CLASS X CHAPTER 1: FORCE

SECTION A (Moment of a force and equilibrium)

Translatory Motion

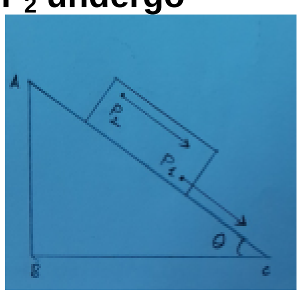
A type of motion in which all parts of the body move the same distance in a given time is known as the translatory motion. Translatory motion can be of two types: rectilinear and curvilinear.

If a body moves as a whole such that every part of the body moves through the same distance in a given time, then the body is said to be in translatory motion. Given below in a table is the difference between rectilinear and curvilinear translatory motion, for your better understanding.

Translatory Motion Examples

Let us understand translational motion with the help of examples.

- **Let's imagine a rectangular block placed on the slanting edge of a right-angled triangle. If the block is assumed to slide down this edge without any side movement, every point in the rectangular block experiences the same displacement and more importantly, the distance between the points is also maintained. In pure translational motion, every point in the body experiences the same velocity be it at any instant of time. Both the points, P_1 and P_2 undergo the exact same motions.**

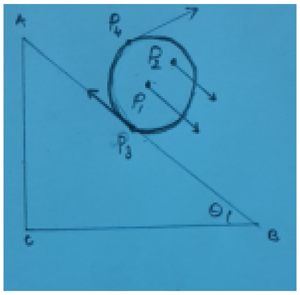


A rectangular block sliding down the slanting edge of a right-angled triangle covers equal distance in equal intervals of time.

- **A car moving in a straight line, the path of a bullet out of a gun etc are examples of translational motion.**

Rotational Motion

Now let us imagine a circular block going down the edge of the right-angled triangle. Examining the location and orientation of different points on the cylindrical block will tell us something new. The points on the cylindrical body experience something much different than the rectangular block.



A circular block rolling down the slanting edge of a right-angled triangle experiences different magnitude of velocity in different directions.

As shown by the arrows in the diagram representing the velocity, each point experiences a different magnitude of velocity in a different direction. Here the points are arranged with respect to an axis of rotation. Rotation is what you achieve when you constrain a body and fix it along a straight line. This means that the body can only turn around the line, which is defined as rotational motion. Ceiling fan, a potter's wheel, a vehicle's wheel are all examples of rotational motion.

Say you go to a bowling alley, and throw the bowling ball towards the pins. If you notice closely, you will see that the ball is not just moving forwards i.e performing translational motion but it is also spinning on itself because of which you can spin and curve the entry of the ball; this motion is categorized as rotational motion. The motion of a rigid body which is not fixed or pivoted is either a pure translational motion or a combination of translational and rotational motion. Rigid bodies which are fixed/pivoted experience motion which is rotational

Exercise Ex. 1A

Solution 1

State the condition when on applying a force, the body has:
(a)the translational motion,
(b)the rotational motion.

Solution 1
(a)When the body is free to move it produces translational motion.
(b)When the body is pivoted at a point, it produces rotational motion.

Question 2
Define moment of force and state its S.I. unit.

Solution 2
The moment of force is equal to the product of the magnitude of the force and the perpendicular distance of the line of action of force from the axis of rotation.
S.I. unit of moment of force is Newton metre (Nm).

Question 3
State whether the moment of force is a scalar or vector quantity?

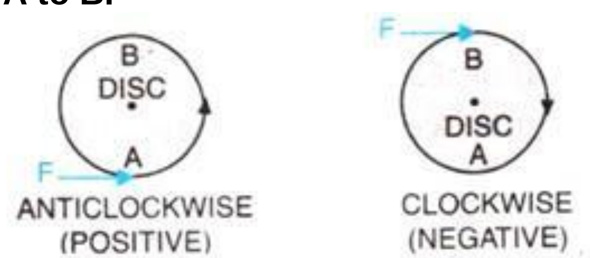
Solution 3
Moment of a force is a vector.

Question 4
State two factors affecting the turning effect of a force.

Solution 4
Moment of force about a point depends on the following two factors:
- **(a)The magnitude of the force applied and,**
- **(b)The distance of line of action of the force from the axis of rotation.**

Question 5
When does a body rotate? State one way to change the direction of rotation of a body. Give a suitable example to explain your answer.

Solution 5
When the body is pivoted at a point, the force applied on the body at a suitable point rotates the body about the axis passing through the pivoted point.
The direction of rotation can be changed by changing the point of application of force. The given figure shows the anticlockwise and clockwise moments produced in a disc pivoted at its centre by changing the point of application of force F from A to B.



Question 6
Write the expression for the moment of force about a given axis.

Solution 6
Moment of force about a given axis= Force x perpendicular distance of force from the axis of rotation.

Question 7
What do you understand by the clockwise and anticlockwise moment of force? When is it taken positive?

Solution 7
If the turning effect on the body is anticlockwise, moment of force is called anticlockwise moment and it is taken as positive while if the turning effect on the body is clockwise, moment of force is called clockwise moment and is taken negative.

Question 8
State one way to reduce the moment of a given force about a given axis of rotation.

Solution 8
Moment of force depends on the distance of line of action of the force from the axis of rotation. Decreasing the perpendicular distance from the axis reduces the moment of a given force.

Question 9
State one way to obtain a greater moment of a force about a given axis of rotation.

Solution 9
Moment of a force is the product of the force and the perpendicular distance of force from axis of rotation. So, one way to increase the moment would be to increase the distance from the axis of rotation where the force would act.

Question 10
Why is it easier to open a door by applying the force at the free end of it?

Solution 10
It is easier to open a door by applying the force at the free end of it because larger the perpendicular distance, less is the force needed to turn the body.

Question 11
The stone of hand flour grinder is provided with a handle near its rim. Give a reason.

Solution 11
The stone of hand flour grinder is provided with a handle near its rim so that it can be rotated easily about the iron pivot at its centre by a small force applied at the handle.

Question 12
It is easier to turn the steering wheel of a large diameter than that of a small diameter. Give reason.

Solution 12
It is easier to turn the steering wheel of a large diameter than that of a small diameter because less force is applied on steering of large diameter which is at a large distance from the centre of rim.

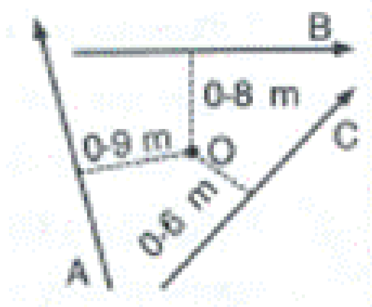
Question 13
A spanner (or wrench) has a long handle. Why?

Solution 13
A spanner (or wrench) has a long handle to produce larger turning moment so that nut can easily be turned with a less force.

Question 14
A jack screw is provided with a long arm. Explain why?

Solution 14
A jack screw has a long arm so that less effort is required to rotate it to raise or lower the jack, which is used to lift a heavy load like a vehicle.

Question 15
A, B and C are the three forces each of magnitude 4N acting in the plane of paper as shown in Figure. The point O lies in the same plane.



(i) Which force has the least moment about O? Give a reason.

(ii) Which force has the greatest moment about O? Give a reason.

(iii) Name the forces producing

(a) clockwise and

(b) anticlockwise moments.

(iv)What is the resultant torque about the point O?

Solutions:15

(i) As we know that,

Moment of force = Force × Perpendicular distance

Since vector C perpendicular distance is least from the point O

So, vector C will have least moment about O.

(ii) As we know that,

Moment of force = Force × Perpendicular distance

Since vector A perpendicular distance is greatest from the point O

So, vector A will have greatest moment about O.

(iii) (a) Clockwise moments are produced by vectors A and B.

Explanation: If the turning effect on the body is clockwise, moment of force is called clockwise moment and it is negative.

(b) Anticlockwise moment is produced by vector C

Explanation: If the turning effect on the body is anticlockwise, moment of force is called anticlockwise moment and it is positive.

(iv) Sum of torques due to vectors A, B and C = Resultant torque about point O

So,

Resultant torque about point O = – (4 × 0.9) – (4 × 0.8) + (4 × 0.6) Nm

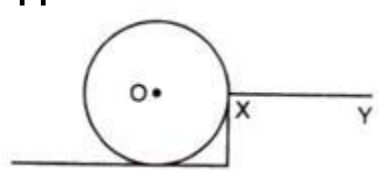
= – 3.6 – 3.2 + 2.4

= – 6.8 + 2.4

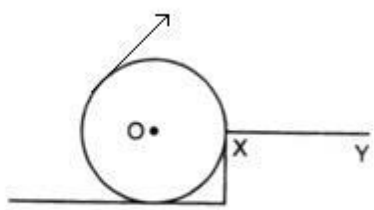
= – 4.4 Nm

Question 16

The adjacent diagram shows a heavy roller, with its axle at O, which is to be raised on a pavement XY. If there is friction between the roller and pavement, show by an arrow on the diagram the point of application and the direction of force to be applied.



Solution 16



Force F should be provided in the direction as shown in the diagram.

Question 17

A body is acted upon by two forces each of magnitude F, but in opposite directions. State the effect of the forces if

(a)both forces act at the same point of the body.

(b)the two forces act at two different points of the body at a separation r.

Solution 17

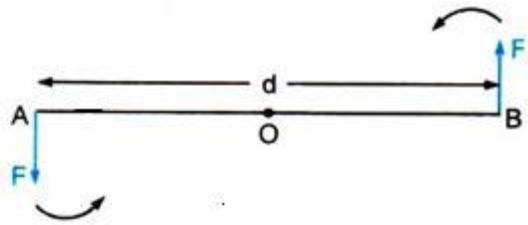
(a)Resultant force acting on the body = F-F=0 moment of forces = 0 i.e., no motion of the body

(b)The forces tend to rotate the body about the mid-point between two forces, Moment of forces= Fr

Question 18

Draw a neat labelled diagram to show the direction of two forces acting on a body to produce rotation in it. Also mark the point O about which the rotation takes place.

Solution 18



At A and B, two equal and opposite forces each of magnitude F are applied. The two forces rotate the bar in anticlockwise direction.

Question 19
What do you understand by the term couple? State its effect. Give two examples in our daily life where couple is applied to turn a body.

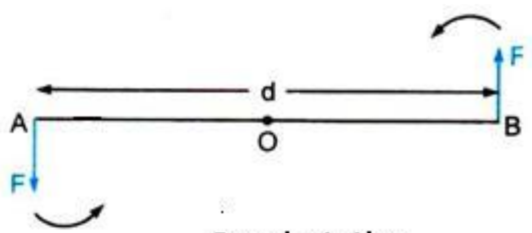
Solution 19
Two equal and opposite parallel forces not acting along the same line, form a couple. A couple is always needed to produce the rotation. For example, turning a key in a lock and turning a steering wheel.

Question 20
Define moment of a couple. Write its S.I unit.

Solution 20
The moment of a couple is equal to the product of the either force and the perpendicular distance between the line of action of both the forces. S.I unit of moment of couple is Nm.

Question 21
Prove that
Moment of couple = Force x Couple arm.

Solution 21



Couple Action

At A and B, two equal and opposite forces each of magnitude F are applied. The two forces rotate the bar in anticlockwise direction. The perpendicular distance between two forces is AB which is called the couple arm.
Moment of force F at the end A
= F x OA(anticlockwise)
Moment of force F at the end B
= F x OB(anticlockwise)
Total moment of couple =F x OA + F x OB

= F x (OA +OB)= F x AB
= F x d(anticlockwise)
=Either force x perpendicular distance between the two forces (or couple arm)
Thus, Moment of couple = Force x Couple arm

Question 22
What do you mean by equilibrium of a body?

Solution 22
When a number of forces acting on a body produce no change in its state of rest or of motion, the body is said to be in equilibrium.

Question 23
State the condition when a body is in (i) static, (ii) dynamic, equilibrium. Give one example each of static and dynamic equilibrium.

Solution 23

- **(i)When a body remains in the state of rest under the influence of the applied forces, the body is in static equilibrium. For example a book lying on a table is in static equilibrium.**
- **(ii)When a body remains in the same state of motion (translational or rotational), under the influence of the applied forces, the body is said to be in dynamic equilibrium. For example, a rain drop reaches the earth with a constant velocity is in dynamic equilibrium.**

Question 24
State two conditions for a body, acted upon by several forces to be in equilibrium.

Solution 24
For a body to be in equilibrium:

- **(i)The resultant of all the forces acting on the body should be equal to zero.**
- **(ii)The resultant moment of all the forces acting on the body about the point of rotation should be zero.**

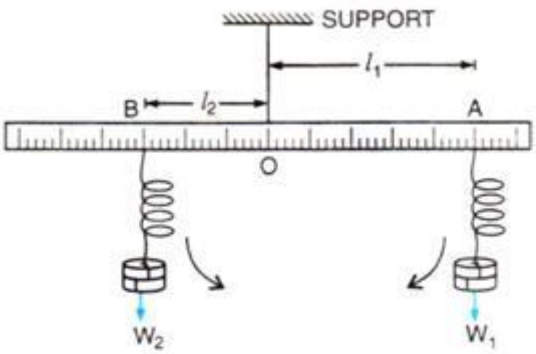
Question 25
State the principle of moments. Name one device based on it.

Solution 25
According to the principle of moments, if the algebraic sum of moments of all the forces acting on the body about the axis of rotation is zero, the body is in equilibrium. A physical balance (or beam balance) works on the principle of moments.

Question 26
Describe a simple experiment to verify the principle of moments, if you are supplied with a metre rule, a fulcrum and two springs with slotted weights.

Solution 26
Suspend a metre rule horizontally from a fixed support by means of a strong thread at O as shown. Now suspend two spring balances with some slotted

weights W_1 and W_2 on them on either side of the thread. The scale may tilt to one side. Now adjust the distances of two spring balances from the support by keeping one at A and the other at B in such a way that the scale again becomes horizontal.



Let the weight suspended on the right side of thread from the spring balance at A be W_1 at distance OA=l_1, while the weight suspended on the left side of thread from the spring balance at B be W_2 at distance OB= l_2.
The weight W_1 tends to turn the scale clockwise, while the weight W_2 tend to turn the scale anticlockwise.
Clockwise moment = $W_1 \times l_1$
Anticlockwise moment = $W_2 \times l_2$
In equilibrium, when the scale is horizontal, it is found that
Clockwise moment = Anticlockwise moment
i.e.,$W_1 \times l_1 = W_2 \times l_2$
This verifies the principle of moments.

Question 27
Complete the following sentences:
(i) The S.I. unit of moment of force is _________.
(ii) In equilibrium algebraic sum of moments of all forces about the point of rotation is ______________.
(iii) In a beam balance when the beam is balanced in a horizontal position, it is in ____________equilibrium.
(iv) The moon revolving around the earth is in ____________ equilibrium.

Solution 27
(i) The S.I. unit of moment of force is newton-metre.
(ii) In equilibrium algebraic sum of moments of all forces about the point of rotation is zero.
(iii) In a beam balance when the beam is balanced in a horizontal position, it is in static equilibrium.
(iv) The moon revolving around the earth is in dynamic equilibrium.

Question 28
The moment of a force about a given axis depends:

(a) Only on the magnitude of force

(b) Only on the perpendicular distance of force from the axis
(c) Neither on the force nor on the perpendicular distance of force from the axis
(d) Both on the force and its perpendicular distance from the axis.

Solution 28
The moment of a force about a given axis depends on both on the force and its perpendicular distance from the axis.

Hint: Moment of force = Force x Perpendicular distance

Question 29
A body is acted upon by two unequal forces in opposite directions, but not in same line. The effect is that
(a) The body will have only the rotational motion
(b) The body will have only the translational motion
(c) The body will have neither the rotational motion nor the translational motion
(d) The body will have rotational as well as translational motion.

Solution 29
The body will have rotational as well as translational motion.

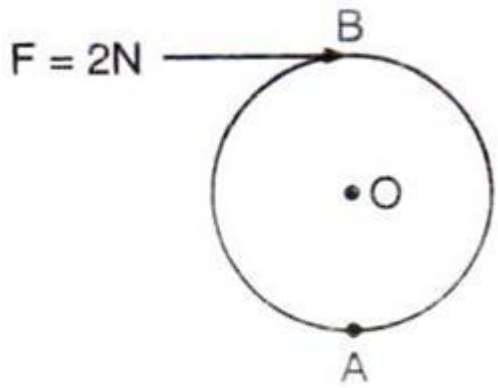
Question 30
The moment of a force of 10N about a fixed point O is 5Nm. Calculate the distance of the point O from the line of action of the force.

Solution 30
Moment of force= force x perpendicular distance of force from point O
Moment of force= F x r
5Nm= 10 x r
R= 5/10 =0.5 m

Question 31
A nut is opened by a wrench of length 10cm. If the least force required is 5.0N, find the moment of force needed to turn the nut.

Solution 31
Length, r=10cm =0.1m
F= 5N
Moment of force= F x r= 5 x 0.1= 0.5 Nm

Question 32
A wheel of diameter 2m is shown with axle at O. A force F = 2N is applied at B in the direction shown in figure. Calculate the moment of force about (i) the centre O, and (ii) the point A.



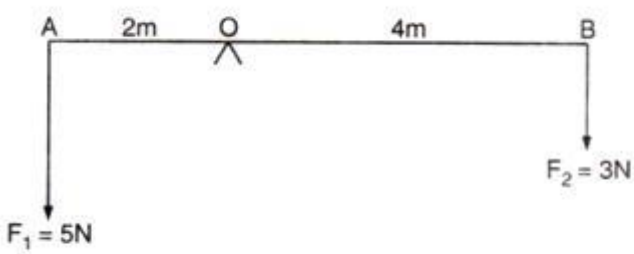
Solution 32
Given , F= 2N
Diameter=2m
Perpendicular distance between B and O =1m

(i)Moment of force at point O
= F x r
=2 x 1=2Nm (clockwise)

(ii)Moment of force at point A= F x r
=2 x 2=4Nm (clockwise)

Question 33
The diagram shows two forces F_1= 5N and F_2 = 3N acting at points A and B of a rod pivoted at a point O, such that OA = 2m and OB = 4m
Calculate:

(i) the moment of force F_1 about O.
(ii) the moment of force F_2 about O.
(iii) total moment of the two forces about O.



Solution 33
Given AO=2m and OB=4m

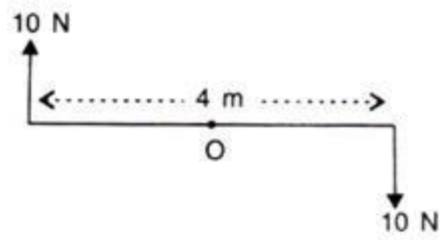
(i)Moment of force F_1(=5N) at A about the point O
=F_1 x OA
=5 x 2= 10Nm (anticlockwise)

(ii)Moment of force F_2(=3N) at B about the point O
= F_2 x OB
=3 x 4=12 Nm(clockwise)

(iii)Total moment of forces about the mid-point O=
= 12- 10=2Nm(clockwise)

Question 34

Two forces each of magnitude 10N act vertically upwards and downwards respectively at the two ends A and B of a uniform rod of length 4m which is pivoted at its mid-point O as shown. Determine the magnitude of resultant moment of forces about the pivot O.



Solution 34

Given, AB=4m hence, OA=2m and OB =2m

Moment of force F(=10N) at A about the point O

= F x OA= 10 x 2= 20Nm (clockwise)

Moment of force F (=10N) at point B about the point O

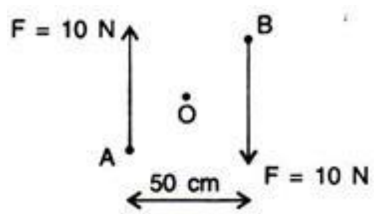
= F x OB= 10 x 2 =20Nm (clockwise)

Total moment of forces about the mid-point O=

=20 +20= 40Nm(clockwise)

Question 35

Figure shows two forces each of magnitude 10N acting at the points A and B at a separation of 50 cm, in opposite directions. Calculate the resultant moment of the two forces about the point (i) A, (ii) B and (iii) O, situated exactly at the middle of the two forces.



Solution 35

(i)Perpendicular distance of point A from the force F=10 N at B is 0.5m , while it is zero from the force F=10N at A

Hence, moment of force about A is

= 10 N x 0.5m=5Nm(clockwise)

(ii)Perpendicular distance of point B from the force F=10 N at A is 0.5m, while it is zero from the force F=10N at B

Hence, moment of force about B is

= 10 N x 0.5m=5Nm(clockwise)

(iii)Perpendicular distance of point O from either of the forces F=10N is 0.25 m

Moment of force F(=10N) at A about O= 10N x 0.25m

=2.5Nm(clockwise)

And moment of force F(=10N) at B about O

=10N x 0.25m=2.5Nm(clockwise)

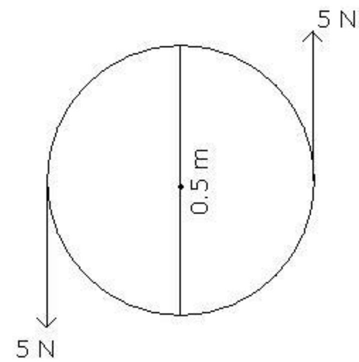
Hence, total moment of the two forces about O

=0.25 + 0.25=5Nm (clockwise)

Question 36

A steering wheel of diameter 0.5m is rotated anti-clockwise by applying two forces each of magnitude 5N. Draw a diagram to show the application of forces and calculate the moment of forces applied.

Solution 36



Moment of couple = either force x couple arm
= 5 N x 0.5m
=2.5 Nm

Question 37

A uniform metre rule is pivoted at its mid-point. A weight of 50gf is suspended at one end of it. Where a weight of 100gf should be suspended to keep the rule horizontal?

Solution 37

Let the 50gf weight produce anticlockwise moment about the middle point of metre rule .i.e, at 50cm.
Let a weight of 100gf produce a clockwise moment about the middle point. Let its distance from the middle be d cm. Then,
according to principle of moments,
Anticlockwise moment = Clockwise moment
50gf x 50 cm=100gf x d

So, d= $\frac{50 \times 50}{100} = 25$ cm from the other end

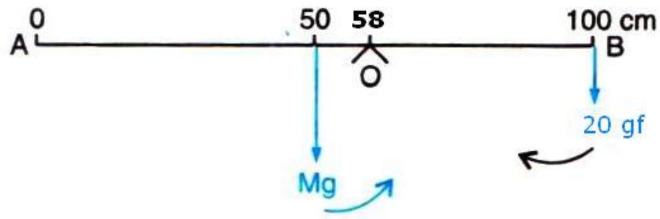
Question 38

A uniform metre rule balances horizontally on a knife edge placed at the 58 cm mark when a weight of 20gf is suspended from one end.

- **(i)Draw a diagram of the arrangement.**
- **(ii)What is the weight of the rule?**

Solution 38

(i)Weight mg (W) of rule produces an anti-clockwise moment about the knife edge O. In order to balance it, 20gf must be suspended at the end B to produce clockwise moment about the knife edge O.

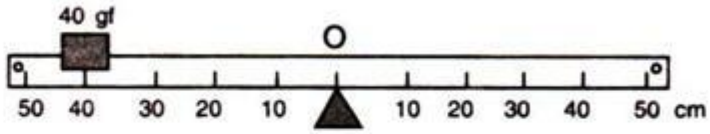


(ii)

From the principle of moments,
Anticlockwise moment= Clockwise moment
Wx (58-50) =20gf x (100-58)
W x 8=20gf x 42

W = $\frac{20gf \times 42}{8} = 105gf$

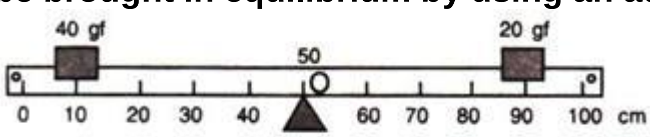
Question 39
The diagram shows a uniform bar supported at the middle point O. A weight of 40gf is placed at a distance 40cm to the left of the point O. How can you balance the bar with a weight of 80gf?



Solution 39
Anticlockwise moment= 40gf x 40 cm
Clockwise moment= 80gf x d cm
From the principle of moments,
Anticlockwise moment= Clockwise moment
40gf x 40 cm =80gf x d

So, d = $\frac{40gf \times 40}{80}$ = 20 cm to the right of point O.

Question 40
Figure shows a uniform metre rule placed on a fulcrum at its mid-point O and having a weight 40gf at the 10 cm mark and a weight of 20gf at the 90 cm mark. (i) Is the metre rule in equilibrium? If not, how will the rule turn? (ii) How can the rule be brought in equilibrium by using an additional weight of 40gf?



Solution 40
(i)Anticlockwise moment= 40gf x (50-10)cm

=40gf x 40cm=1600 gf x cm
Clockwise moment= 20gf x (90- 50) =20gf x 40cm
=800 gf x cm
Anticlockwise moment is not equal to clockwise moment. Hence the metre rule is not in equilibrium and it will turn anticlockwise.
(ii)To balance it, 40gf weight should be kept on right hand side so as to produce a clockwise moment about the middle point. Let its distance from the middle be d cm. Then,
clockwise moment= 20gf x 40cm + 40gf x d cm
From the principle of moments,
Anticlockwise moment= Clockwise moment
40 gf x 40 cm= 20gf x 40 + 40 x d cm
1600-800=40gf x dcm

So, d= $\frac{800\text{gf cm}}{40\text{gf}} = 20\text{ cm}$ **(on the other side)**

Hence, by placing the additional weight of 40gf at the 70cm mark the rule can be brought in equilibrium.

Question 41
When a boy weighing 20kgf sits at one end of a 4m long see-saw, it gets depressed at its end. How can it be brought to the horizontal position by a man weighing 40kgf.

Solution 41
From the principle of moments,
Anticlockwise moment= Clockwise moment
20kgf x 2m =40kgf x d

So, d= $\frac{20\text{kgf} \times 2\text{m}}{40\text{kgf}} = 1\text{m}$ **from the centre on the side opposite to the boy.**

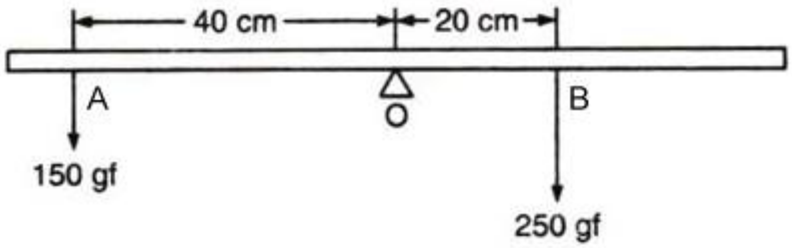
Question 42
A physical balance has its arms of length 60 cm and 40 cm. What weight kept on a pan of longer arm will balance an object of weight 100gf kept on other pan?

Solution 42
From the principle of moments,
Anticlockwise moment= Clockwise moment
100 gf x 40 cm =W x 60 cm
So, weight on the longer pan ,

W= $\frac{100\text{gf} \times 40\text{cm}}{60\text{cm}} = \frac{200\text{gf}}{3} = 66.67\text{ gf}$

Question 43
The diagram shows a uniform metre rule weighing 100gf, pivoted at its centre O. Two weights 150gf and 250gf hang from the point A and B respectively of the metre rule such that OA = 40 cm and OB = 20 cm. Calculate: (i) the total anticlockwise moment about O, (ii) the total clockwise moment about O, (iii) the

difference of anticlockwise and clockwise moment, and (iv) the distance from O where a 100gf weight should be placed to balance the metre rule.



Solution 43

(i)Total anticlockwise moment about O

= 150gf x 40 cm=6000gf cm

(ii)Total clockwise moment about O,

=250gf x 20 cm= 5000gf cm

(iii)The difference of anticlockwise and clockwise moment= 6000- 5000= 1000gf cm

(iv)From the principle of moments,

Anticlockwise moment= Clockwise moment

To balance it, 100gf weight should be kept on right hand side so as to produce a clockwise moment about the O. Let its distance from the point O be d cm. Then,

150gf x 40 cm=250gf x 20 cm +100gf x d

6000gf cm= 5000gf cm + 100gf x d

1000gf cm =100 gf x d

So, d= $\frac{1000\text{gf cm}}{100\text{gf}} = 10\text{cm}$ **on the right side of O.**

Question 44

A uniform metre rule of weight 10gf is pivoted at its 0 mark. (i) What moment of force depresses the rule? (ii) How can it be made horizontal by applying a least force?

Solution 44

(i)Anticlockwise moment= 10gf x 50 cm= 500gf cm

(ii)From the principle of moments,

Anticlockwise moment= Clockwise moment

10gf x 50 cm= W x 100cm

So, W= $\frac{10\text{gf} \times 50\text{cm}}{100\text{cm}} = 5\text{gf}$

By applying a force 5gf upwards at the 100cm mark, rule can be made horizontal

Question 45

A uniform half metre rule can be balanced at the 29.0 cm mark when a mass 20g is hung from its one end.

(a) Draw a diagram of the arrangement.

(b) Find the mass of the half metre rule.

Solution 45

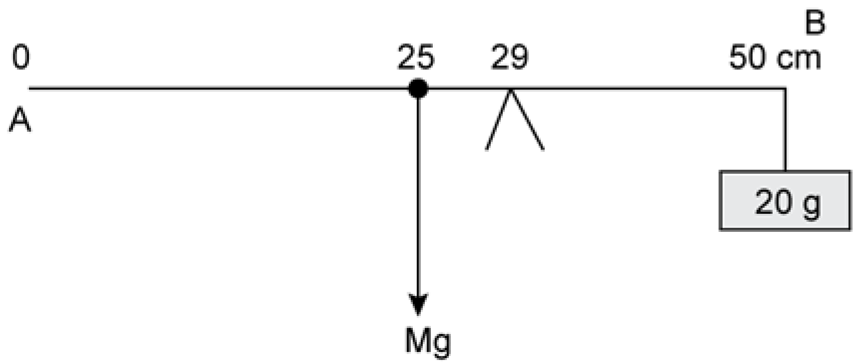


Figure shows a uniform half metre rule PQ which is balanced at 29cm mark. Let M be the mass of the rule. A uniform rule has same distribution of mass throughout its length So its weight Mg will act at its middle point which is at 25cm. The weight mg produces anticlockwise moment about point o. In order to balance the 20g (0.02kg) weight is tied at 50cm mark which generates clockwise moment.
Hence from the principle of moments
Anticlockwise moment= clockwise moment
Mg(29-25)=0.02g(50-29)
M=21(0.02)/4
M=0.105kg
M=105g

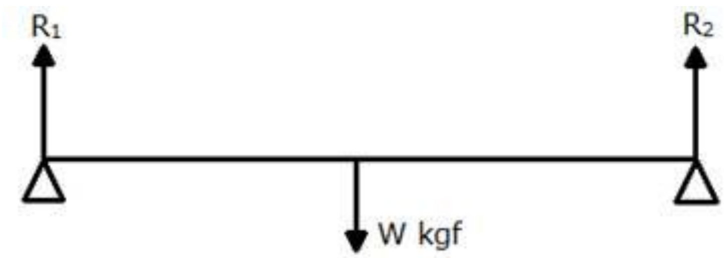
Question 46
A uniform metre rule of mass 100g is balanced on a fulcrum at mark 40cm by suspending an unknown mass m at the mark 20cm. (i) find the value of m. (ii) To which side the rule will tilt if the mass m is moved to the mark 10cm? (iii) What is the resultant moment now? (iv) How can it be balanced by another mass 50 g?

Solution 46
(i) From the principle of moments,
Clockwise moment= Anticlockwise moment
100g x (50-40) cm= mx(40-20) cm
100g x 10 cm = m x 20 cm = m =50 g
(ii)The rule will tilt on the side of mass m (anticlockwise), if the mass m is moved to the mark 10cm.
(iii)Anticlockwise moment if mass m is moved to the mark 10 cm= 50g x (40-10)cm =50 x 30=1500g cm
Clockwise moment=100g x (50-40) cm= 1000g cm
Resultant moment= 1500g cm -1000g cm= 500g cm (anticlockwise)
(iv) From the principle of moments,
Clockwise moment= Anticlockwise moment
To balance it, 50g weight should be kept on right hand side so as to produce a clockwise moment .Let its distance from fulcrum be d cm. Then,

100g x (50-40) cm + 50g x d =50g x (40-10)cm

1000g cm + 50g x d =1500 g cm
50 g x d= 500g cm
So, d =10 cm
By suspending the mass 50g at the mark 50 cm, it can be balanced.

Question 47
In figure below, a uniform bar of length *l* m is supported at its ends and loaded by a weight *W* kgf at its middle. In equilibrium, find the reactions R_1 and R_2 at the ends.



$$\left[\text{Hint: In equilibrium } R_1 + R_2 = W \text{ and } R_1 \times \frac{l}{2} = R_2 \times \frac{l}{2}\right]$$

Solution 47
According to the principle of moments,
Clockwise moments = anticlockwise moments

$$R_1 + R_2 = W$$

As the system is in equilibrium,

$$R_1 \times \frac{l}{2} = R_2 \times \frac{l}{2}$$

$$\therefore R_1 = R_2$$

$$\therefore 2R_1 = W$$

$$\therefore R_1 = R_2 = \frac{W}{2} \text{ kgf}$$