FACTFILE:

GCSE Engineering and Manufacturing

3.3.5 Systems in Engineering and Manufacturing – Moments

Rewarding Learning

Systems in Engineering and Manufacturing – Moments

Learning outcomes

Students should be able to:

- perform calculations using the Principle of Moments: moment of a force = force × distance (M = f × d).

The turning effect of forces (known as moments) may be used every day, for example when using devices such as levers. In some situations, we need to prevent the turning effect of forces by balancing them with an opposing moment. Understanding the principles involved will allow us to both utilise and prevent the turning effect of forces.

What is a Moment?

A moment is the turning effect of a force around a fixed point called a pivot. For example, this could be a car door opening around a fixed hinge or a spanner turning around a fixed nut.

The size of a moment depends on two factors:

- the size of the force applied; and
- the perpendicular distance from the pivot to the line of action of the force.

This is the reason why less force is needed to open a door at the side furthest from the hinge than at any point closer to the hinge. To push at the hinge side of the door requires more force to be exerted because the distance is smaller.

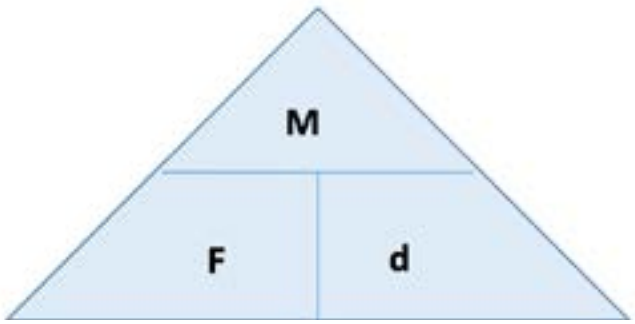
A moment can be calculated using this equation:

M = F × d

M = the moment of the force in newton metres, Nm

F = the force in newtons, N

d = the perpendicular distance from the line of action of the force to the pivot in metres, m



A motorist has a puncture and needs to replace the wheel. A force of 25 N is applied to the end of the spanner, which is 40 cm away from the centre of the nut. Calculate the moment produced by the force.

M = F × d

- d = 40 cm = 0.40 m
- F = 25 N

- moment = force × perpendicular distance
- moment = 25 N × 0.40 = 10 Nm

Balancing moments

Where an object is not turning around a pivot, the total clockwise moment must be exactly balanced by the total anticlockwise moment. The opposing moments are balanced:

sum of the clockwise moments = sum of the anticlockwise moments

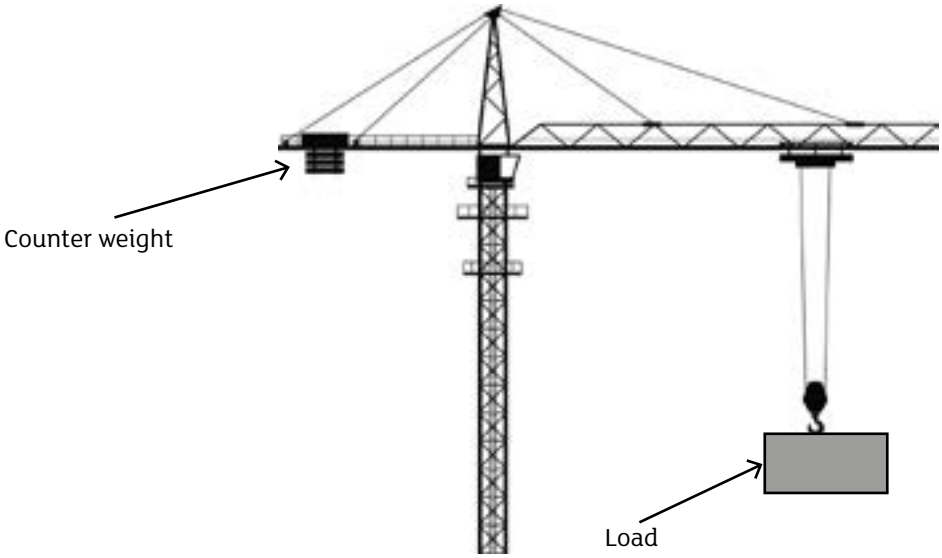
A see-saw has a pivot in the middle:

- the object on the right exerts a force downward – which causes a clockwise moment
- the object on the left exerts a force downward – which causes an anticlockwise moment

If the objects have identical weights and are placed identical distances from the pivot, the see-saw will balance. This is because the total clockwise moment is balanced by the total anticlockwise moment.

The see-saw can still be made to balance even if the objects have different weights. To do this, the object with the greater weight must be placed closer to the pivot. This reduces the size of the moment so the opposing moments are once again balanced.

Cranes used in construction to lift heavy building materials use a horizontal arm called a jib. To prevent the crane toppling over, concrete blocks are attached to the other end of the jib. They act as a counter-weight to create a moment that opposes the moment due to the load.



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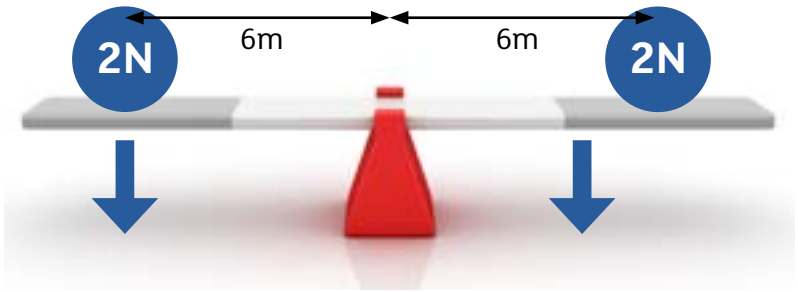
The principle of moments states that when in equilibrium the total sum of the anticlockwise moment is equal to the total sum of the clockwise moment. When a system is stable or balanced it is said to be in equilibrium as all the forces acting on the system cancel each other out.



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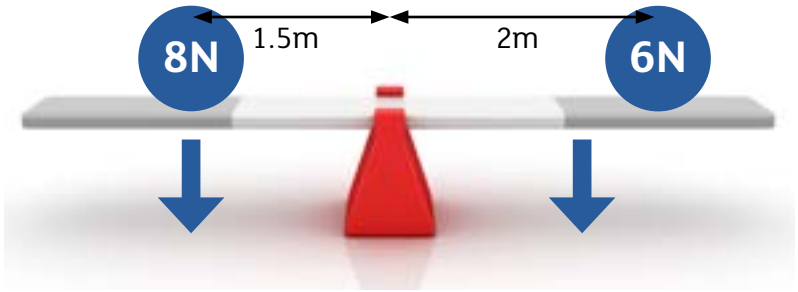
This equilibrium can also be achieved with differing loads by placing them at differing distances from the pivot. This is illustrated in the diagram below.



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Revision Questions

1. The moment of a force causes an object to:
   - A Move forward;
   - B Move backward;
   - C Turn about a fixed point;
   - D Or, stop moving.

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2. The turning effect of a force on a door is greater when applied at:
   - A A point near the hinges parallel to the door;
   - B A point far away from the hinges parallel to the door;
   - C A point near the hinges perpendicular to the door;
   - D Or, A point far away from the hinges perpendicular to the door.

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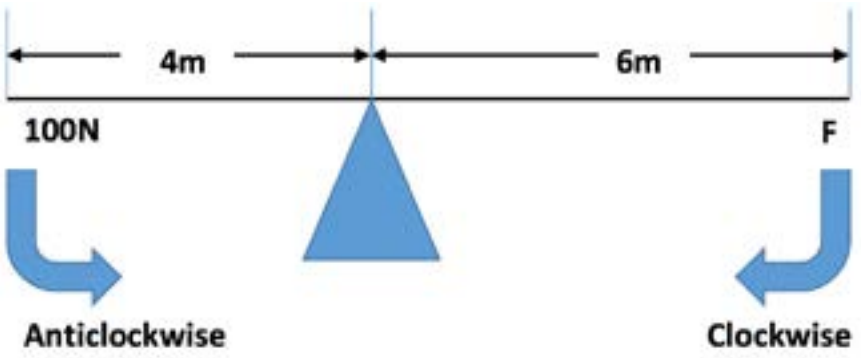
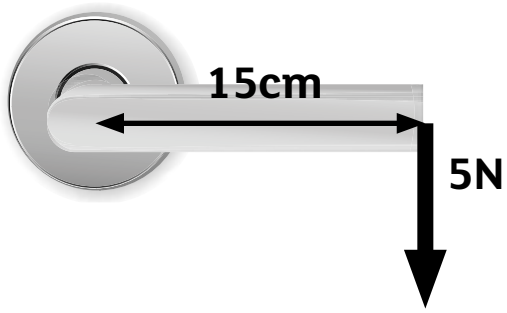
3. In the diagram below, a plank is supported by a pivot. Two forces, 100 N and F are acting on the plank. Given that the plank is perfectly balanced (has rotational equilibrium), calculate F.



4. What is the size of the moment if a force of 5 N is applied to a door handle with a length of 15 cm?



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5. A see-saw is balanced on a pivot with two children on it. The boy is sitting 1.5 m to the left of the pivot and has a mass of 50 kg. His younger sister has a mass of 30 kg and is sitting on the right hand side of the pivot. What distance away from the pivot is the girl?

   A 30 cm

   B 1.5 m

   C 2.5 m

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6. What is the force that creates a moment of 10 Nm when it is applied 0.25 m from the pivot?

   A 30 N

   B 40 N

   C 50 N

   D 60 N

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7. If the point of application of the force was moved further away from the pivot, what would be the effect on the moment?

   A The moment would be greater because the distance is greater,

   B The moment would remain the same because the force hasn't changed,

   C Or the moment would be smaller because it is further away and therefore having less effect on the pivot.

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8. A plank of wood is balanced on a pivot. A load weighing 10 kg is then placed 1 m to the left of the pivot on the wood. What weight needs to be placed 0.5 m to the right of the pivot for the wood to still be balanced?

   A 10 kg

   B 20 kg

   C 10 N

   D 200 N

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Additional Resources

http://physicsnet.co.uk/a-level-physics-as-a2/mechanics/moments/

http://www.passmyexams.co.uk/GCSE/physics/turning-effect-forces.html

http://www.s-cool.co.uk/

https://www.miniphysics.com

https://youtu.be/bsb67yG6sBQ

https://www.youtube.com/watch?v=UoCWHoHR8IU

https://www.youtube.com/watch?v=yhrR4384SGE