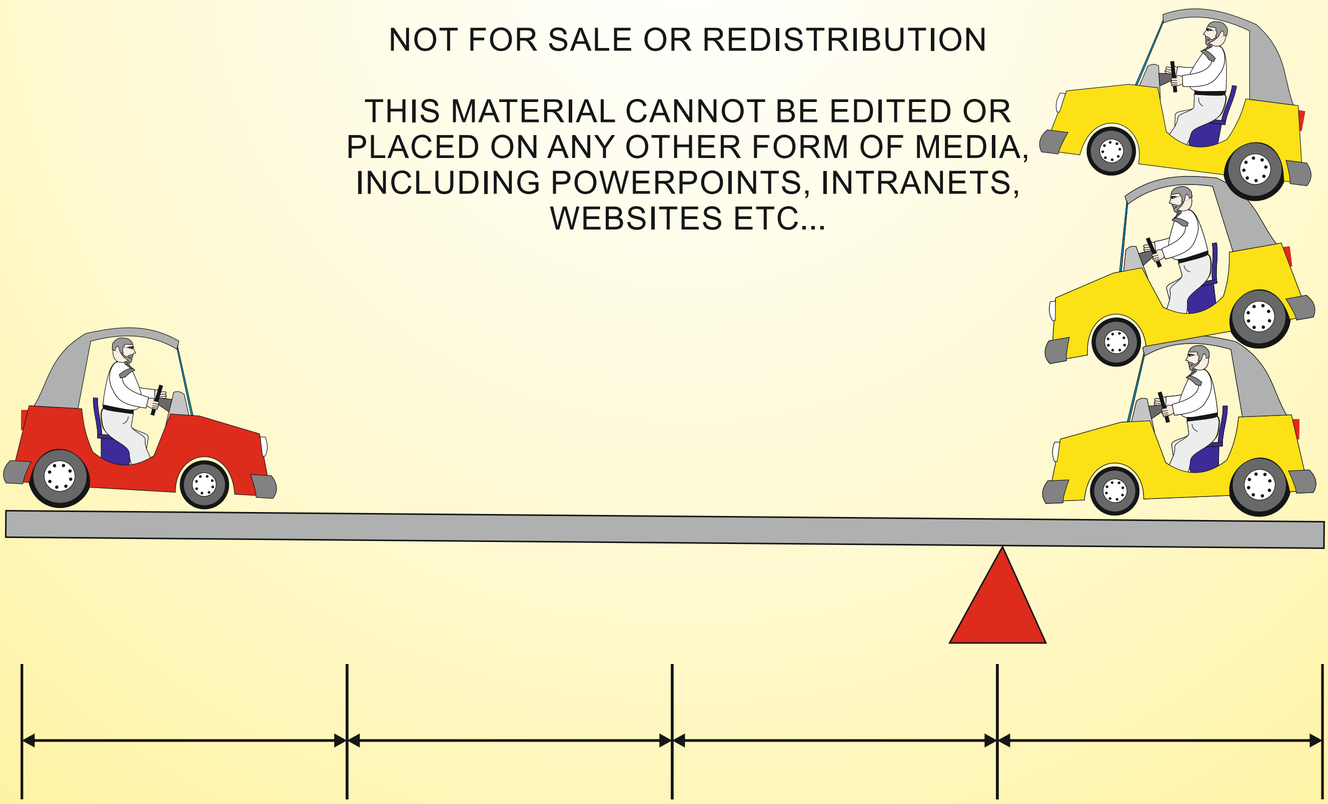
MATHEMATICAL SKILLS

MOMENTS OF FORCE (RATIOS) AND EQUILIBRIUM

AND

ASSOCIATED EXAMINATION QUESTIONS

DESIGN AND TECHNOLOGY



WORLD ASSOCIATION OF TECHNOLOGY TEACHERS https://www.facebook.com/groups/254963448192823/ www.technologystudent.com © 2017 V.Ryan © 2017

For animations to help explain Moments of Force and Equilibrium and questions and answers go to:

http://www.technologystudent.com/forcmom/force2.htm

For a PRACTICAL PROJECT on Equilibrium go to:

http://www.technologystudent.com/forcmom/cengrav1.html

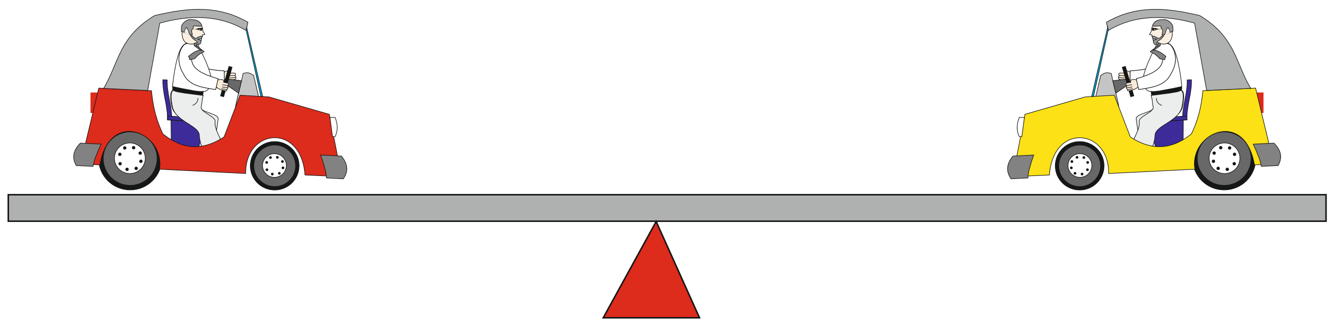
and

http://www.technologystudent.com/forcmom/balance1.html

MOMENTS OF FORCE AND EQUILIBRIUM

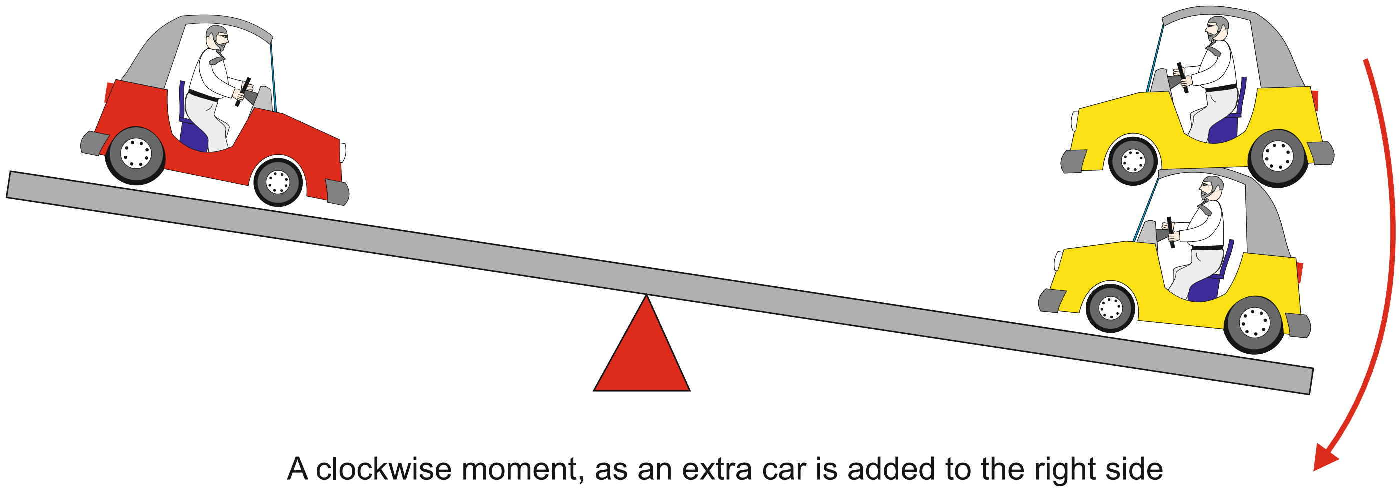
The diagram below clearly shows a state of equilibrium. The cars on either side of the seesaw are exactly the same in weight and height, in fact they are the same model. As a result, the seesaw stays level. The centre of the seesaw is called the 'fulcrum', seen here as a triangle and this is where the beam, that the cars rest on, tilts backwards and forwards. However, because of the state of equilibrium, they remain completely still.

The weight of the cars is called the effort.



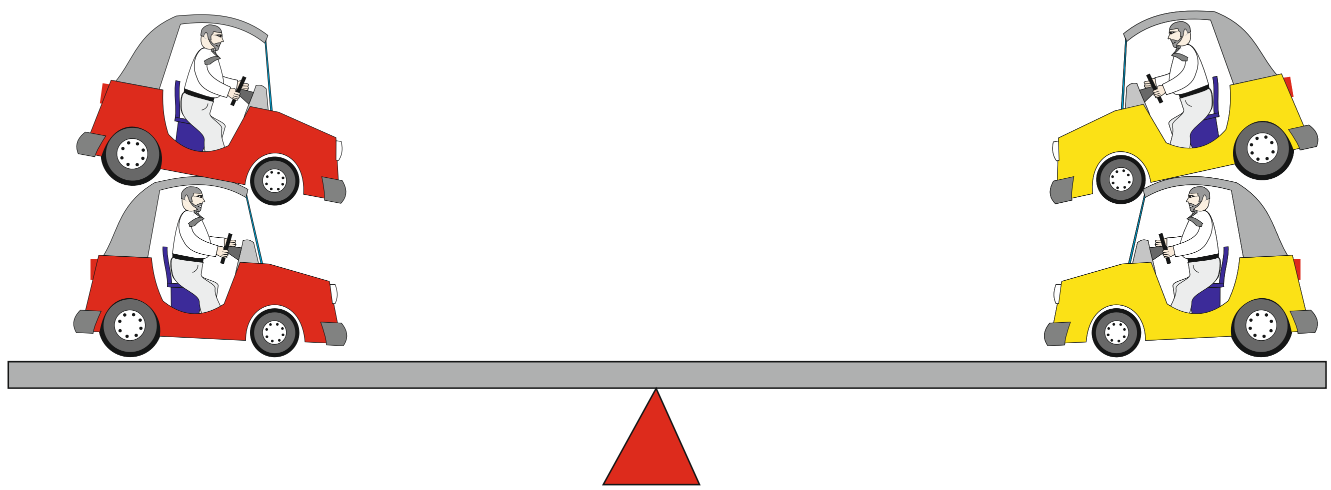
The cars are in a 'state of equilibrium' because the weight, on either side, is exactly the same. The distance from each car to the fulcrum, is also the same.

If an extra car is added to the right hand side (see diagram below), then the seesaw will turn in a clockwise direction - called a clockwise moment.
Alternatively, if more cars are added to the left hand side, the seesaw will turn in an anticlockwise direction - called an anticlockwise moment.

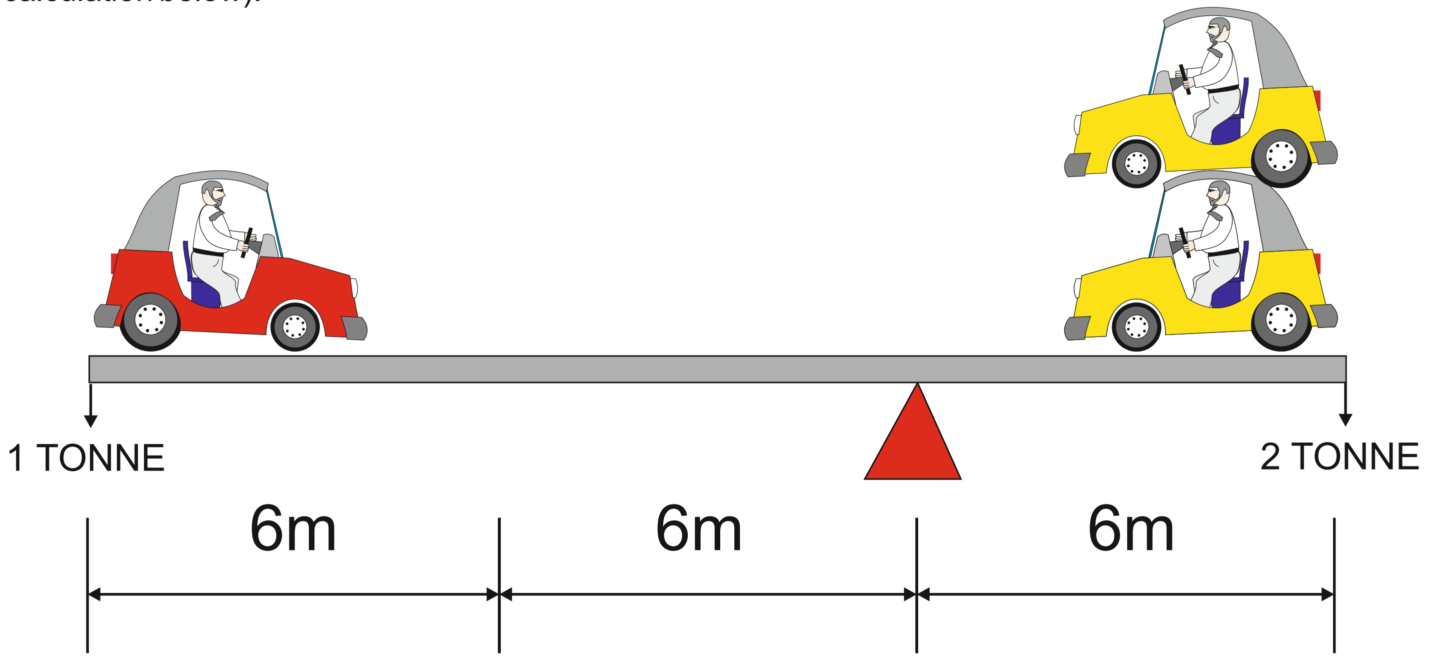


A clockwise moment, as an extra car is added to the right side

If the seesaw is to be in equilibrium, the clockwise moments must be equal to the anticlockwise moments. The seesaw is back in 'equilibrium' because a second car has been added to the left hand side, as well.



A state of equilibrium is also seen below. Each of the cars weighs the same (1 Tonne). Despite the fact that there is only one car on the left-hand side, the moments balance because, the car on the left-hand side, is twice the distance from the fulcrum, compared to the cars on the right-hand side. (see the calculation below).



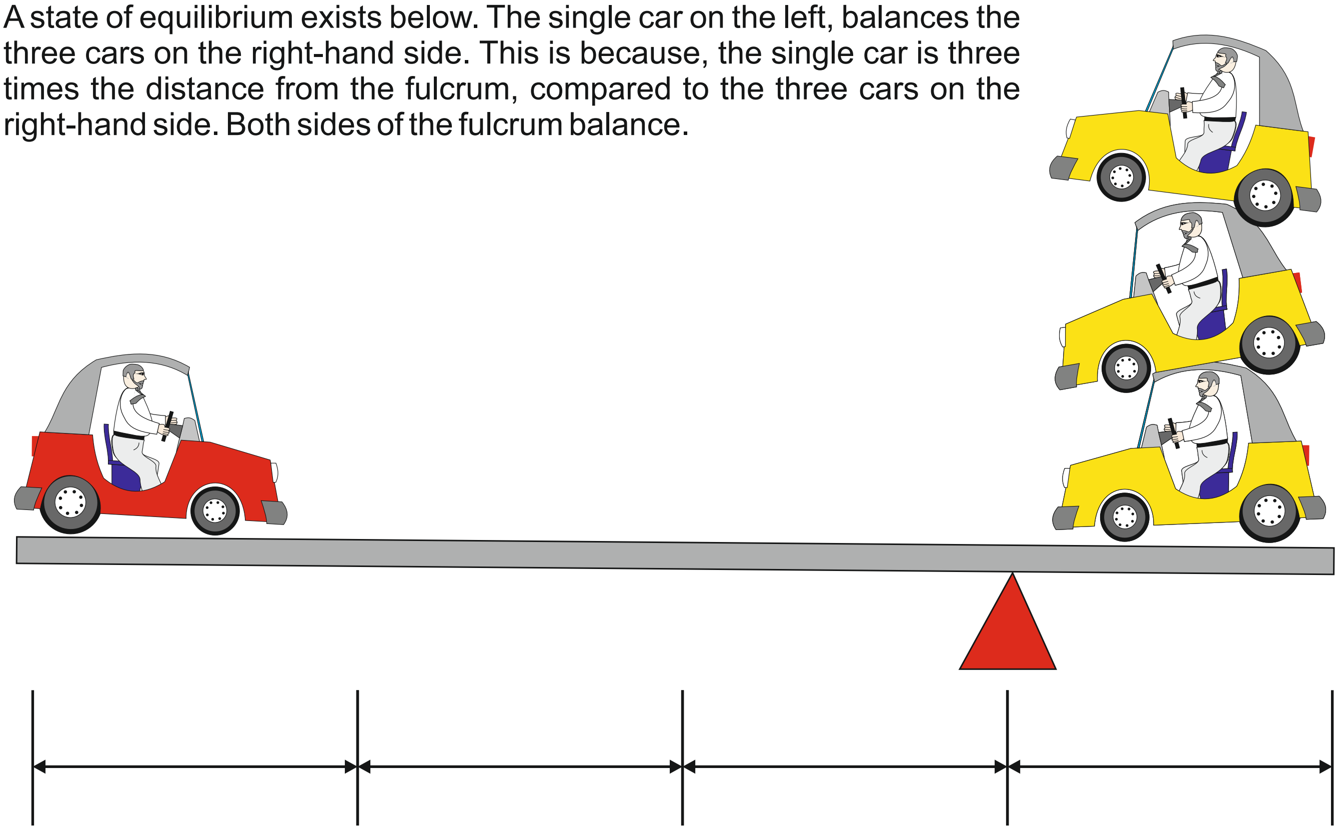
CLOCKWISE MOMENTS = ANTI-CLOCKWISE MOMENTS

1 TONNE X 12m = 2 TONNE x 6m

12 = 12

STATE OF EQUILIBRIUM

A state of equilibrium exists below. The single car on the left, balances the three cars on the right-hand side. This is because, the single car is three times the distance from the fulcrum, compared to the three cars on the right-hand side. Both sides of the fulcrum balance.

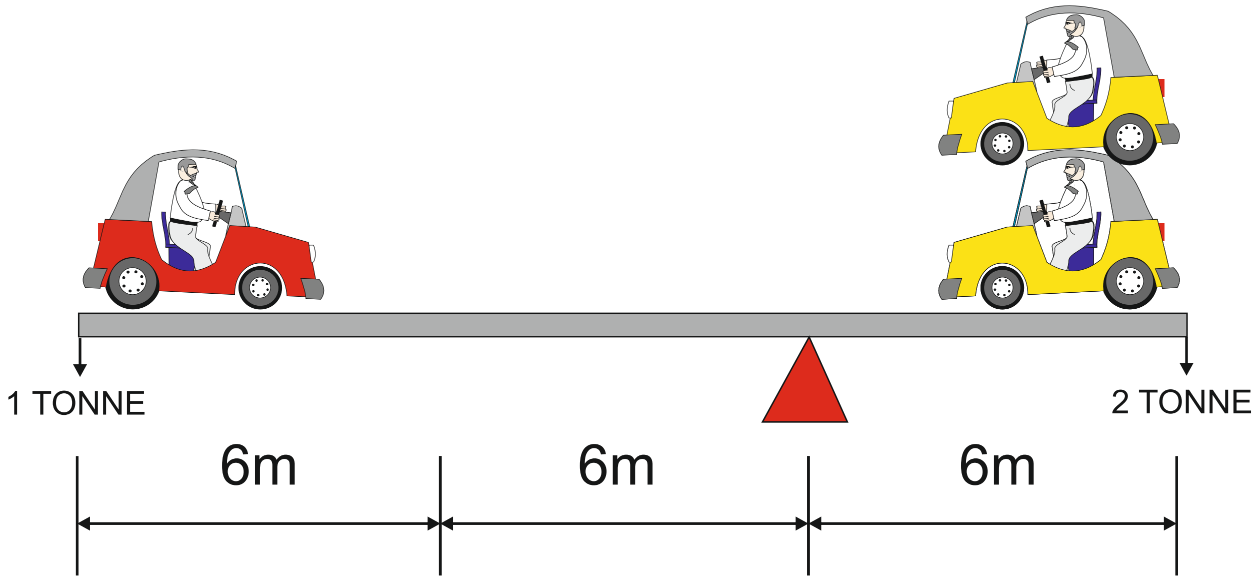


EXAMINATION QUESTION - MOMENTS OF FORCE AND EQUILIBRIUM

1. What is equilibrium? To answer this question you must complete the diagram below, clearly demonstrating 'equilibrium' and add explanatory notes.

What is the fulcrum?

Explain why the diagram below shows a state of equilibrium, especially as there appears to be an imbalance of two cars on the right, to one car on the left. You will need to include the correct calculation and notes in your answer.

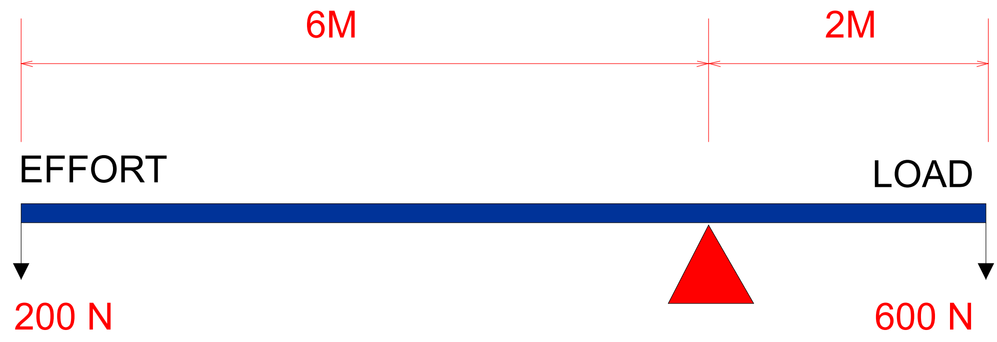


CALCULATION

NOTES/EXPLANATION

EXAMPLE EXAMINATION QUESTIONS AND ANSWERS

1. The diagram below shows a lever where an effort of 200 N balances a load of 600 N. The effort force is 6 metres from the fulcrum. The load force is two metres from the fulcrum.



Clockwise moment = 600 x 2 Nm

Anti-clockwise moment = 200 x 6 Nm

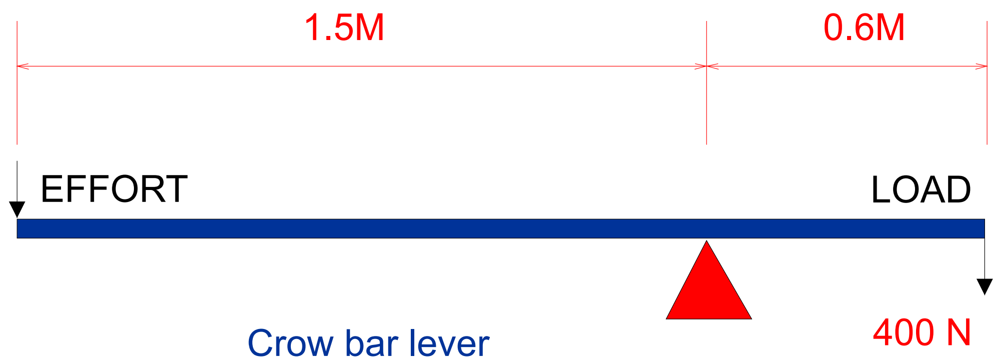
In a state of equilibrium,

clockwise moments = anti-clockwise moments

600 X 2 Nm = 200 x 6 Nm

1200 = 1200

2. In the diagram below a crow-bar is used to move a 400n load. What effort is required to move the load?



Clockwise moments = 400 N x 0.6 m

Anticlockwise moments = effort x 1.5m

In equilibrium;

clockwise moments = anti-clockwise moments

400 x 0.6 = effort x 1.5

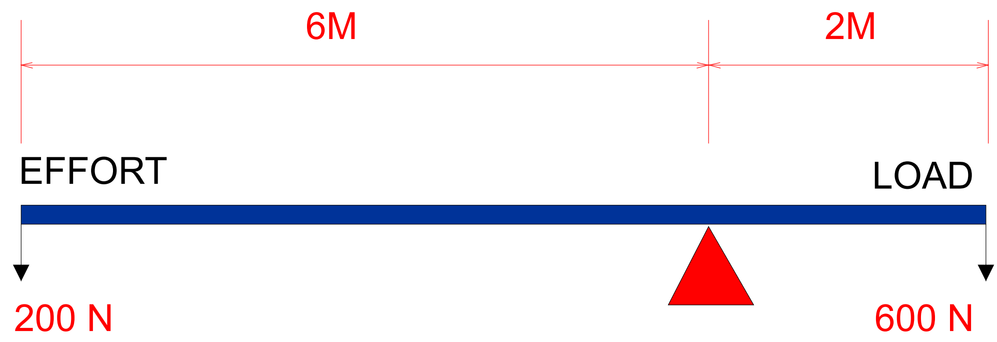
$$\text{effort} = \frac{400 \times 0.6}{1.5}$$

$$\text{effort} = \frac{240}{1.5}$$

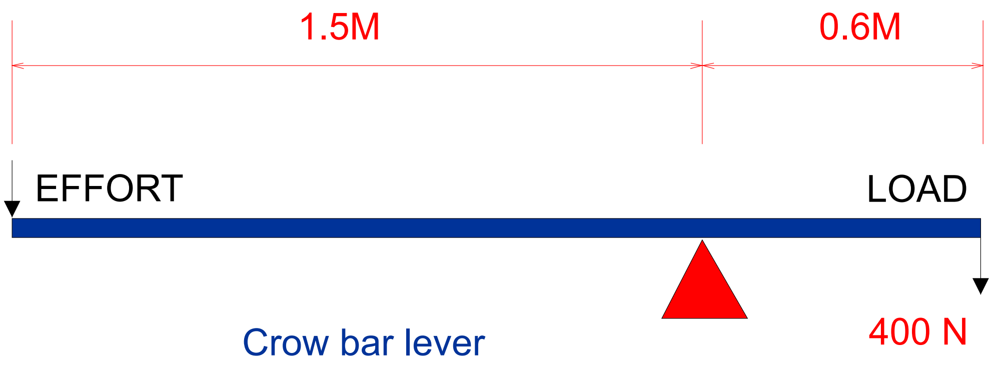
$$= 160 \text{ N}$$

EXAMPLE EXAMINATION QUESTIONS

1. The diagram below shows a lever, where an effort of 200 N balances a load of 600 N. Show how this is correct, by calculating the clockwise and anticlockwise moments.



2. In the diagram below, a crow-bar is used to move a 400n load. What effort is required to move the load?



EXAMPLE EXAMINATION QUESTIONS AND ANSWERS

3. Another crow-bar is used to lever a load of 120N. The load is 2m from the fulcrum and the effort is 6m from the fulcrum. What effort is required to move the load ?

Clockwise moments = 120 N x 2 m

Anticlockwise moments = effort x 6m

In equilibrium;

clockwise moments = anti-clockwise moments

120 x 2 = effort x 6

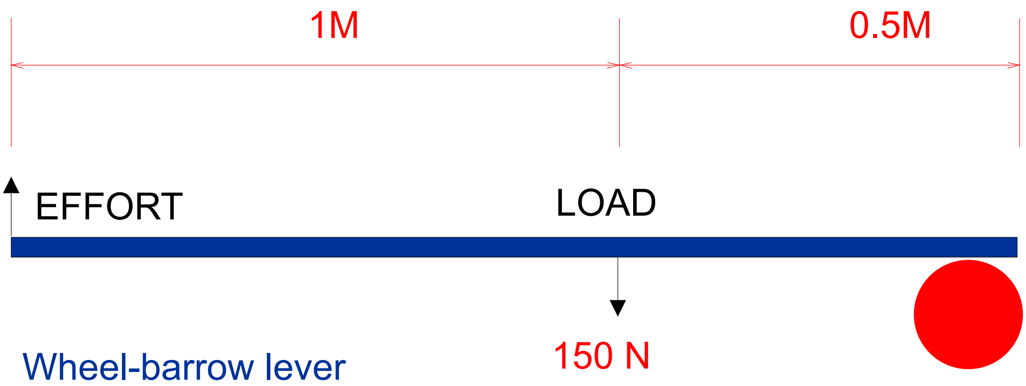
$$\text{effort} = \frac{120 \times 2}{6}$$

$$\text{effort} = \frac{240}{6}$$

$$= 40 \text{ N}$$

An effort of over **40 N** is required to move the load.

4. A wheel-barrow is used to lift a load of 150N. The wheel acts as the fulcrum. Calculate the effort required.



Clockwise moments = 150 N x .5 m

Anticlockwise moments = effort x 1.5m

In equilibrium;

clockwise moments = anti-clockwise moments

150 x .5 = effort x 1.5

$$\text{effort} = \frac{150 \times .5}{1.5}$$

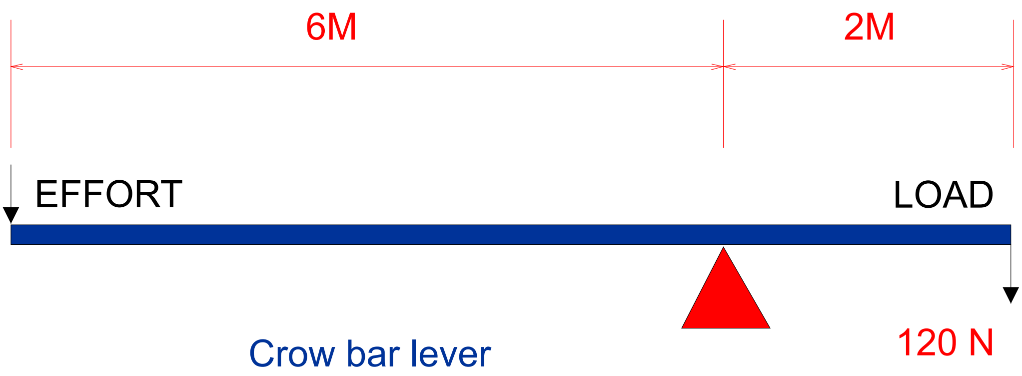
$$\text{effort} = \frac{75}{1.5}$$

$$= 50 \text{ N}$$

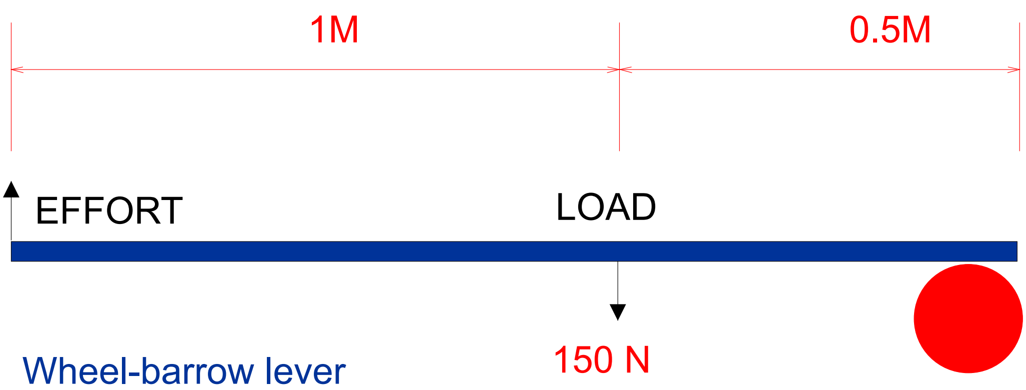
An effort of over **50 N** is required to lift the wheel-barrow.

EXAMPLE EXAMINATION QUESTIONS

3. Another crow-bar is used to lever a load of 120N. The load is 2m from the fulcrum and the effort is 6m from the fulcrum. What effort is required to move the load ?

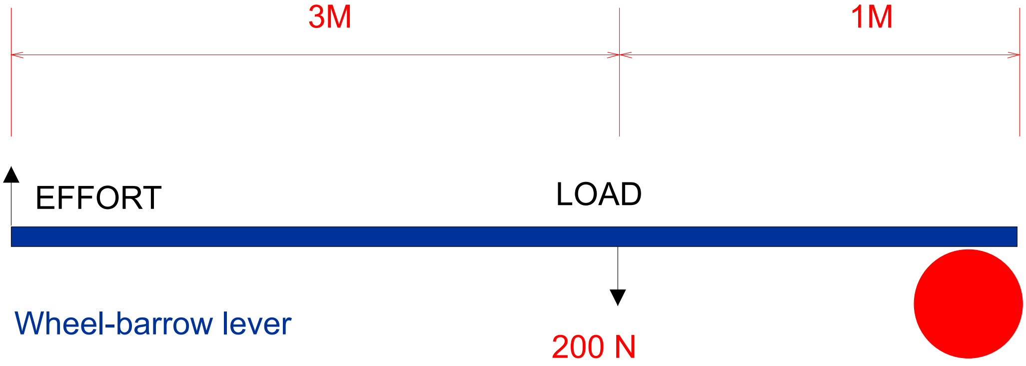


4. A wheel-barrow is used to lift a load of 150N. The wheel acts as the fulcrum. Calculate the effort required.



EXAMPLE EXAMINATION QUESTIONS AND ANSWERS

5. A wheel-barrow is used to lift a load of 200N. The wheel acts as the fulcrum. Calculate the effort required.



Clockwise moments = 200 N x 1 m

Anticlockwise moments = effort x 4m

In equilibrium;

clockwise moments = anti-clockwise moments

200 x 1 = effort x 4

$$\text{effort} = \frac{200 \times 1}{4}$$

$$\text{effort} = \frac{200}{4}$$

= 50 N

An effort of over **50 N** is required to lift the wheel-barrow.

6. A metal bar is used to lever a load of 150N. The load is 1m from the fulcrum and the effort is 5m from the fulcrum. What effort is required to move the load ?

Steel bar lever

Clockwise moments = 150 N x 1 m

Anticlockwise moments = effort x 5m

In equilibrium;

clockwise moments = anti-clockwise moments

150 x 1 = effort x 5

$$\text{effort} = \frac{150 \times 1}{5}$$

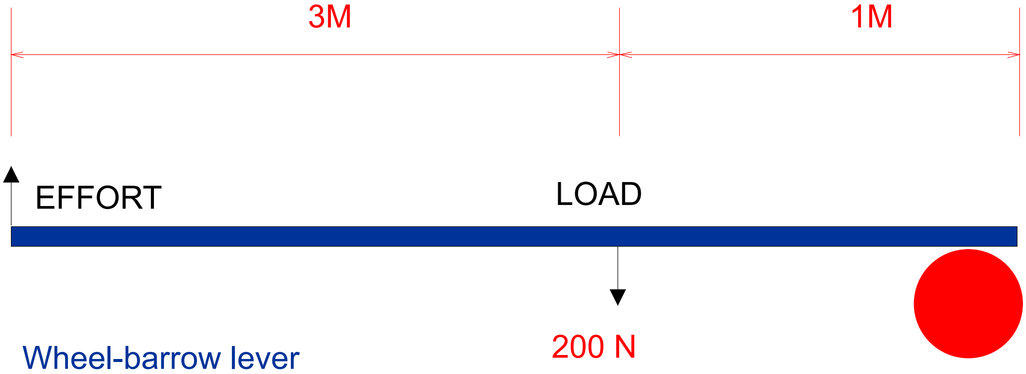
$$\text{effort} = \frac{150}{5}$$

= 30 N

An effort of over **40 N** is required to move the load.

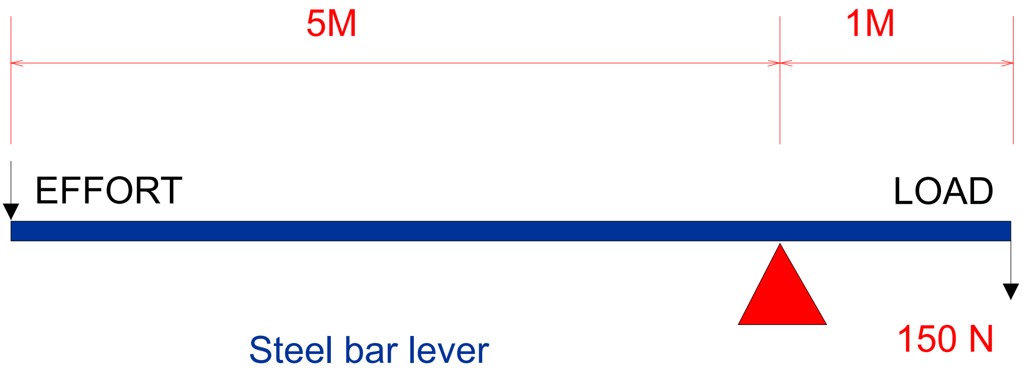
EXAMPLE EXAMINATION QUESTIONS

5. A wheel-barrow is used to lift a load of 200N. The wheel acts as the fulcrum. Calculate the effort required.



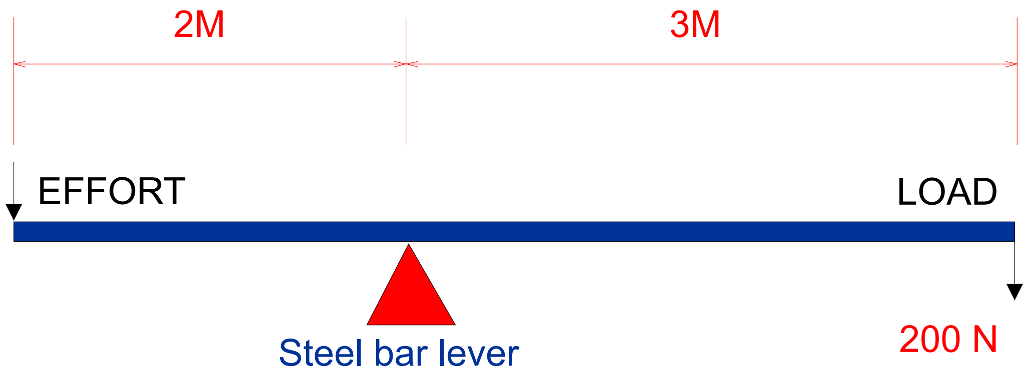
Wheel-barrow lever

6. A metal bar is used to lever a load of 150N. The load is 1m from the fulcrum and the effort is 5m from the fulcrum. What effort is required to move the load ?



Steel bar lever

7. Another metal bar is used to lever a load of 200N. The load is 3m from the fulcrum and the effort is 2m from the fulcrum. What effort is required to move the load ?



Clockwise moments = 200 N x 3 m

Anticlockwise moments = effort x 2m

In equilibrium;

clockwise moments = anti-clockwise moments

200 x 3 = effort x 2

$$\text{effort} = \frac{200 \times 3}{2}$$

$$\text{effort} = \frac{600}{2}$$

= 300 N

An effort of over **300 N** is required to move the load.

EXAMPLE EXAMINATION QUESTIONS

7. Another metal bar is used to lever a load of 200N. The load is 3m from the fulcrum and the effort is 2m from the fulcrum. What effort is required to move the load ?