

GCSE Physics (9 – 1)

Moments, levers and Gears

Name:

Group:



Instructions

- Read each question carefully before you begin to answer it.
- Use black ink or black ball-point pen for your answers.
- Fill in the boxes at the top of this page with your name and group.
- Attempt to answer every question in the booklet.
- Answer the questions in the spaces provided – there may be more space than you need in some answer spaces.
- Calculators may be used for this booklet.
- For any calculations, you **must** show all your working.
- Any and all drawings or graphs should be completed in pencil.

For markers use	
Question	Mark
1	/4
2	/8
3	/8
4	/11
5	/6
6	/9
7	/8
Total	/54
%	
Grade	

Information

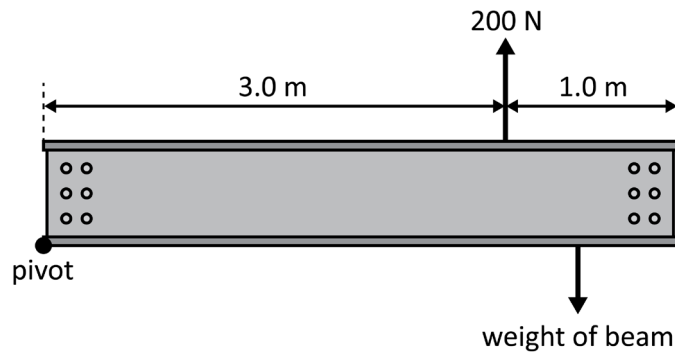
- The maximum mark for this paper is 54 marks.
- The marks for each question are shown in brackets.
- Please be aware that good English and clear presentation are required in your answers.



1. Moments, levers, and gears are simple mechanical systems that allow us to transmit forces and multiply their turning effects.

For each of the following questions **circle** the letter of the correct answer.

- a) The figure below shows a steel beam. A crane cable provides an upward force of 200 N to keep the beam in equilibrium.

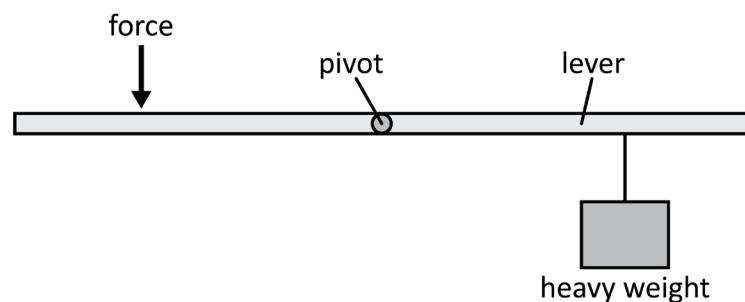


What is the weight of the steel beam?

- | | | | |
|----------|----------|----------|----------|
| A | B | C | D |
| 150 N | 600 N | 200 N | 800 N |

(1 mark)

- b) The figure below shows a force being applied to a lever to lift a heavy weight that a teacher is trying to lift.

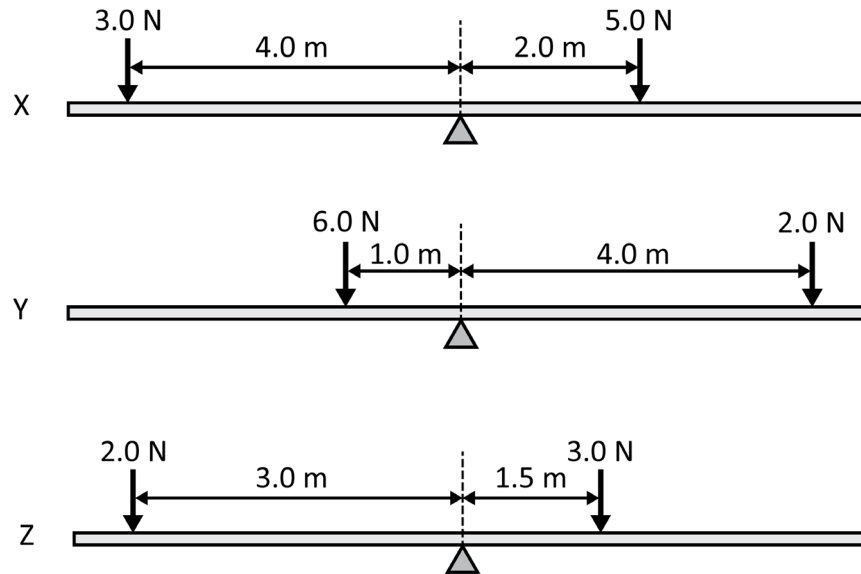


Which change would the teacher need to make to lift the heavy weight with a smaller force?

- A** Move the heavy weight to the right.
- B** Move the force to the right.
- C** Move the pivot to the left.
- D** Move the force to the left.

(1 mark)

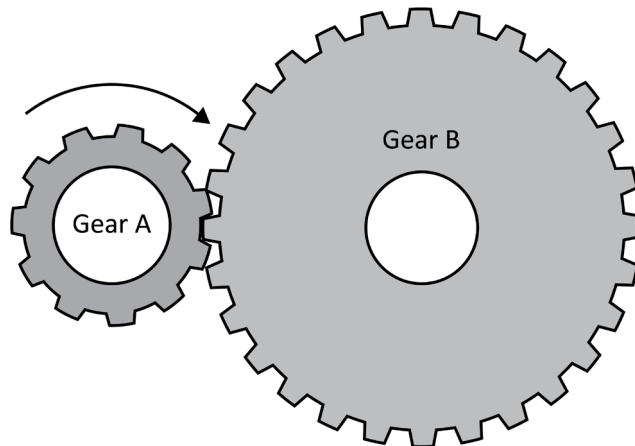
- c) The figure below shows three uniform beams X, Y, and Z. Each beam is perfectly balanced on a pivot at its centre. Two downward forces are applied to each beam as shown.



Which of the beams will rotate anticlockwise?

- | | | | |
|--------------|--------------|----------|----------|
| A | B | C | D |
| X and Y only | X and Z only | Y only | Z only |
- (1 mark)**

- d) The diagram shows a simple gear train. Gear A is the driving gear, and it is turned clockwise by a motor.



Which statement correctly describes the motion and turning effect of the larger driven gear (Gear B)?

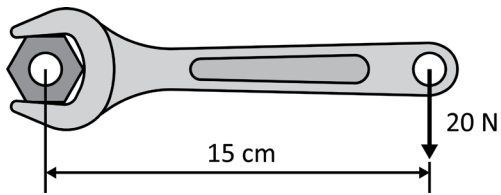
- A** Gear B rotates clockwise, turns slower than Gear A, and has a smaller turning effect.
- B** Gear B rotates anticlockwise, turns faster than Gear A, and has a larger turning effect.
- C** Gear B rotates anticlockwise, turns slower than Gear A, and has a larger turning effect.
- D** Gear B rotates clockwise, turns faster than Gear A, and has a smaller turning effect.

(1 mark)

(Total for Question 1 is 4 marks)

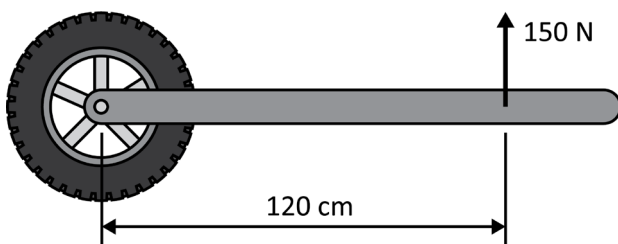
2. For each of the scenarios below calculate the moment of the force.

a) Calculate the moment of the force applied to the spanner.



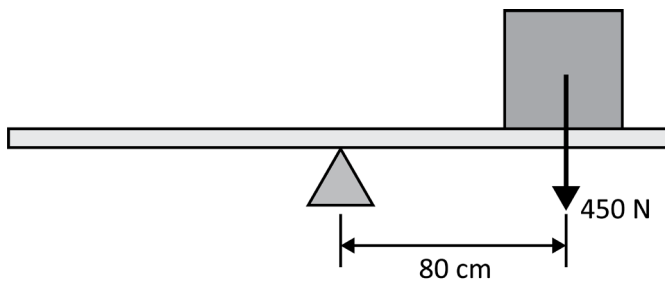
Moment = ... unit:
(2 marks)

b) Calculate the moment of the force applied to lift the wheelbarrow.



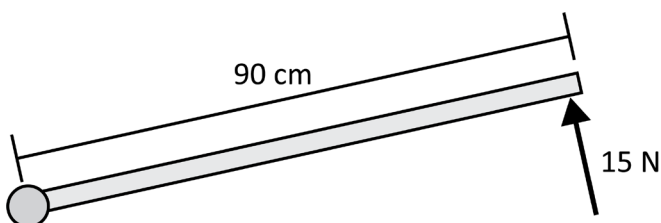
Moment = ... unit:
(2 marks)

c) Calculate the moment caused by the box resting on the see-saw.



Moment = ... unit:
(2 marks)

d) Calculate the moment of the force pushing the door open in **Diagram D**.

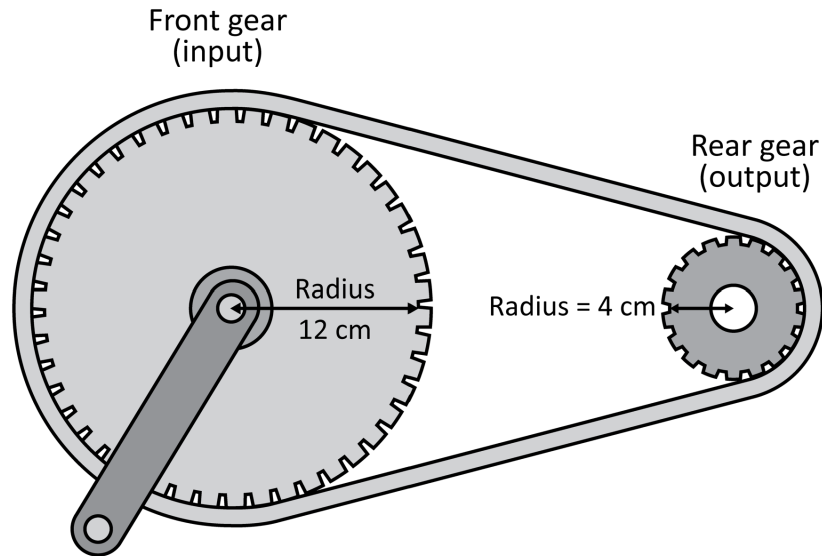


Moment = ... unit:
(2 marks)

(Total for Question 2 is 8 marks)

3. A cyclist is pedalling a bicycle.

The diagram shows the gear system connecting the pedals to the rear wheel.



- a) The cyclist applies a downward force to the pedal. This creates an input moment of 45 Nm on the front gear. The radius of the front gear is 12 cm.

Calculate the force pulling on the bicycle chain.

Force on chain = ... N

(3 marks)

- b) The force from the chain pulls on the rear gear, which has a radius of 4 cm.

Calculate the output moment (turning effect) on the rear gear.

Output moment = ... Nm

(2 marks)

- c) The cyclist turns the front gear at a steady speed of **1.5 rotations per second**.

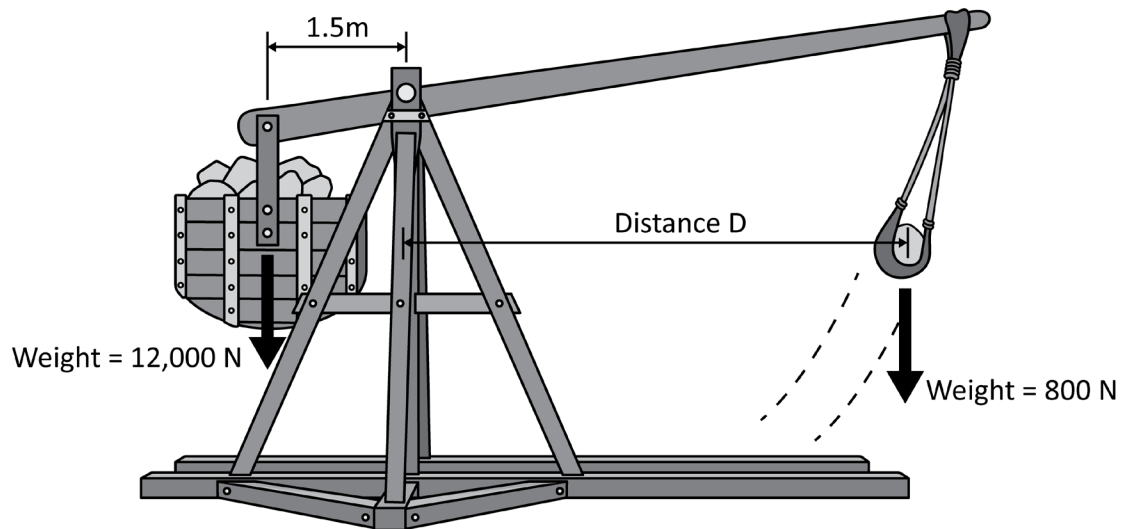
Calculate how many times the rear gear will rotate in exactly 10 seconds.

Rotations = ...

(3 marks)

(Total for Question 3 is 8 marks)

4. In the medieval period very large catapults called trebuchets were used to hurl very heavy stones at walls and other fortifications. The figure below shows a trebuchet and a large stone.



- a) State the equation that links moment, force and distance.

.....
(1 mark)

- b) Calculate the anticlockwise moment produced by the counterweight.

Moment = ... unit:
(3 marks)

- c) Calculate the distance between the pivot and the stone.

Distance = ... m
(3 marks)

- d) For the next launch, the team wants to hurl a much heavier stone.
They decide to slide the heavy counterweight further to the left, away from the pivot.

Explain why moving the counterweight further from the pivot allows the trebuchet to lift a heavier stone.

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(2 marks)

- e) The trebuchet is triggered, and the wooden arm swings upwards.

As the arm swings past an angle of 45° , the heavy counterweight is still hanging straight down with a force of 12,000 N. However, the anticlockwise moment it produces is now **less** than it was.

Explain why the moment produced by the counterweight decreases as the arm swings upwards.

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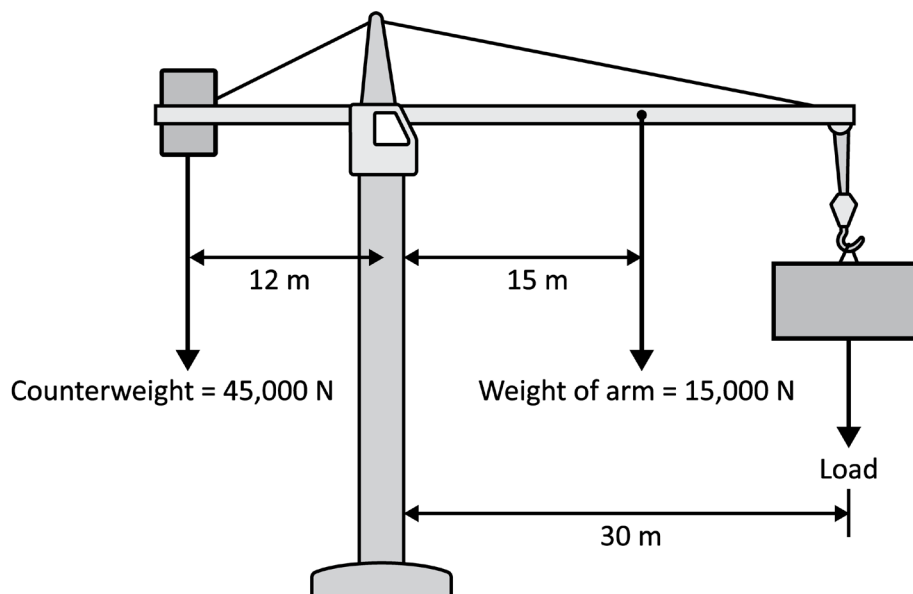
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(2 marks)

(Total for Question 4 is 11 marks)

5. A large tower crane is lifting a shipping container on a construction site.

The crane operator must ensure the crane is perfectly balanced before lifting the load.



The crane's horizontal arm is balanced on a central pivot.

Calculate the maximum weight of the load the crane can lift.

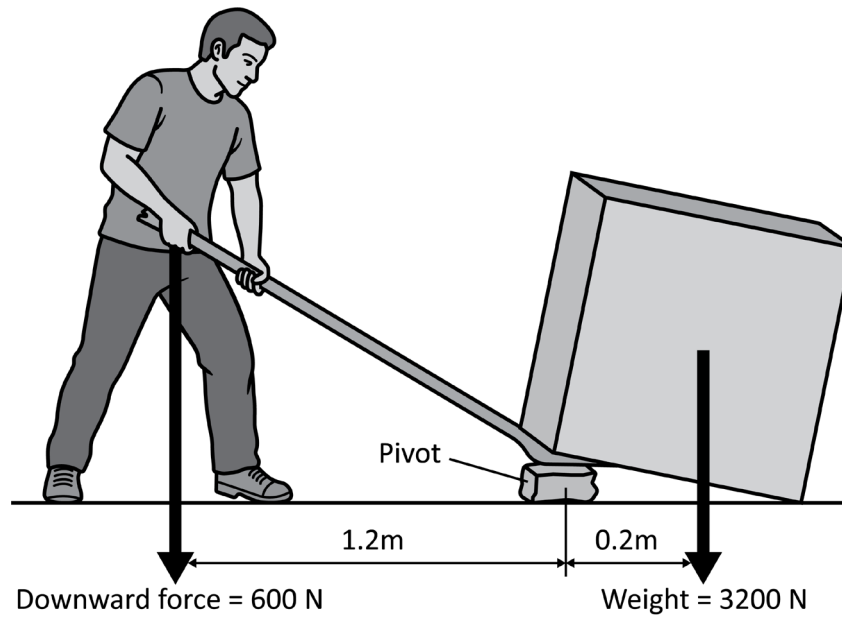
You must show all of your working.

Weight = ... N

(6 marks)

(Total for Question 5 is 6 marks)

6. A worker uses a metal crowbar as a lever to try and lift a heavy crate. The figure below shows the worker.



- a) State what is meant by the term moment of a force.

.....

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(2 marks)

- b) Calculate the anticlockwise moment produced by the worker.

Moment = ... unit:

(3 marks)

- c) Determine whether the worker is able to lift the crate using the lever.
You must show calculations to justify your answer.

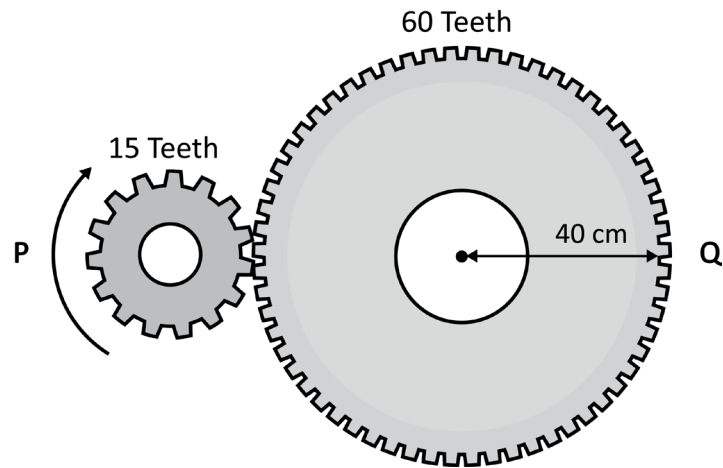
.....
(3 marks)

- d) The worker is unable to increase the downward force they apply to the crowbar.
Suggest **one** change the worker could make to the arrangement in the figure above to successfully lift the crate.

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(1 mark)

(Total for Question 6 is 9 marks)

7. A motor is connected to an industrial gearbox. The gearbox contains two gears, **P** and **Q**.



Gear P is the input gear and has **15 teeth**.

Gear Q is the output gear, has **60 teeth**, and a radius of 40 cm.

- a) State the direction of rotation of Gear Q.

.....
(1 mark)

- b) Explain **how** the gear system shown in the diagram acts as a force multiplier.

.....

 (2 marks)

- c) The motor applies an input moment of 120 Nm to turn Gear P.
Calculate the moment produced by Gear Q.

Moment = ...
(2 marks)

d) Calculate the force exerted by the teeth of Gear Q.

Force = ... N

(3 marks)

(Total for Question 7 is 8 marks)