

# Turning effects of forces

## Equilibrium

### Centre of mass

Turning effect ( moment of a force):

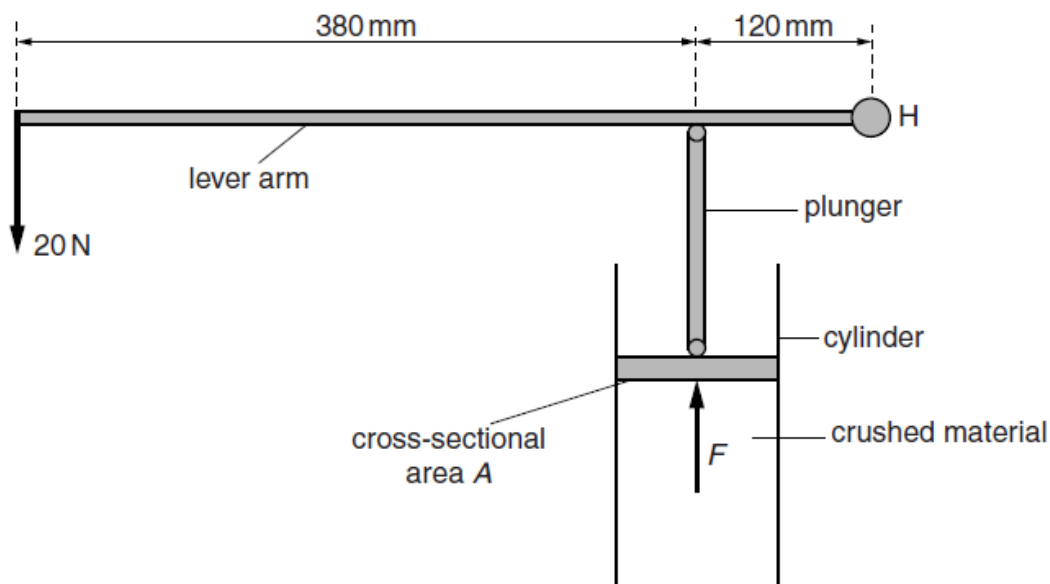
**Definition:** The turning effect of a force is termed as the moment of a force.  
Moment of a force= Force X perpendicular distance from the pivot

Unit: Nm

Clockwise moment and anti-clockwise moment:

Following is a device used for compressing crushed material:

lockwise moment



The lever arm rotates about the hinge H at its right-hand end. A force of 20 N acts downwards on the left-hand end of the lever arm. The force  $F$  of the crushed material on the plunger acts upwards. Ignore the weight of the lever arm.

Two types of moments are present about point H:

- **Clockwise moment:** It is moment that causes the lever arm to turn in the clockwise direction.

Clockwise moment is caused by the crushed material at F.

- **Anticlockwise moment:** It is moment that causes the lever arm to turn in the anti-clockwise direction. In this case it is caused by the 20N weight.

In this example:

Clockwise moment = anticlockwise moment

$$20 \times 500 = F \times 120$$

$$F = 83.3\text{N}$$

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**Pivot ( Fulcrum):** The point about which the object rotates is called as the pivot or the fulcrum.

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**For an object in equilibrium:**

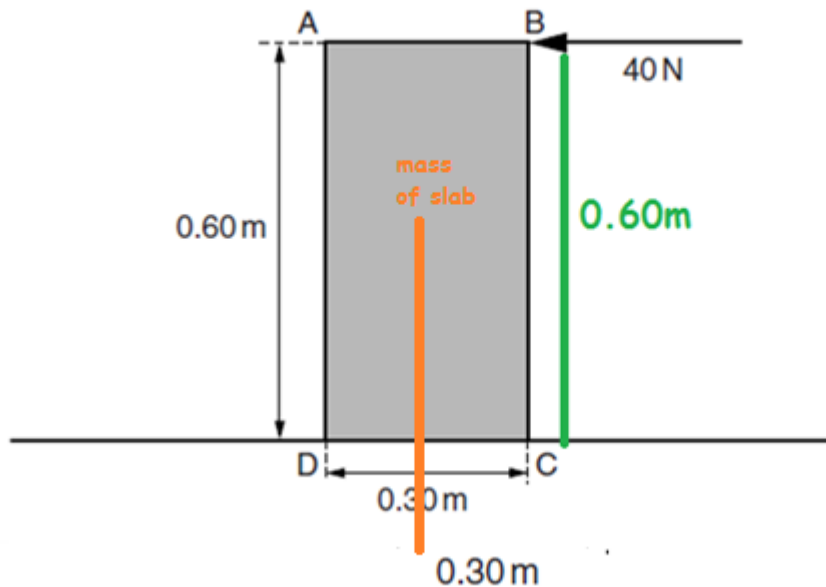
- There is no resulting turning effect (Clockwise moment = anticlockwise moment)
- There is no resultant force.

**Principle of moments:**

For an object in equilibrium, the sum of the clockwise moments about any point is equal to the sum of the anticlockwise moment about the same point.

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**Example:**



**The moment of 40N force about the point D**  $= 40 \times 0.60 = 24\text{Nm}$  ( ACM)

Suppose the weight of slab  $W=180\text{N}$ .

**Then the moment due to W about point D**  $= 180 \times 0.30 = 27\text{Nm}$  (CM).

Suppose the ground is rough and the slab does not slide. But if the horizontal force at B is gradually increased, the corner C lifts from the ground because anticlockwise moment becomes greater than the clockwise moment.

**Note:**

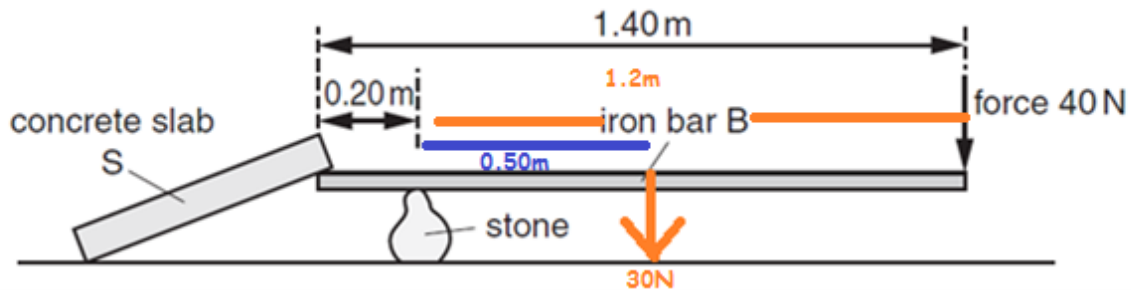
ACM= Anticlockwise moment

CM= Clockwise moment



## Moment of a force when the weight of the bar is not considered negligible

Fig. 3.1 shows a uniform iron bar B of weight 30N and length 1.40m. The bar is being used to lift one edge of a concrete slab S. A stone, placed 0.20m from one end of B, acts as a pivot. A force of 40N pushing down at the other end of B is just enough to lift the slab and hold it as shown.



- The weight of the bar acts through the center of the mass. ( at a distance of 0.70m from the corner of the bar and at 0.50m from the stone) as shown by the orange arrow.

- **Clockwise moment on the bar B:**

Due to the weight of the bar + Due to the 40N force

$$\Rightarrow (30 \times 0.50) + (40 \times 1.2) = 63 \text{ Nm}$$

Note here how the perpendicular distance is calculated.

- **Slab S exerts a downward force on the bar B**

$$\Rightarrow F \times 0.2 = 63$$

$$F \Rightarrow \frac{63}{0.2} = 315 \text{ N}$$

- We can reduce the force needed to lift the slab by: moving the pivot (stone) to the left.

## Uses of moment of a force:

Man-made devices in everyday use that depend upon their action on the moment of a force.

- Spanners
- Scissors
- Taps
- Nut crackers
- Sea-saw

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A uniform rod AB is acted upon by three equal forces but the rod is not in equilibrium because:

- There is a resultant force. (Example: there may be more force up than down)
- There is a resultant moment. (Clockwise moment is not equal to the anticlockwise moment.)

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Suppose two forces act on an object. Then it is impossible for an object to be in equilibrium if both the forces act in the same direction.  
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**[Please refer to the mark-schemes available online based on the question details given below]**

3 (a) Complete the following statement.

F/M15-P32

An object is in equilibrium when both the ..... and the ..... on the object are zero. [2]

(b) Fig. 3.1 shows a ladder AB. End A of the ladder rests against a vertical wall. End B rests on rough ground.

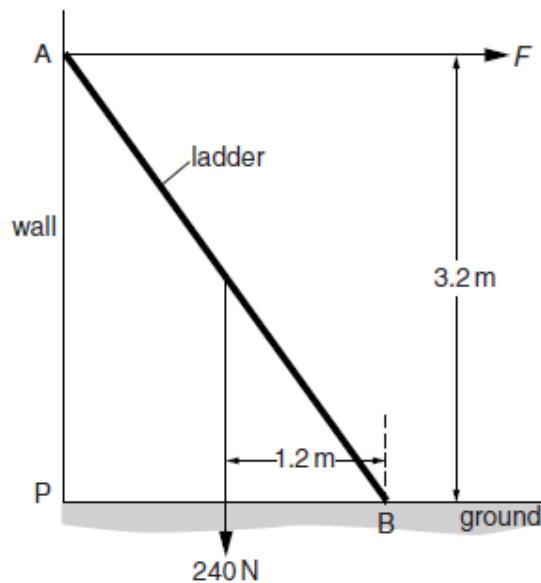


Fig. 3.1

Fig. 3.1 shows two of the forces acting on the ladder. The only force on the ladder at A is  $F$ , which acts at right-angles to the wall. The weight of the ladder is 240 N acting at the centre of mass of the ladder.

(i) 1. Calculate the moment of the weight of the ladder about point B.

moment = ..... [1]

2. Write an expression, in terms of  $F$ , for the moment of  $F$  about point B.

moment = ..... [1]

(ii) Use your answers from (i) to calculate  $F$ .

$F =$  ..... [2]

2 Fig. 2.1 shows apparatus for investigating moments of forces.

O/N/05-P3

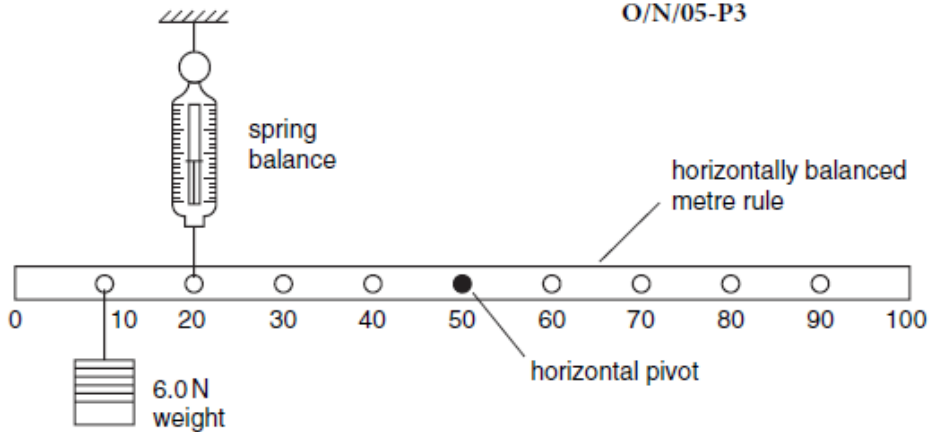


Fig. 2.1

The uniform metre rule shown in Fig. 2.1 is in equilibrium.

(a) Write down two conditions for the metre rule to be in equilibrium.

condition 1 .....

.....

.....

condition 2 .....

.....

..... [2]

(b) Show that the value of the reading on the spring balance is 8.0 N. [2]

(c) The weight of the uniform metre rule is 1.5 N.

Calculate the force exerted by the pivot on the metre rule.

magnitude of force = .....

direction of force ..... [2]

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- 3 (a) A uniform metre rule is pivoted at its centre, which is also the position of its centre of mass.

Three loads, 2.0 N,  $F$  and 3.0 N are positioned on the rule at the 20 cm, 30 cm and 90 cm marks respectively, as shown in Fig. 3.1.

O/N/10-P32

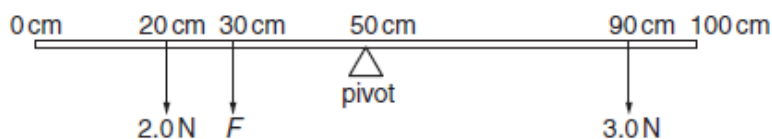


Fig. 3.1

- (i) Calculate the moment of the 3.0 N load about the pivot.

moment = ..... [1]

- (ii) Calculate the moment of the 2.0 N load about the pivot.

moment = ..... [1]

- (iii) The force  $F$  maintains the metre rule in equilibrium on the pivot.

Calculate the value of  $F$ .

$F =$  ..... [3]

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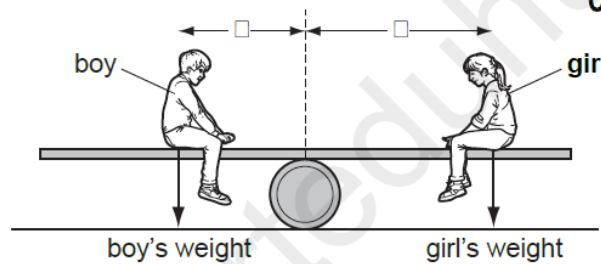


**APPLICATION BASED QUESTIONS-MCQ:**

11 A see-saw is made by resting a long plank of wood with its centre of mass on a barrel.

A boy sits on one side of the barrel and a girl sits on the other side so that the see-saw is balanced.

0625/12/O/N/12



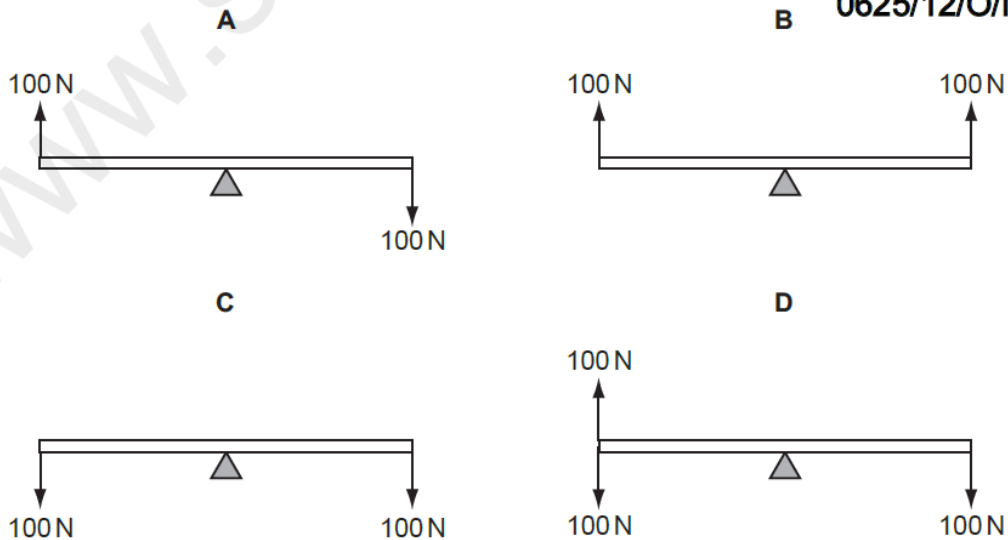
Which statement **must** be true?

- A boy's weight = girl's weight
- B distance  $x$  = distance  $y$
- C total downward force = total moment about the barrel
- D resultant force and resultant moment are both zero

9 A uniform rod rests on a pivot at its centre. The rod is not attached to the pivot. Forces are then applied to the rod in four different ways, as shown. The weight of the rod can be ignored.

Which diagram shows the rod in equilibrium?

0625/12/O/N/11



7 Two forces act on an object.

0625/01/M/J/06

In which situation is it **impossible** for the object to be in equilibrium?

- A The two forces act in the same direction.
- B The two forces act through the same point.
- C The two forces are of the same type.
- D The two forces are the same size.

8 What are the conditions for equilibrium?

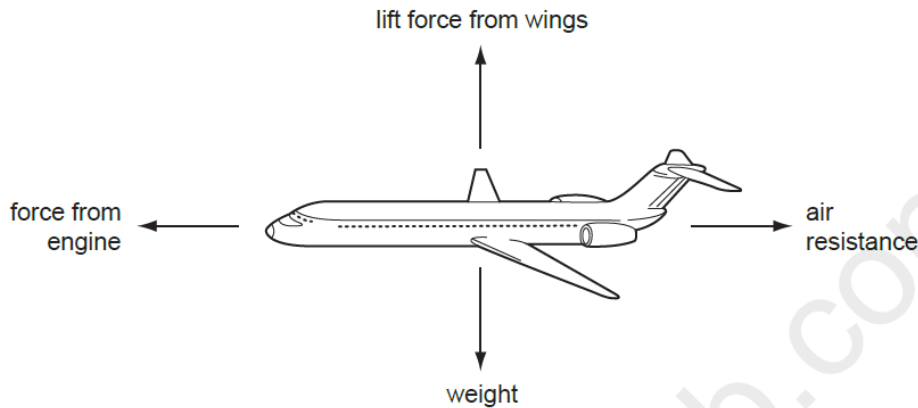
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	resultant force acting	resultant turning effect acting
A	yes	yes
B	yes	no
C	no	yes
D	no	no

9 An aeroplane is in equilibrium.

0625/01/O/N/07

The diagram shows the forces acting on the aeroplane.



Which statement about the forces is correct?

	force from engine	lift force from wings
A	equal to air resistance	equal to weight
B	equal to air resistance	greater than weight
C	greater than air resistance	equal to weight
D	greater than air resistance	greater than weight