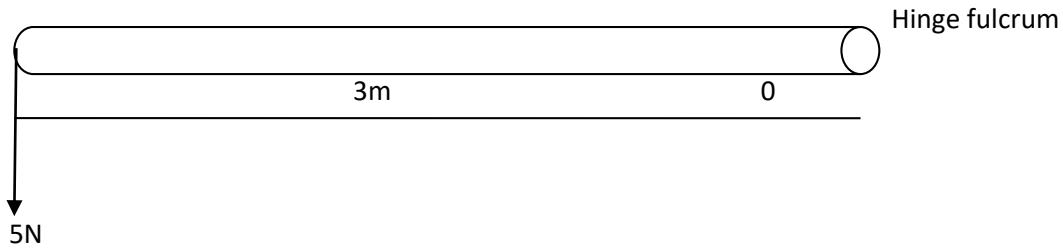
Moments

Moment of a force is also called turning reflect of a force.
Moment a force is a product of a force and the perpendicular distance of the line of action of the force from the fulcrum (pivot).

Moment of a force = Force x perpendicular distance of the line of action of the force from the fulcrum

The SI unit of moment is Newton metre (NM). Moment is a vector quality.



Calculate the moment of 5N

F = 5N d from fulcrum = 3m
Moment = F x d
= 5 x 3
= 15 Nm

Factors affecting moments

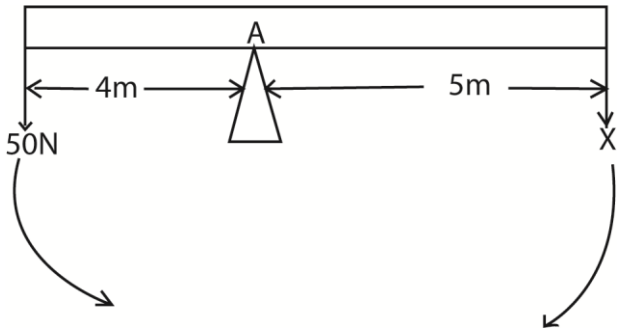
The moment of a force depends on:-
(i) The magnitude of a force
(ii) Perpendicular distance from the fulcrum

Law/Principle of moment

This states that when a body is in a state of equilibrium the sum of clockwise moments about any points is equal to the sum of anticlockwise moments about the point.

Sum of anti-clockwise moments about any point = Sum of clockwise moments about the point.

Example 2
Find the value of X in the figure below



Taking moment about A

Clockwise moments = 5 x x

Anticlockwise moments =50 x 4 = 200N

And by law of moment:

Sum of clockwise moments = Sum of anti-clockwise moment about any point

5x=200

5/5x =200/5

X = 40N

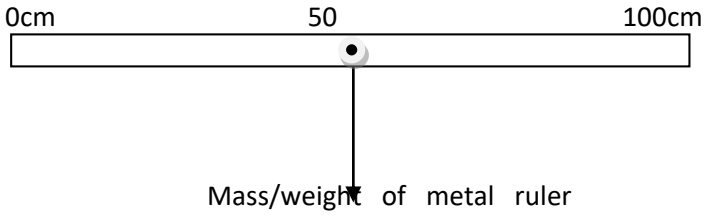
From the above it can be noted that it is easier to close the door by pushing it at a point as far away from the hinges as possible. Because the force applied can easily balance with the reaction at the hinges.

Note: When calculating moments about a point (pivot) all distances should be measured from that point

Finding the mass/weight of uniform body

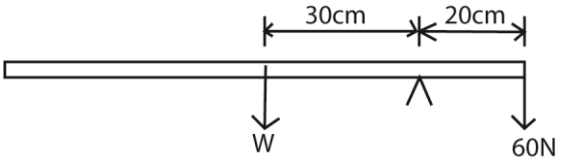
When a body is uniform, the mass or weight must act at the centre.

For a uniform metre rule the centre at which the mass of the metre rule must act is 50cm mark.



A metre rule is marked from 0-100cm mark. Its mass/weight must act in the middle which is 50cm mark. The mass or weight is calculated by applying the principle of moment.

Example 3



Find the weight W, of a uniform metre rule if a force of 60N at one end balances it as shown in the above figure

From the principle of moments

30 x w = 60 x 20

w = 40N

Example 4

Figure below shows a uniform metre rule of mass 0.1kg pivoted at the 80 cm mark. It balances horizontally when a mass P is hang at the 95 cm mark. Find the value of P.

Take moments about the pivot

Mass a ruler = 0.1kg acts at 50cm mark

So 0.1 x (80 -50) = P x (95 – 80)

P = $\frac{0.1\ x\ 30}{15} = 0.2kg$

Condition for a body in equilibrium

When a number of parallel forces are in equilibrium;

i) the sum of the forces in one direction is equal to the sum of the forces in the opposite direction,

ii) the sum; of the anticlockwise moments about any point is equal to the sum of the clockwise moments about the point

Center of gravity

This is a point where the resultant force of attraction of a body acts

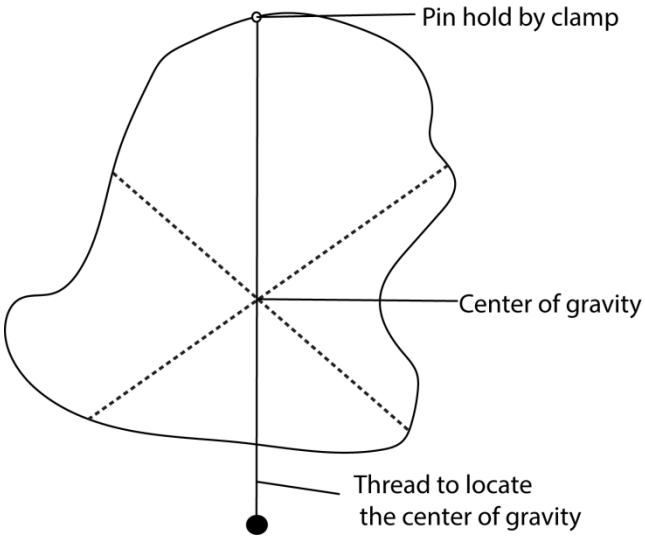
Center of gravity of regular object

For regular shape bodies, the center of gravity is at the geometric center of the body e.g. the center of gravity of a Uniform meter ruler is at 50cm mark, for circle, it is at the center. For a rectangular and square body it is at the point of intersection of the diagonals.

Irregular body

The best way of finding the center of gravity of an irregular object is by use a plumb line. A plumb line is made from a thread of cotton with a loop at one end and a weight tied at other end.

For a irregular card board for instance, three small holes are made at well-shaped intervals around the edge of the card



A pin is then put through one of the holes and firmly by a clamp and stand so that the card board swings on it.

The card board will come to rest with its center of gravity below the point of support along the vertical line of plumb line.

The cardboard is hung through another hole, the point of interception of the two vertical lines is the center of gravity.

Factors that affect stability

1. The position of center of gravity, should be low.
2. Width of the base: the wider the width of the base, the more stable the body is.

Way of increasing stability

1. Increasing the base area
2. Lowering the center of gravity

Application of center of gravity

1. cars have very heavy framed to lower center of gravity
2. Racing cars have wide wheel base to lower center of gravity.

Couples

Couples are equal and opposite parallel forces.
Moment of couple = one of the forces x perpendicular distance between them.
A couple can only produce a rotation because it is not possible to find a single force to replace a couple as it can only be balanced by an equal and opposite couple.

Stability

There are three terms used in connection with stability:
(a).Stable equilibrium.
(b). Unstable equilibrium.

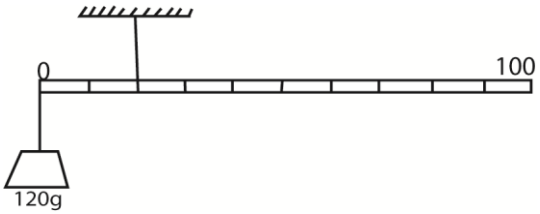
(c). Neutral equilibrium.

Stable equilibrium
If the body in stable equilibrium is slightly displaced, the centre of gravity of the body is raised. And when released, the body returns to its original position.

Unstable equilibrium
If the body in unstable equilibrium is slightly displaced, the centre of gravity of the body is lowered. And when released, the body moves farther away from its original position.

Neutral equilibrium:
If the body in neutral equilibrium is slightly displaced, the centre of gravity of the body is not raised or lowered. And when released, the body stays in its new position.

Exercise

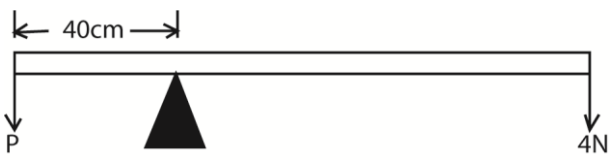
1. 

A uniform metre rule is suspended with a string at the 20cm mark and is kept horizontal by a mass of 120kg from one end as shown above. Find the mass of the metre rule

A. 80g B. 30g C. 24g D. 120g

2. A bus carrying a heavy load on its rack is more unstable when moving because
   A. its centre of gravity is raised B. the friction on the ground increases
   C. its total weight is increased D. the pressure on the tyres is increased

3. When a body in stable equilibrium is tilted slightly
   A. the position of its centre of gravity is lowered
   B. the position of its centre of gravity is raised
   C. the position of its centre of gravity doesn't change
   D. it topples over

4. 

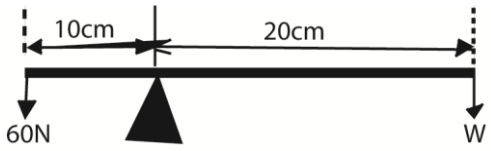
A uniform metre rule of weight 2N is pivoted at the 40cm mark. Find the value of the force, P required to keep the metre rule in equilibrium if a force of 4N acts at the end of the metre rule as in the diagram above

A. 2.5N B. 5.5N C. 6N D. 6.5N

5. A uniform metre rule pivoted at the 25cm mark balances when a mass of 0.15kg is hung at the 8cm mark. Calculate the mass of the metre rule
   A. 0.020kg B. 0.048kg C. 0.102kg D. 1.020kg

6. The stability of a bus is reduced when a heavy load is placed on its root rack because
   A. the total weight is increased
   B. the pressure upon the tyres is increased
   C. the maximum speed is reduced
   D. the centre of gravity is raised

7.



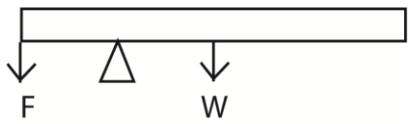
Two weights are balanced on a rule of negligible mass as shown above. What is the value of W?

A. 2.5N B. 10N C. 30N D. 60N

8. (a) What is meant by
   (i) center of gravity

   (ii) moment of force

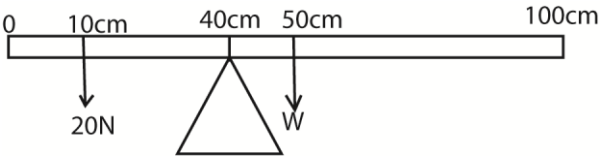
(b)



The figure above shows a uniform rod of length 4.0m pivoted at 1.0m from one end. If the weight of the rod is 120N, find the force F which keep the rod horizontal. (02marks)

9. (a) (i) Define moment of a force.
   (ii) State the principle of moments.

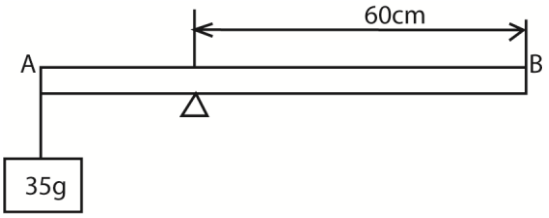
(b)



A uniform meter ruler is pivoted at the 40 cm mark as shown in the figure above. The meter ruler is the equilibrium under its weight W and a 20 N force acting at the 10 cm mark. Calculate W.

10. (a) State the principle of moments

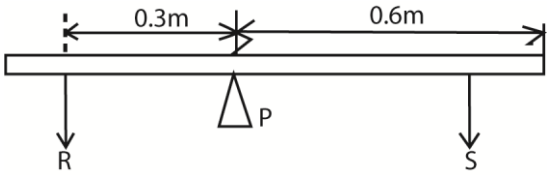
(b)



The figure, a uniform metre rule AB balances at F when the mass at A is 35g. Calculate the mass of the meter rule

11. (a) State the principle of moments.

(b) A uniform beam of weight 2.5 N is pivoted at its mid-point P, as shown in figure blow. the beam remains in equilibrium when force R and S act on it. If R is 5N,



Find the:

(i) value of S.

(ii) reaction at the pivot.

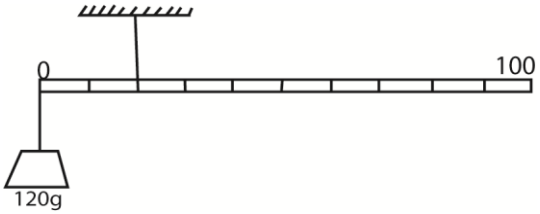
12. (a) (i) State the principle of moments.

(ii) State the conditions for a body to be in equilibrium

(b) What is meant by centre of gravity?

Suggested answers

1.



A uniform metre rule is suspended with a string at the 20cm mark and is kept horizontal by a mass of 120kg from one end as shown above. Find the mass of the metre rule

A. 80g B. 30g C. 24g D. 120g

Taking moments at 20cm mark

120 x 20 = M x (50 – 30)

M = $\frac{120\ x\ 20}{30}$= 80g

2. A bus carrying a heavy load on its rack is more unstable when moving because

A. its centre of gravity is raised B. the friction on the ground increases

C. its total weight is increased D. the pressure on the tyres is increased

3. When a body in stable equilibrium is tilted slightly

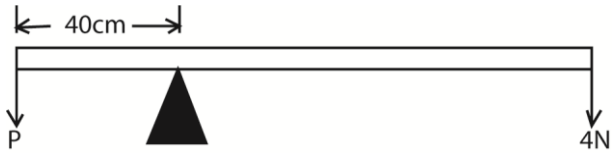
A. the position of its centre of gravity is lowered

B. the position of its centre of gravity is raised

C. the position of its centre of gravity doesn't change

D. it topples over

4.



A uniform metre rule of weight 2N is pivoted at the 40cm mark. Find the value of the force, P required to keep the metre rule in equilibrium if a force of 4N acts at the end of the metre rule as in the diagram above

A. 2.5N B. 5.5N **C.** 6N D. 6.5N

Taking moments at the pivot

P x 40 = 4 x 60

P = 6N

5. A uniform metre rule pivoted at the 25cm mark balances when a mass of 0.15kg is hung at the 8cm mark. Calculate the mass of the metre rule

A. 0.020kg B. 0.048kg **C.** 0.102kg D. 1.020kg

Taking moments at the pivot

0.15 x (25 – 8) = M x (50 – 25)

M = 0.102kg

6. The stability of a bus is reduced when a heavy load is placed on its root rack because

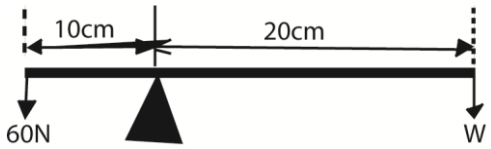
A. the total weight is increased

B. the pressure upon the tyres is increased

C. the maximum speed is reduced

D. the centre of gravity is raised

7.



Two weights are balanced on a rule of negligible mass as shown above. What is the value of W?

A. 2.5N B. 10N **C.** 30N D. 60N

Taking moments at the pivot

60 x 10 = 20 x W

8. (a) What is meant by

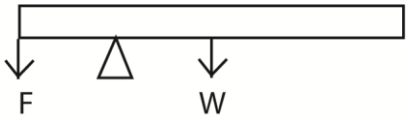
(i) center of gravity

It the point where the resultant weight of a body acts or it is the point of application of the resultant force due to the Earth's attraction on the body.

(ii) moment of force

It is a product of force and the perpendicular distance of its line of action from the turning point.

(b)



The figure above shows a uniform rod of length 4.0m pivoted at 1.0m from one end. If the weight of the rod is 120N, find the force F which keep the rod horizontal. (02marks)

Anticlockwise moment = clockwise moment

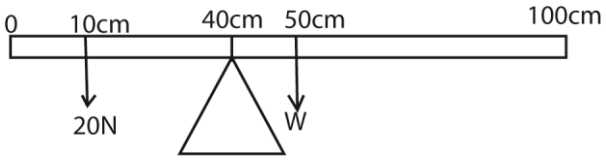
F x 1 = 120 x 1

F = 120N

9. (a) (i) Define moment of a force.
Moment of force is a product of force and the perpendicular distance of its linear action from the fulcrum
(ii) State the principle of moments.

When a body is in equilibrium, the sum of clockwise moments about a point is equal to sum of anticlockwise moments

(b)



A uniform meter ruler is pivoted at the 40 cm mark as shown in the figure above. The meter ruler is the equilibrium under its weight W and a 20 N force acting at the 10 cm mark. Calculate W.

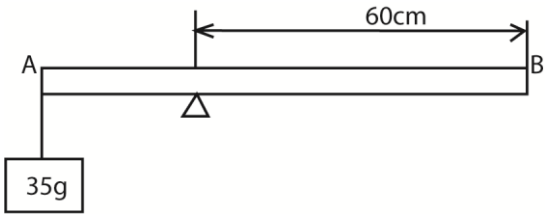
Taking moments

20 x (40 – 10) = W x (50 – 40)

W = 60N

10. (a) State the principle of moments
When a body is in equilibrium, the sum of clockwise moments about a point is equal to sum of anticlockwise moments

(b)



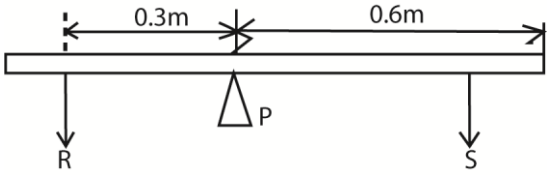
The figure, a uniform metre rule AB balances at F when the mass at A is 35g. Calculate the mass of the meter rule

35 x 40 = m x (50 – 40)

m = 140g

11. (a) State the principle of moments.
When a body is in equilibrium, the sum of anticlockwise moments a bout a point is equal to the sum of clockwise mementum about the same

(b) A uniform beam of weight 2.5 N is pivoted at its mid-point P, as shown in figure blow. the beam remains in equilibrium when force R and S act on it. If R is 5N,



Find the:

(i) value of S.

5 x 0.3 = S x 0.6

S= $\frac{5\ x\ 0.3}{0.6} = 2.5N$

(ii) reaction at the pivot.

Upward force = downwards force

R = 5 + 2.5 + 2.5 = 10N

12. (a) (i) State the principle of moments.
When a body is in equilibrium, the sum of anticlockwise moments a bout a point is equal to the sum of clockwise mementum about the same

(ii) State the conditions for a body to be in equilibrium

When a body is in equilibrium, the sum of clockwise moments about a point is equal to sum of anticlockwise moments

(b) What is meant by centre of gravity?

It the point where the resultant weight of a body acts or it is the point of application of the resultant force due to the Earth's attraction on the body.