle power} = \frac{9.8 \times \text{jump height}}{\text{time}}$$

One volunteer has a muscle power of 41 W/kg

He was in the air for 0.12 s

Calculate his jump height.

[3 marks]

Jump height = _____ m

Question 28 · continued

0 3 . 2 Write down the equation which links kinetic energy, mass and speed.

[1 mark]

0 3 . 3 One volunteer had a kinetic energy of 270 J and a speed of 3.0 m/s at the moment he left the ground.

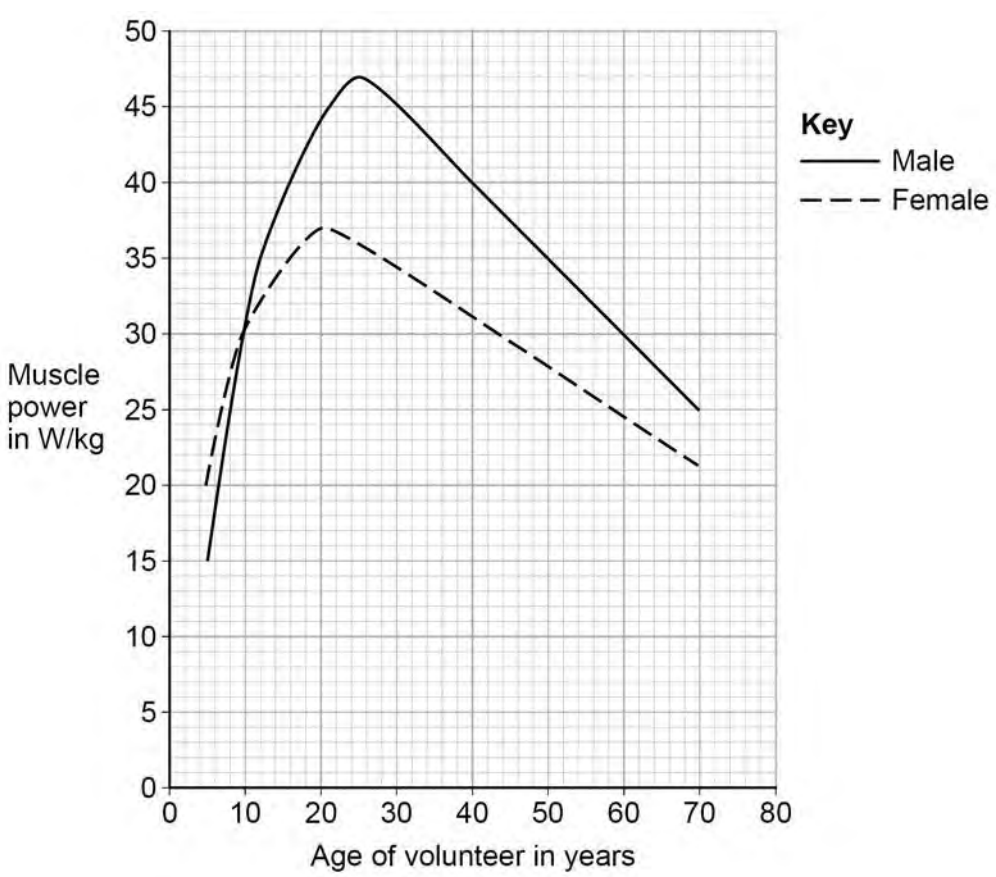
Calculate his mass.

[3 marks]

Mass = _____ kg

Figure 5 shows the scientist's results.

Figure 5



4.5.4 Moments, levers and gears (physics only)

Question 28 · continued

0 3 . 4 Compare the muscle power of males with the muscle power of females.

Use data from **Figure 5** in your answer.

[4 marks]

0 3 . 5 The muscle power of each volunteer was measured five times.

The highest muscle power reading was recorded instead of calculating an average.

Suggest **one** reason why.

[1 mark]

12

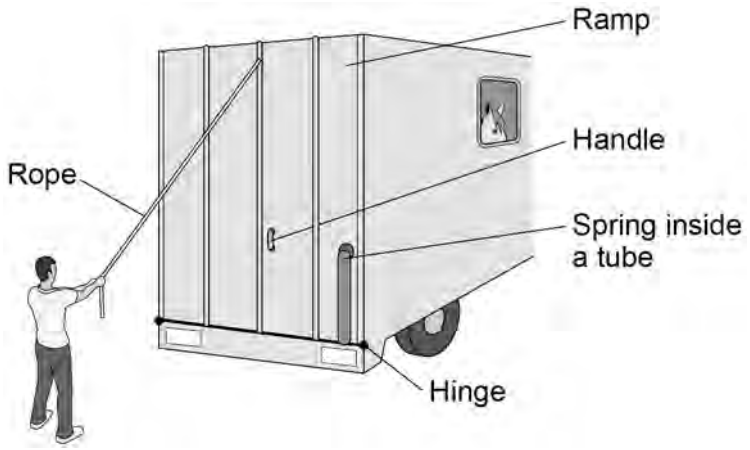
4.5.4 Moments, levers and gears (physics only)

Question 29

June 2019 | 8463/2H | Original Q10

1 0 **Figure 19** shows the back of a lorry. The lorry is used to carry horses.

Figure 19



The ramp is lowered by pulling on the rope or by pulling on the handle.

The hinge acts as a pivot.

1 0 . 1 Explain why it is easier to lower the ramp by pulling on the rope rather than pulling on the handle.

[2 marks]

Question 10 continues on the next page

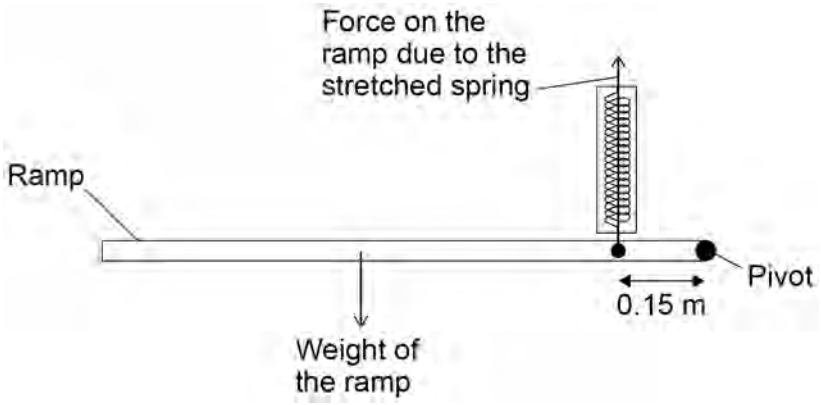
4.5.4 Moments, levers and gears (physics only)

Question 29 · continued

When the ramp is lowered, work is done to stretch a spring on the side of the ramp. Elastic potential energy is stored in the stretched spring.

Figure 20 shows the ramp part way down in a balanced horizontal position.

Figure 20



1 0 . 2 With the ramp horizontal:

the moment caused by the weight of the ramp = 924 Nm

the spring is stretched by 0.250 m

Calculate the elastic potential energy stored in the stretched spring.

Use data from **Figure 20**.

[6 marks]

Elastic potential energy = _____ J

8

4.5.4 Moments, levers and gears (physics only)

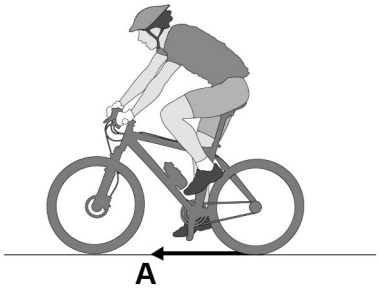
Question 30

November 2021 | 8463/2H | Original Q7

0 7 **Figure 11** shows a cyclist riding a bicycle.

Force **A** causes the bicycle to accelerate forwards.

Figure 11

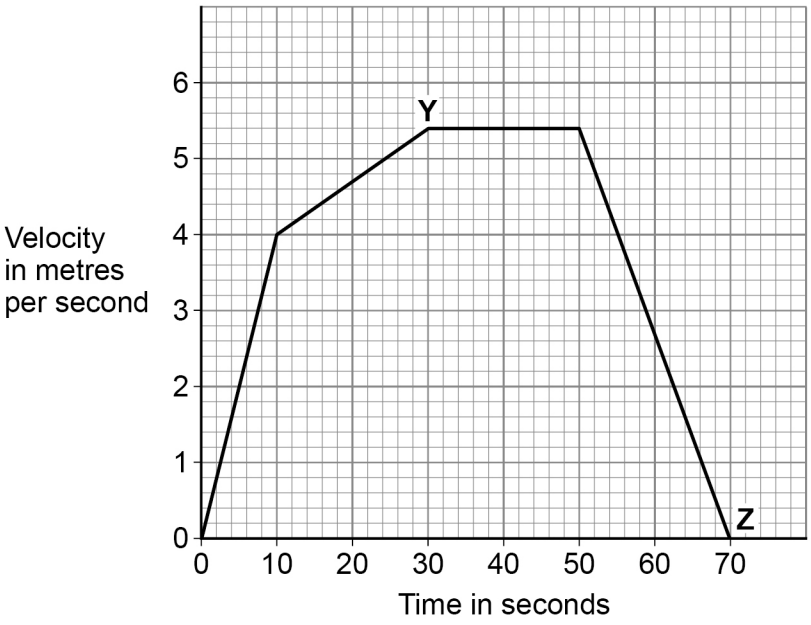


0 7 . 1 What name is given to force **A**?

[1 mark]

Figure 12 shows how the velocity of the cyclist changes during a short journey.

Figure 12



Question 30 · continued

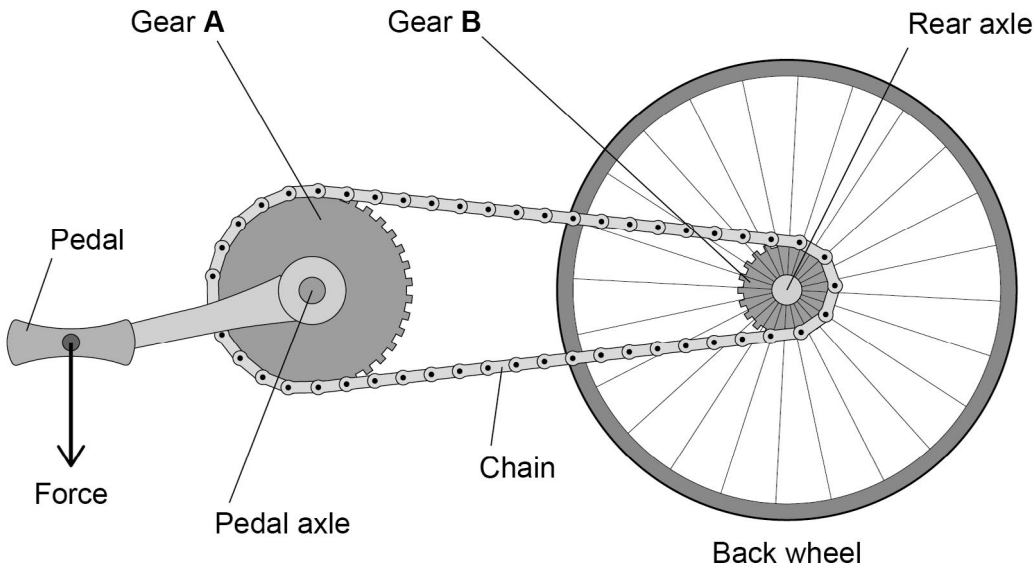
0 7 . 2 Determine the distance travelled by the cyclist between **Y** and **Z**.

[3 marks]

Distance travelled by the cyclist between **Y** and **Z** = _____ m

0 7 . 3 **Figure 13** shows the gears on the bicycle.

Figure 13



Describe how the force on the pedal causes a moment about the rear axle.

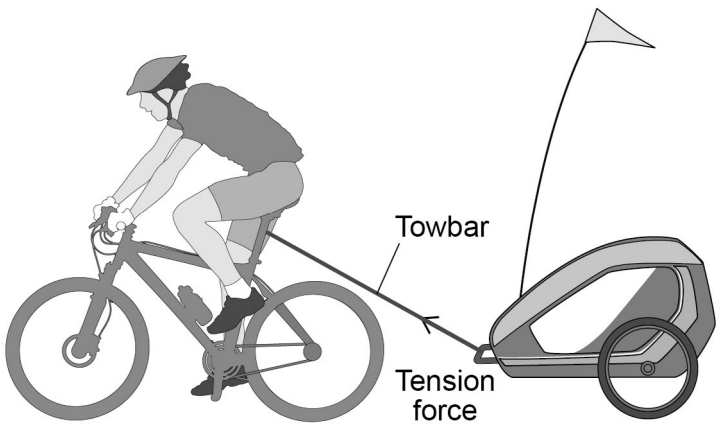
[2 marks]

Question 7 continues on the next page

Question 30 · continued

Figure 14 shows a different cyclist towing a trailer.

Figure 14



0 7 . 4 The speed of the cyclist and trailer increased uniformly from 0 m/s to 2.4 m/s.

The cyclist travelled 0.018 km while accelerating.

Calculate the initial acceleration of the cyclist.

[3 marks]

Acceleration = _____ m/s^2

4.5.4 Moments, levers and gears (physics only)

Question 30 · continued

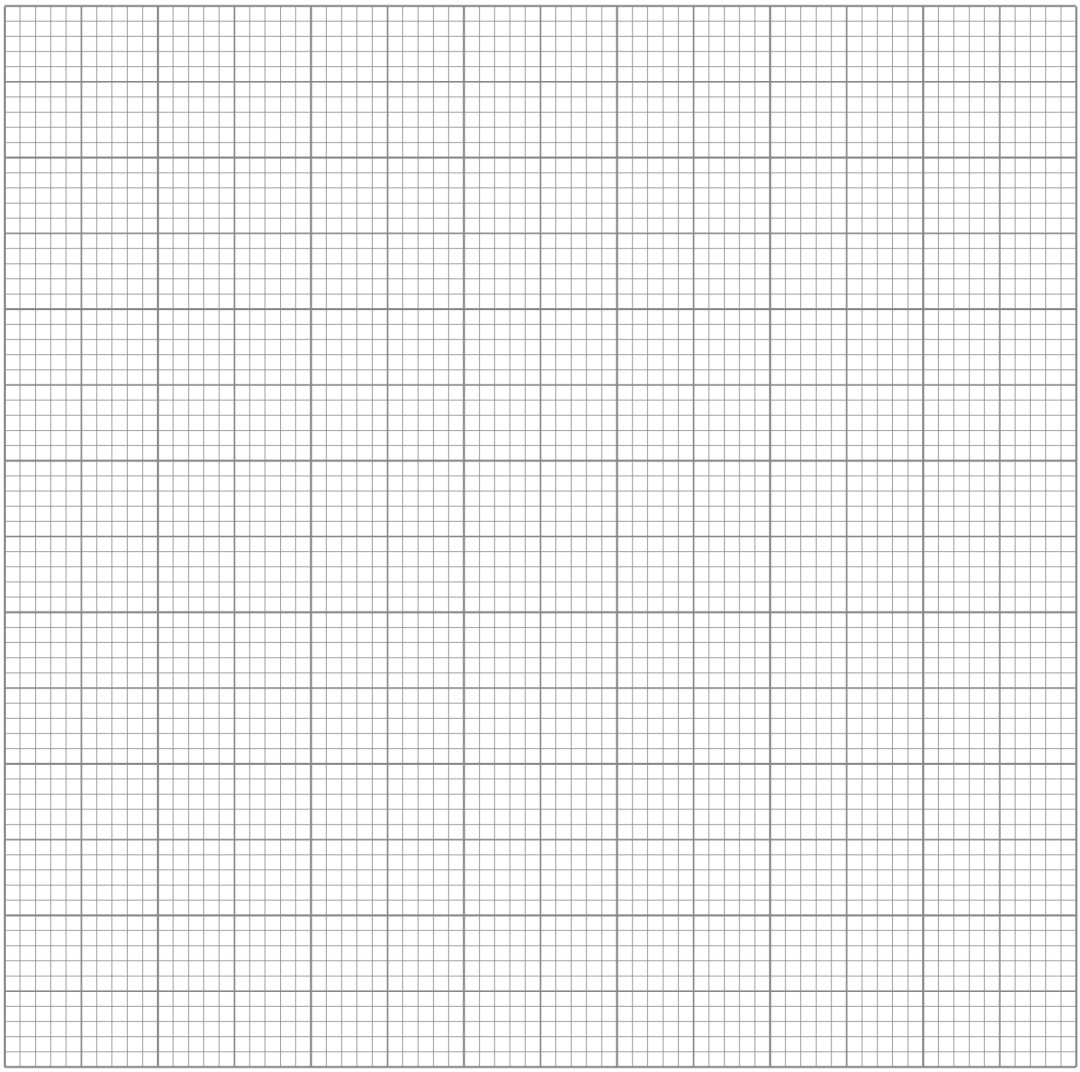
0 7 . 5 The resultant force of the towbar on the trailer has a horizontal component and a vertical component.

horizontal force = 200 N

vertical force = 75 N

Determine the magnitude and direction of the resultant force of the towbar on the trailer by drawing a vector diagram.

[4 marks]



Magnitude of force = _____ N

Direction of force = _____ degrees

13

4.5.4 Moments, levers and gears (physics only)

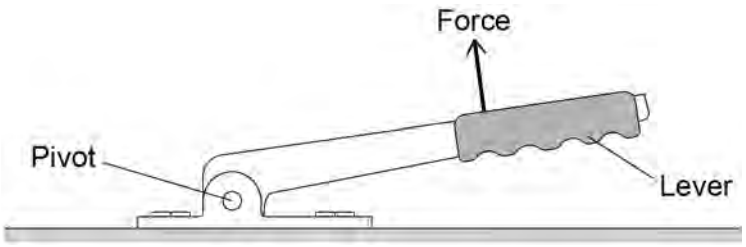
Question 31

June 2023 | 8463/2H | Original Q3

0 3 Some cars have a lever that is used to apply the handbrake.

Figure 8 shows the handbrake lever in a car.

Figure 8



0 3 . 1 The driver applies the force shown in **Figure 8**. The force produces a moment about the pivot.

How could the driver increase the moment about the pivot without increasing the size of the force?

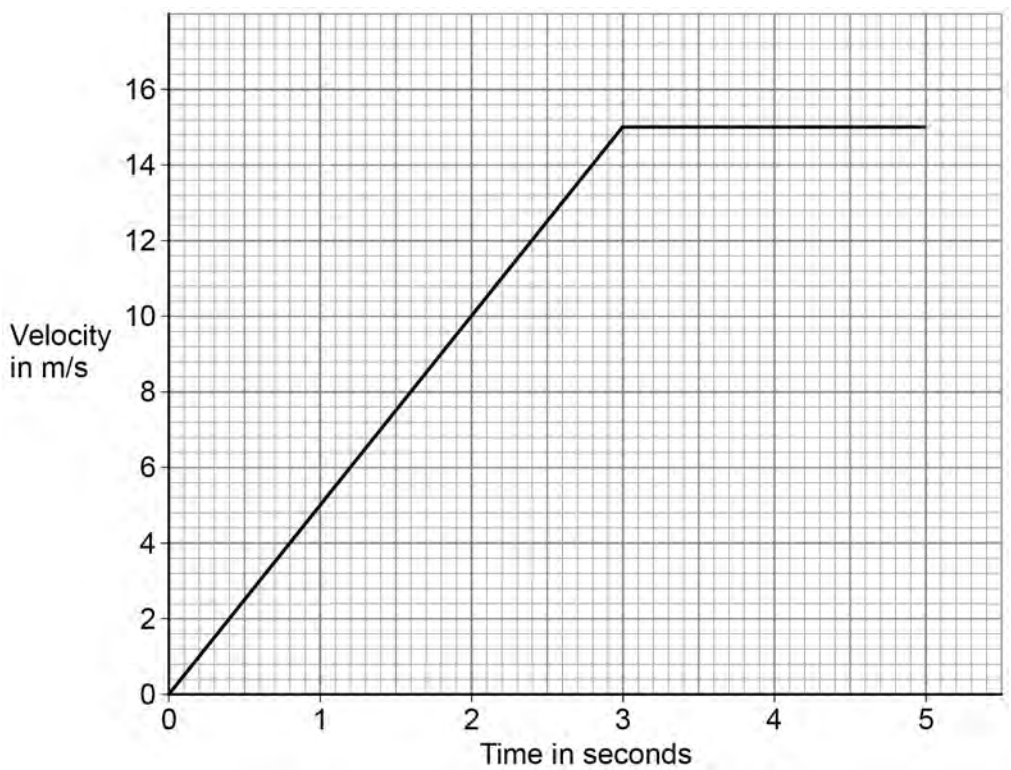
[1 mark]

Question 3 continues on the next page

The driver releases the handbrake.

Figure 9 shows how the velocity of the car changes during the first 5 seconds of a journey.

Figure 9



0 3 . 2 After 3 seconds, the momentum of the car is 24 000 kg m/s.

Calculate the mass of the car.

Use the Physics Equations Sheet.

[4 marks]

Mass = _____ kg

4.5.4 Moments, levers and gears (physics only)

Question 31 · continued

0 3 . 3 Determine the distance travelled by the car during the first 5 seconds of the journey.

Use **Figure 9**.

[3 marks]

Distance travelled by the car = _____ m

Question 3 continues on the next page

0 3 . 4 In an emergency the driver needs to apply the brakes suddenly to stop the car quickly.

The driver of the car is distracted.

Explain why the distraction will increase the stopping distance.

[3 marks]

0 3 . 5 Explain why the temperature of the brakes increases as they are used.

[2 marks]

13

4.5.4 Moments, levers and gears (physics only)

Question 32

0 2 **Figure 5** shows a young child using a baby walker.

Figure 5



0 2 . 1 The child is standing still.

What is the resultant **vertical** force on the child?

Give a reason for your answer.

[2 marks]

Resultant vertical force = _____ N

Reason _____

_____

4.5.4 Moments, levers and gears (physics only)

Question 32 · continued

Use the Physics Equations Sheet to answer questions **02.2** and **02.3**.

0 2 . 2 Write down the equation which links distance (*s*), force (*F*) and work done (*W*).

[1 mark]

0 2 . 3 The child pushed the baby walker 2.8 m across a horizontal floor.

The work done by the child was 35 J.

Calculate the horizontal force the child applied to the baby walker.

[3 marks]

Horizontal force = _____ N

0 2 . 4 The child pushed the baby walker from a carpet onto a hard floor.

The child applied the same horizontal force to the baby walker.

Explain why the speed of the baby walker increased.

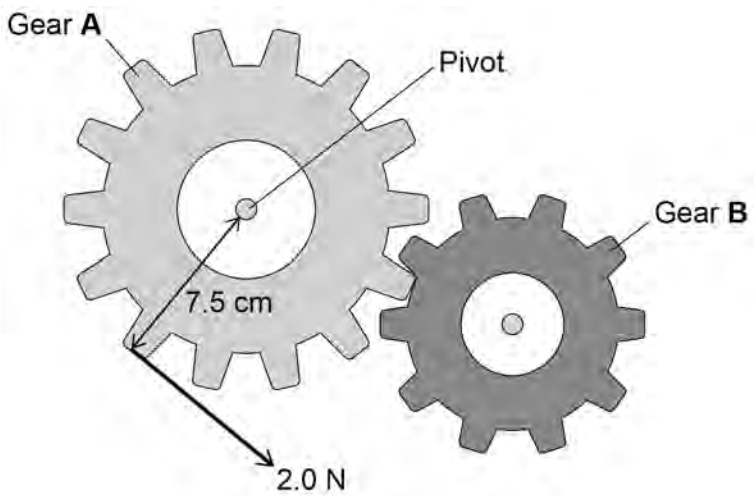
[2 marks]

Question 32 · continued

There are some toy gears on the front of the baby walker.

Figure 6 shows the gears.

Figure 6



The child applies a force to gear **A**.

This causes a moment about the pivot, so gear **A** rotates.

4.5.4 Moments, levers and gears (physics only)

Question 32 · continued

Use the Physics Equations Sheet to answer questions **02.5** and **02.6**.

0 2 . 5 Write down the equation which links distance (*d*), force (*F*) and moment of a force (*M*).

[1 mark]

0 2 . 6 The child applies a force of 2.0 N on gear **A**.

The perpendicular distance between the force and the pivot is 7.5 cm.

Calculate the moment of the force about the pivot.

[3 marks]

Moment of force = _____ N m

0 2 . 7 Explain what happens to gear **B** when the child applies the force to gear **A**.

[2 marks]

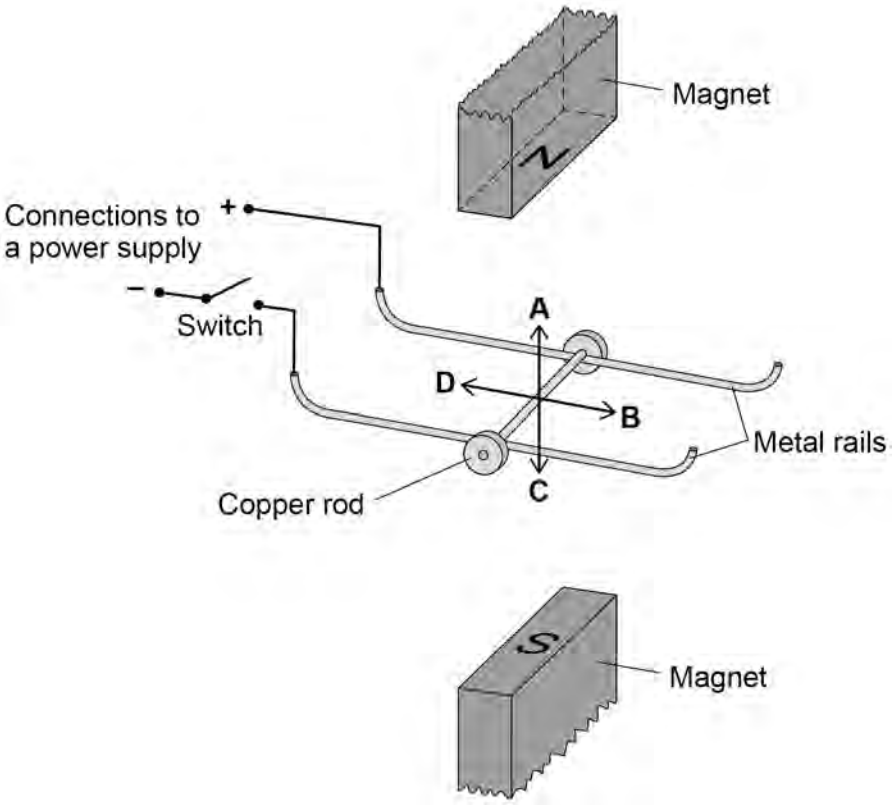
14

4.5.4 Moments, levers and gears (physics only)

Question 33

0 7 **Figure 7** shows some apparatus used to demonstrate the motor effect.

Figure 7



When the switch is closed the copper rod accelerates.

0 7 . 1 What direction is the acceleration of the copper rod?

[1 mark]

Tick (✓) **one** box.

A ☐

B ☐

C ☐

D ☐

Question 33 · continued

0 7 . 2 The copper rod has a mass of 5.0 g.

The length of the copper rod in the magnetic field is 0.070 m.

The magnetic flux density is 0.30 T.

Calculate the initial acceleration of the rod when the current in the rod is 2.0 A.

Use the Physics Equations Sheet.

[5 marks]

Initial acceleration = _____ m/s^2

Question 7 continues on the next page

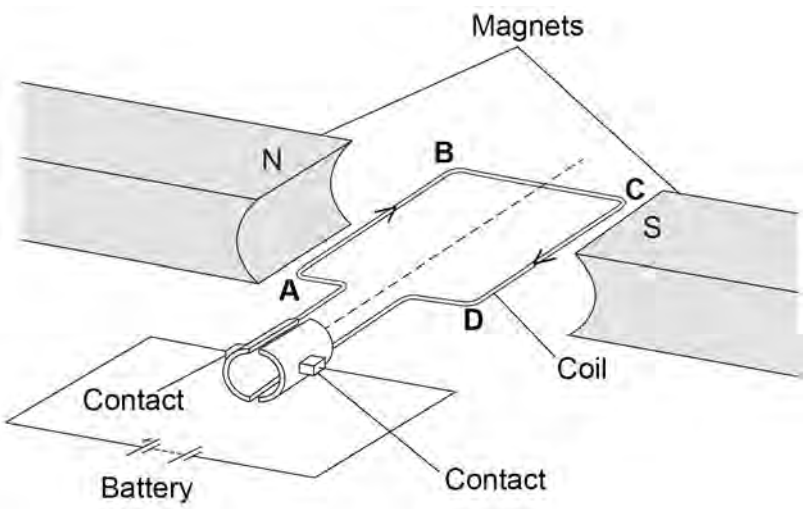
Question 33 · continued

Figure 8 shows a simple motor.

There is a magnetic field between the two permanent magnets.

When there is a current in the coil, a magnetic field is produced around the coil.

Figure 8



0 7 . 3 Explain how these magnetic fields cause the coil to continuously rotate.

[4 marks]

4.5.4 Moments, levers and gears (physics only)

Question 33 · continued

0 7 . 4 In **Figure 8** the coil of the motor is in a horizontal position.

Explain why the resultant moment on the coil is zero when the coil is in a vertical position.

[2 marks]

12

Turn over for the next question