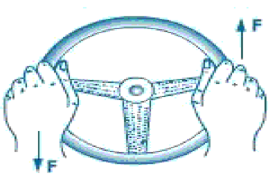
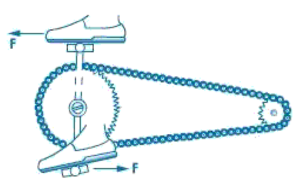
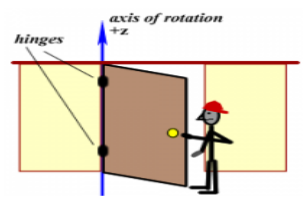
***SUBJECT*: PHYSICS**

Class – X **Chapter-1 Force** **Date: 24/04/2020**

- ***<u>Linear or Translational motion</u>***: When a force acts on a <u>rigid body</u> which is free to move, the body starts moving in a <u>straight path</u> in the <u>direction of the of force</u>.
  For example, a train moving in its track, a man walking on the road, birds flying in the sky, etc.
- ***<u>Rotational motion</u>***: When a body is <u>pivoted at a point</u> and the applied <u>force rotates it about the axis passing the pivoted point</u>.
  Fan moving in the house, table fan, hand blender's blades motion are all examples of rotational motion.
- ***<u>Turning force</u>***: The force applied at a point of a fixed body, rotates the body about the fixed point.
- The turning of a body by a force depends on the following two factors:
  1. The magnitude of the force applied
  2. The distance between the line of action of force and the axis of rotation (or pivoted point).
- ***Examples of turning effect of force***:
  (1) To open and shut a door, we apply a force (push or pull) normal to the door at its handle, which is at the maximum distance from the hinge.
  (2) The upper circular stone of a hand flour grinder is provided with a handle near its rim (i.e. maximum distance from the centre) so that it can easily be rotated about the iron pivot at its centre by applying a small force at the handle.
  (3) For turning a steering wheel, a force is applied tangentially on the rim of the wheel.
  (4) In a bicycle, to turn the wheel anticlockwise, a small force is applied on the pedal of a toothed wheel.
- ***<u>Moment of force</u>*(*<u>Torque</u>*):**
  It is equal the product of the magnitude of the force and the perpendicular distance of the line of action of force from the axis of rotation. It is a vector quantity. Its direction is normal to the plane containing the perpendicular distance and the force. Maximum torque is transmitted when force is applied at the farthest possible distance from the axis of rotation.
  CGS Unit of Moment of a Force is <u>dyne cm</u> and SI Unit of Moment of a Force is <u>N m</u>.
  1N m = 107 dyne cm
  The gravitational units of moment of force in MKS and CGS system are kgf m and gf cm respectively.
  1kgf m = 9.8 Nm and 1 gf cm = 980 dyne cm.



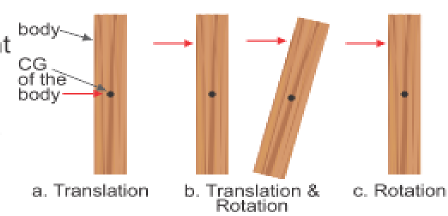




a. If a force is applied at the midpoint of a free, rigid, uniform object, it will slide the object such that every point moves an equal distance. The object is said to translate.

b. If the same force is applied at some other point as in (fig. b), then the object will both translate and rotate.

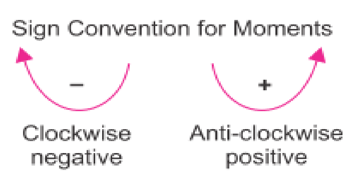
c. If the midpoint of the object is pivoted, (fig. c) then the applied force causes only rotational motion.



Clockwise and Anticlockwise Moments

The direction of turning produced on the body depends on the point of application of the force and on the direction of the force.

If the turning effect on the body is anticlockwise, moment of force is called **anticlockwise moment** and it is considered **positive**.
If the turning effect on the body is clockwise, moment of force is called the **clockwise moment** and it is considered as **negative**.

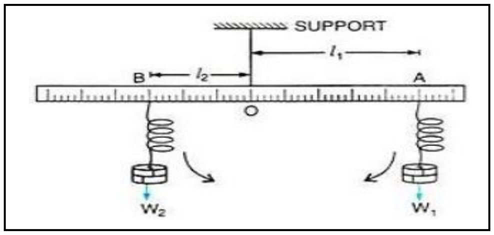


Units of moment of force
S.I. unit of moment of force = Units of force × Unit of distance = newton × metre = N m
C.G.S. unit = dyne × cm

- **Equilibrium:**
  When a number of forces acting on a body produce no change in its state of rest it is said to be in static equilibrium, if there is no change in its state of motion(translational or rotational) it is said to be in dynamic equilibrium.

- **Conditions for Equilibrium:**
  The resultant of all the forces acting on the body should be equal to zero.
  The resultant of all the forces acting on the body about the point of rotation should be zero. According to the Principle of Moments, in equilibrium, the algebraic sum of anticlockwise moments is equal to the algebraic sum of clockwise moments.
- 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.

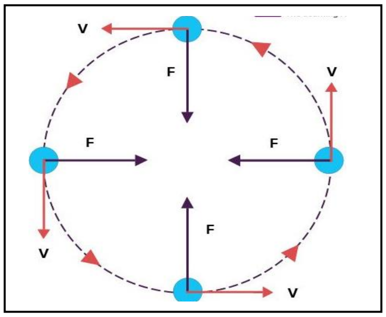
Suspend a metre rule horizontally from a fixed support by means of a strong thread at O as shown. Now suspend two spring balances with some slotted weights W_1 and W_2 on them on either side of the thread. The scale may tilt to one side. Now adjust the distances of two spring balances from the support 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.



Centre of Gravity:
The centre of gravity of a body is the point about which the algebraic sum of moments of weights of all the particles constituting the body is zero.
The entire weight of the body can be considered to act at this point, how so ever the body is placed
The position of the centre of gravity of a body of given mass depends on its shape i.e., on the distribution of mass. It is not necessary that the centre of gravity will always be within the material of the body.
The movement of an object in a circular path, with a constant speed, is known as uniform circular motion.
A bike moving around a circular path is in a circular motion. The bike moving in a circular path with uniform speed is known as uniform circular motion.
Circular Motion
Circular motion is an accelerated motion because the direction of the velocity changes continuously.
If a body moves on a circular path with uniform speed, it is called uniform circular motion.
The acceleration of this body is known as centripetal Acceleration, which is directed towards the center of the circle.
Following are the examples of uniform circular motion:

- Motion of artificial satellites around the earth is an example of uniform circular motion. The gravitational force from the earth makes the satellites stay in the circular orbit around the earth.
- The motion of electrons around its nucleus.
- The motion of blades of the wind mills.
- The tip of second's hand of a watch with circular dial shows uniform circular motion.

Since this acceleration is perpendicular to the velocity of particle at every instant, it is only changing the direction of velocity and not magnitude and that's why the motion is uniform circular motion. We call this acceleration centripetal acceleration (or radial acceleration), and the force acting towards the centre is called centripetal force.



Exercise 1(A)

Question: 1

State the condition when on applying a force, the body has:

(a)the translational motion,

(b)the rotational motion.

Solutions:

(a) Translational motion is produced when the body is free to move.

(b) Rotational motion is produced when the body is pivoted at a point.

Question: 2

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

Solutions:

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.

The S.I unit of moment of force is Newton × meter

= Newton meter (Nm)

Question: 3

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

Solutions:

The moment of force is a vector quantity.

Question: 4

State two factors affecting the turning effect of a force.

Solutions:

The following are the two factors on which moment of force about a point depends

(a) The magnitude of the force applied and,

(b) The distance of the line of action of the force from the axis of rotation

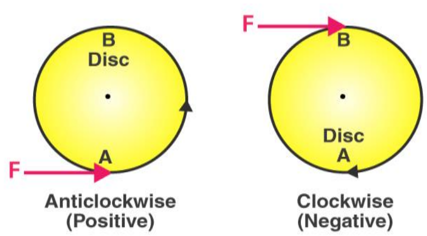
Question: 5

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.

Solutions:

The force applied on the body at a suitable point rotates the body about the axis passing through the pivoted point, when the body is pivoted at a point.

By changing the point of application of force, the direction of rotation can be changed. Figures given below 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.

Solutions:

The expression for the moment of force is given by

Moment of force about a given axis = Force × perpendicular distance of force from the axis of rotation.

Question: 7

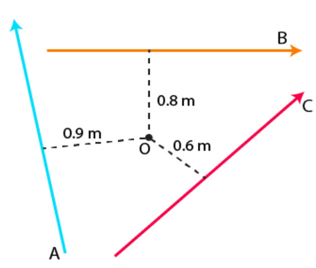
What do you understand by the clockwise and anticlockwise moment of force? When is it taken positive?

Solutions:

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

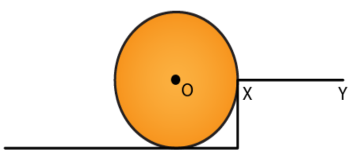
Question: 8

State one way to reduce the moment of a given force about a given axis of rotation.
Solutions:
The moment of force depends on the perpendicular distance of the line of action of force from the axis of rotation. The moment of a given force reduces by decreasing the perpendicular distance from the axis.
Question: 9
State one way to obtain a greater moment of a force about a given axis of rotation.
Solutions:
Moment of force is equal to the product of force and the perpendicular distance of force from axis of rotation. By increasing the distance from the axis of rotation where the force would act is one of the way to increase the moment of a force about a given axis of rotation.
Question: 10
Why is it easier to open a door by applying the force at the free end of it?
Solutions:
Larger the perpendicular distance, less force is needed to turn the body. Hence it is easier to open a door by applying the force at the free end of it.
Question: 11
The stone of hand flour grinder is provided with a handle near its rim. Give a reason.
Solutions:
The stone of hand flour grinder is provided with a handle near its rim because by applying small force at the handle it can be rotated easily about the iron pivot at its centre.
Question: 12
It is easier to turn the steering wheel of a large diameter than that of a small diameter. Give reason.
Solutions:
To turn the steering wheel of a large diameter need less force which is at a large distance from the centre of rim. So it is easier to turn the steering wheel of a large diameter than that of a small diameter.
Question: 13
A spanner (or wrench) has a long handle. Why?
Solutions:
The long handle of spanner produces a larger turning moment by which nut can easily be turned with a less force. So the spanner has a long handle.
Question: 14
A jack screw is provided with a long arm. Explain why?
Solutions:
A long arm of a jack screw which is used to lift a heavy load like a vehicle will help to apply less effort which is required to rotate it to raise or lower the jack. Hence the jack screw has a long arm.
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.

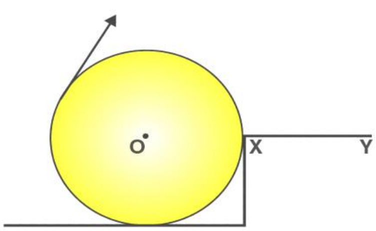


(i) Which force has the least moment about O? Give a reason.
(ii) Which force has the greatest moment about O? Give a reason.
(iii) Name the forces producing
(a) clockwise and
(b) anticlockwise moments.
(iv)What is the resultant torque about the point O?

Solutions:
(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
Here the negative sign indicates that the resultant torque is in clockwise direction.
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.

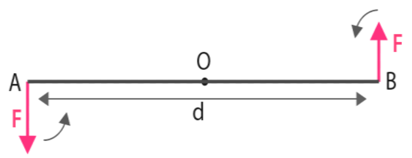


Solutions:

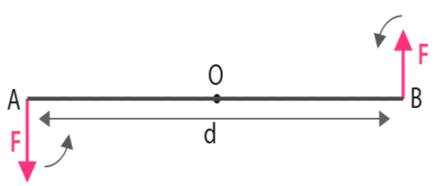


Force F should be applied in the direction as shown in the above figure.
Question: 17
A body is acted upon by two forces each of magnitude F, but in opposite directions. State the effect of the forces if
(a)both forces act at the same point of the body.
(b)the two forces act at two different points of the body at a separation r.
Solutions:
(a) Resultant force acting on the body = 0
F – F = 0
(b) The forces tend to rotate the body between two forces about the midpoint.
Moment of forces = F × r
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:

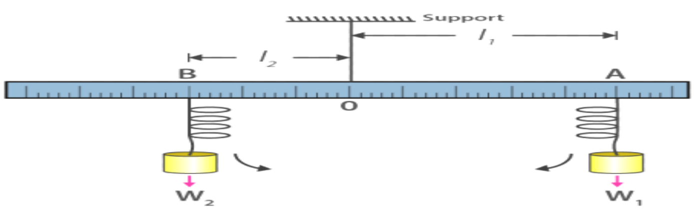


At A and B, two forces each of magnitude F are applied, which are equal and opposite forces. By observing the above figure it is clear that the two forces rotate the bar in anticlockwise direction.
Question: 19
What do you understand by the term couple? State its effect. Give two examples in our daily life where couple is applied to turn a body.
Solutions:
Two forces not acting along the same line, which are equal and opposite parallel forces, form a couple. A couple is always required to produce the rotation.
Examples: turning a key in the hole of a lock and turning the steering wheel of a car.
Question: 20
Define moment of a couple. Write its S.I unit.
Solutions:
Moment of couple is equal to the product of both force and the perpendicular distance between the two forces.
The S.I unit of moment of couple is Nm
Question: 21
Prove that
Moment of couple = Force x Couple arm.
Solutions:



At A and B two forces each of magnitude F are applied, which are equal and opposite forces. The two forces rotate the bar in anticlockwise direction. AB is the perpendicular distance between two forces which is called the couple arm.
Moment of force F at the end A
= F × OA (anticlockwise)
Moment of force F at the end B
= F × OB (anticlockwise)
Total moment of couple = F × OA + F × OB
= F × (OA + OB)
= F × AB
= F × d (anticlockwise)
= Either force × perpendicular distance between the two forces or couple arm
Hence, Moment of couple = Force × Couple arm
Question: 22
What do you mean by equilibrium of a body?
Solutions:
When a number of forces acting on a body produce no change in its state of rest or of linear or rotational 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.
Solutions:
(i) Static equilibrium is defined as when a body remains in the state of rest under the influence of several forces, the body is said to be in static equilibrium.
Example: A book lying on a table is in static equilibrium
(ii) Dynamic equilibrium is defined as when a body remains in the same state of motion under the influence of several forces, the body is said to be in dynamic equilibrium
Example: A rain drop reaches the earth surface with a constant velocity.
Question: 24
State two conditions for a body, acted upon by several forces to be in equilibrium.
Solutions:
The two conditions for a body to be in equilibrium are
(i) The resultant of all the forces acting on a body must be zero.
(ii) The algebraic sum of moments about the point of rotation of all the forces acting on the body should be zero.
Question: 25
State the principle of moments. Name one device based on it.
Solutions:
According to the principle of moments, if the algebraic sum of moments about the axis of rotation of all the forces acting on the body is zero, then the body is said to be in equilibrium. A beam balance is the device which 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.
Solutions:
Suspend a metre rule horizontally from a fixed support by means of a strong thread at point O as shown. Now with some slotted weights W_1 and W_2 suspend two spring balances on either side of the thread. The metre rule may tilt to one side. Now adjust the two spring balance distances from the support by keeping one at A and the other at B so that the scale again becomes horizontal.



Let the W_1 at a distance OA = l_1 be the weight suspended on the right side of thread from the spring balance at A, while W_2 at a distance OB = l_2 be the weight suspended on the left side of thread from the spring balance at B.
The weight W_1 tends to turn the scale clockwise and the weight W_2 tends 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
Hence, $W_1l_1 = W_2l_2$
This verifies the principle of moments.
The moment of force about a given axis depends on both, on the force and its perpendicular distance from the axis.
2. A body is acted upon by two unequal forces in opposite directions, but not in the 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:
A body is acted upon by two unequal forces in opposite directions, but not in the same line. The effect is that the body will have rotational as well as translational motion.

NUMERICALS

Question: 1

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.

Solutions:

We know that,

Moment of Force = Force × Perpendicular distance from the point O

= F × r

So, substituting the values given in the question, we get,

5Nm = 10r

r = 5 / 10

r = 0.5 m

Question: 2

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.

Solutions:

Given

r = 10 cm

= 0.1 m

Required least force = 5 N

Moment of force = F × r

Substituting the values of F and r, we get

= 5 × 0.1

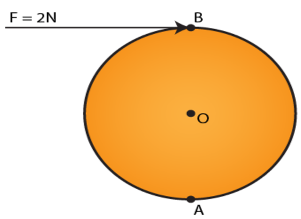
= 0.5 Nm

Question: 3

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.



Solutions:

Given

F = 2N

D = 2m

Since the diameter is 2m. So, the perpendicular distance between B and O is 1m

(i) Moment of force at the centre O

= F × r

= 2 × 1

= 2 Nm

– which is clockwise

(ii) Moment of force at point A

= F × r

= 2 × 2

= 4 Nm

– which is clockwise

Question: 4

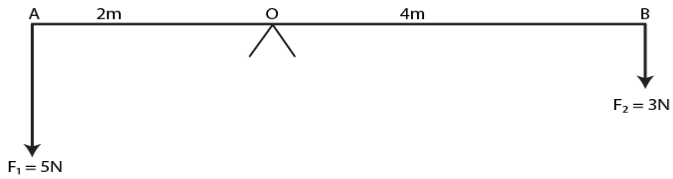
The diagram shows two forces F_1= 5N and F_2 = 3N acting at points A and B of a rod pivoted at a point O, such that OA = 2m and OB = 4m

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.



Solutions:

Given

OA = 2m and OB = 4m

(i) Moment of force F_1 = 5N about the point O at A

= F_1 × OA

= 5 × 2

= 10Nm (anticlockwise)

(ii) Moment of force F_2 = 3N about the point O at B

= F_2 × OB

= 3 × 4

= 12 Nm (clockwise)

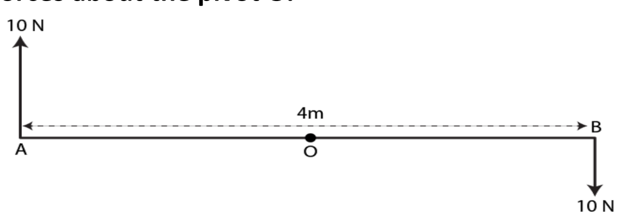
(iii) Total moment of forces about the midpoint O

= 12 – 10

= 2Nm (clockwise)

Question: 5

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.



Solutions:

Given

AB = 4m So, OA = 2m

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

= F × OA

= 10 × 2

= 20 Nm (clockwise)

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

= F × OB

= 10 × 2

= 20 Nm (clockwise)

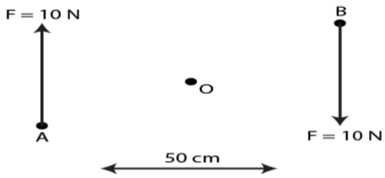
Total moment of forces about the centre O

= 20 + 20

= 40 Nm (clockwise)

Question: 6

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.



Solutions:

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

So, moment of force about A is

= 10N × 0.5Nm

= 5Nm (clockwise)

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

So, moment of force about B is

= 10N × 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 point A about O

= 10N × 0.25m

= 2.5Nm (clockwise)

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

= 10N × 0.25m

= 2.5Nm (clockwise)

∴ Total moment of both the forces about point O

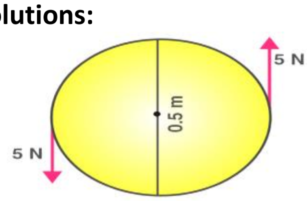
= 0.25 + 0.25

= 5Nm (clockwise)

Question: 7

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.

Solutions:



Moment of couple = either force × couple arm

= 5N × 0.5m

= 2.5 Nm

Question: 8

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

Solutions:

Let the 50 gf weight produce anticlockwise moment about the middle point i.e at 50 cm

Let the weight of 100 gf produce a clockwise moment about the middle point and d cm be the distance from the middle. So, According to principle of moments.

Anticlockwise moment = Clockwise moment

50 gf × 50 cm = 100 gf × d

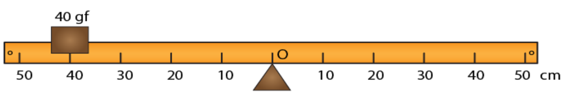
Then d = (50 × 50) / 100

= 25 cm

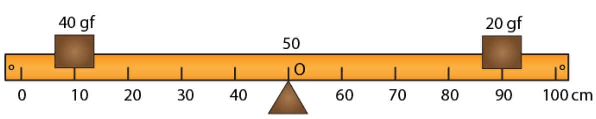
A weight of 100 gf be suspended at a distance 25 cm from the other end to keep the rule horizontal.

Question: 9

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?
Solutions:
(i) Weight of rule produces an anticlockwise moment about the knife edge O. In order to balance 20 gf should be suspended at the end B to produce clockwise moment about the knife edge O
Figure
(ii) According to the principle of moments,
Anticlockwise moment = Clockwise moment
W × (58 – 50)
= 20 gf × (100 – 58)
W × 8 = 20 gf × 42
W = (20 gf × 42) / 8
= 105 gf
Question: 10
The diagram shows a uniform bar supported at the middle point O. A weight of 40 gf is placed at a distance 40cm to the left of the point O. How can you balance the bar with a weight of 80 gf?



Solutions:
Anticlockwise moment = 40 gf × 40 cm
Clockwise moment = 80 gf × d cm
According to principle of moments,
Anticlockwise moment = Clockwise moment
40 gf × 40 cm = 80 gf × d
Hence d = (40 gf × 40) / 80
= 20 cm to the right of point O
We can balance the bar by placing the weight of 80 gf at a distance 20 cm to the right of point O.
Question: 11
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 20 gf 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?



Solutions:
(i) Anticlockwise moment = 40 gf × (50 – 10) cm
= 40 gf × 40 cm
= 1600 gf × cm
Clockwise moment = 20 gf × (90 – 50)
= 20 gf × 40 cm
= 800 gf × cm
Anticlockwise moment is not equal to clockwise moment. So the metre rule is not in equilibrium and it will turn anticlockwise.
(ii) In order to balance 40 gf weight should be kept on right hand side so as to produce a clockwise moment about the middle point. Let d cm be the distance from the middle. Then,

Clockwise moment = 20 gf × 40 cm + 40 gf × d cm
According to the principle of moments,
Anticlockwise moment = Clockwise moment
40 gf × 40 cm = 20 gf × 40 cm + 40 gf × d cm
1600 = 800 + 40 gf × d cm
1600 – 800 = 40 gf × d cm
Hence d = (800 gf cm) / 40
d = 20 cm (on the other side)
The rule can be brought in equilibrium by placing the additional weight of 40 gf at the 70 cm mark.

Question: 12

When a boy weighing 20 kgf 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 40 kgf.

Solutions:

According to the principle of moment,
Anticlockwise moment = Clockwise moment
20 kgf × 2 m = 40 kgf × d
So, d = (20kgf × 2m) / 40 kgf
= 1 m
It can be brought to the horizontal position if a man sits at a distance 1 m from the centre on the side opposite to the boy.

Question: 13

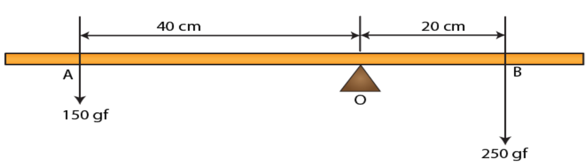
A physical balance has its arms of length 60 cm and 40 cm. What weight kept on a pan of longer arm will balance an object of weight 100 gf kept on other pan?

Solutions:

According to the principle of moments,
Anticlockwise moment = Clockwise moment
100 gf × 40 cm = W × 60 cm
Hence, weight on the longer pan,
W = (100 gf × 40 cm) / 60 cm
= 200 gf / 3
= 66.67 gf

Question: 14

The diagram shows a uniform metre rule weighing 100 gf, 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.



Solutions:

(i) Total anticlockwise moment about the centre O
= 150 gf × 40 cm
= 6000 gf cm
(ii) Total clockwise moment about the centre O
= 250 gf × 20 cm
= 5000 gf cm
(iii) The difference of anticlockwise and clockwise moment
= 6000 – 5000
= 1000 gf cm
(iv) According to the principle of moment

In order to balance, 100 gf weight should be kept on right hand side so as to produce a clockwise moment about the centre O. Let d cm be the distance from the point O. Then,
150 gf × 40 cm = 250 gf × 20 cm + 100 gf × d
6000 gf = 5000 gf + 100 gf × d
6000 gf – 5000 gf = 100 gf × d
1000 gf = 100 gf × d
Hence, d = (1000 gf cm) / 100 gf
= 10 cm on the right side of centre O.

Question: 15

A uniform metre rule of weight 10 gf 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?

Solutions:

Anticlockwise moment = 10 gf × 50 cm
= 500 gf cm
Anticlockwise moment = Clockwise moment
10 gf × 50 cm = W × 100 cm
So, W = (10 gf × 50 cm) / 100 cm
= 5 gf
Rule can be made horizontal by applying a force 5 gf upwards at the 100 cm mark.

Question: 16

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.

Solutions:

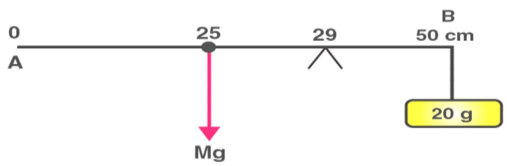


Figure shows a uniform half metre rule PQ which is balanced at 29 cm mark. Let the mass of the rule be M. A uniform rule has same distribution of mass throughout its length, so its weight Mg will act at its middle point which is at 25 cm. The weight mg produces anticlockwise moment about point O. To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

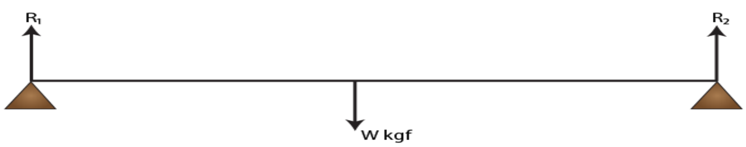
Question: 17

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

Solutions:

(i) From the principle of moments,
Clockwise moment = Anticlockwise moment
100 g × (50 – 40) cm = m × (40 – 20) cm
100 g × 10 cm = m × 20 cm
m = 50 g

(ii) If the mass m is moved to the mark 10 cm, the rule will tilt on the side of mass m (anticlockwise)
Anticlockwise moment if mass m is moved to the mark 10 cm
= 50 g × (40 – 10) cm
= 50 g × 30 cm
= 1500 g cm
Clockwise moment = 100 g × (50 – 40) cm
= 100 g × 10 cm
= 1000 g cm
Resultant moment = 1500 g cm – 1000 g cm
= 500 g cm (anticlockwise)
(iv) According to the principle of moments.
Clockwise moment = Anticlockwise moment
To balance it, 50 g weight should be kept on right hand side so as to produce a clockwise moment. Let d cm be the distance from the fulcrum. Then,
100 g × (50 – 40) cm + 50 g × d = 50 g × (40 – 10) cm
100 g × 10 cm + 50 g × d = 50 g × 30 cm
1000 g cm + 50 g × d = 1500 g cm
50 g × d = 500 g cm
Then, d = 10 cm
It can be balanced by suspending the mass 50 g at the mark 50 cm.
Question: 18
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.



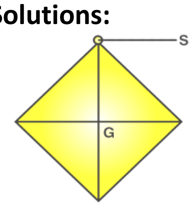
Solutions:
According to the principle of moments,
Clockwise moments = Anticlockwise moments
$R_1 + R_2 = W$
Since the system is in equilibrium,
$R_1 \times 1 / 2 = R_2 \times 1 / 2$
$R_1 = R_2$
Therefore $2R_1 = W$
$R_1 = R_2 = W / 2$ kgf

Exercise 1(B)

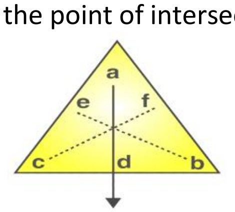
Question: 1
Define the term 'centre of gravity of a body'.
Solutions:
The centre of gravity of a body is defined as the point about which the algebraic sum of moments of weights of particles constituting the body is zero and the entire weight of the body is considered to act at this point.
Question: 2
Can the centre of gravity of a body be situated outside its material of the body? Give an example.
Solutions:
Yes, the centre of gravity of a body can be situated outside its material of the body.
Example: centre of gravity of a ring.
Question: 3
State factor on which the position of centre of gravity of a body depend? Explain your answer with an example.
Solutions:

Centre of gravity of a body of given mass position depends on its shape i.e on the distribution of mass. For example: Uniform wire's centre of gravity is at its mid point. But if this wire is bent to make a circle, its centre of gravity will then be at the centre of circle.

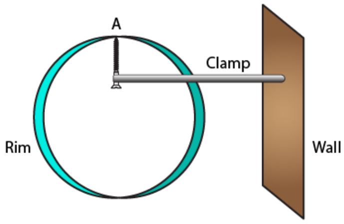
Question: 4
What is the position of centre of gravity of a:
(a) rectangular lamina
(b) cylinder?
Solutions:
(a) The position of centre of gravity of a rectangular lamina is at the point of intersection of its diagonals.
(b) The position of centre of gravity of a cylinder is at the midpoint on the axis of cylinder.
Question: 5
At which point is the centre of gravity situated in:
(a) A triangular lamina and
(b) A circular lamina?
Solutions:
(a) A triangular lamina's centre of gravity is situated at the point of intersection of its medians.
(b) A circular lamina's centre of gravity is situated at the centre of circular lamina.
Question: 6
Where is the centre of gravity of a uniform ring situated?
Solutions:
Uniform ring's centre of gravity is situated at the centre of ring.
Question: 7
A square card board is suspended by passing a pin through a narrow hole at its one corner. Draw a diagram to show its rest position. In the diagram mark the point of suspension by the letter S and centre of gravity by the letter G.
Solutions:



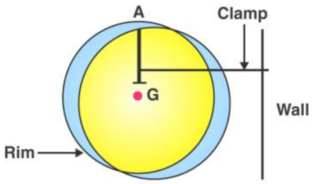
A square card board in rest position as centre of gravity as G and point of suspension as S
Question: 8
Explain how you will determine experimentally the position of centre of gravity for a triangular lamina (or a triangular piece of card board).
Solutions:
Take a triangular lamina. Near the edge of triangular lamina make three fine holes at a, b, c. Now along with a plumb line from hole 'a' suspend the given lamina. Check that the lamina is free to oscillate about the point of suspension. Draw a straight line ad along the plumb line when lamina has come to rest. We get straight lines 'be' and 'cf' respectively by repeating the experiment by suspending the lamina through hole 'b' and then through hole 'c'. It is noticed that the common point G is the position of centre of gravity of triangular lamina where the lines ad, be and cf intersect each other i.e the point of intersection of medians.



Question: 10
A uniform flat circular rim is balanced on a sharp vertical nail by supporting it at point A, as shown in Fig. Mark the position of centre of gravity of the rim in the diagram by the letter G.

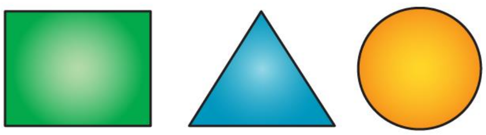


Solutions:



Question: 11

Figure shows three pieces of card board of uniform thickness cut into three different shapes. On each diagram draw two lines to indicate the position of centre of gravity G.



Solutions:

Exercise 1(c)

Question: 1

Explain the meaning of uniform circular motion. Why is such motion said to be accelerated?

Solutions:

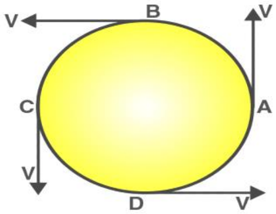
The motion is said to be in circular motion when the particle moves with a constant speed in a circular path. For example: Earth's revolution around the sun is an example of uniform circular motion.

Question: 2

Draw a neat labelled diagram for a particle moving in a circular path with a constant speed. In your diagram show the direction of velocity at any instant.

Solutions:

Movement of a particle in a circular path with a constant speed.



Question: 3

Is it possible to have an accelerated motion with a constant speed? Name such type of motion.

Solutions:

Yes, it's possible to have an accelerated motion with a constant speed. Such type of motion is uniform circular motion.

Question: 4

Give one example of motion in which speed remains uniform, but the velocity changes.

Solutions:

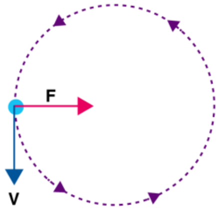
A cyclist's motion on a circular track is an example of motion in which speed remains uniform, but the velocity changes.

Question: 5

A uniform circular motion is an accelerated motion. Explain it. State whether the acceleration is uniform or variable? Name the force responsible to cause this acceleration. What is the direction of force at any instant? Draw diagram in support of your answer.

Solutions:

When the object with uniform speed moves in a circular path, it means that its magnitude of velocity does not change, it only changes its direction continuously. Therefore it is considered as uniformly accelerated motion.



Question: 6

Differentiate between a uniform linear motion and a uniform circular motion.

Solutions:

linear motion	uniform circular motion
The body moves along a straight line	body moves along a circular path
Speed and direction both remains constant	Speed is constant but direction changes continuously.
Not an accelerated motion.	An accelerated motion.

Question: 7

Name the force required for circular motion. State its direction.

Solutions:

The force required for circular motion is centripetal force. The direction of centripetal force is always directed towards the centre of circle.

Question: 8

What is centripetal force?

Solutions:

The centripetal force is defined as the force acting on a body moving in a circular path, in a direction towards the centre of circular path.

Question: 9

Explain the motion of a planet around the sun in a circular path.

Solutions:

A planet moves around the sun in a circular path for which the gravitational force of attraction by the sun provides the necessary centripetal force required for circular motion on the planet.

Question: 10

(a) How does a centripetal force differ from a centrifugal force with reference to the direction in which they act?

(b) Is centrifugal force the force of reaction of the centripetal force?

(c) Compare the magnitudes of centripetal and centrifugal force.

Solutions:

(a) Both forces act in opposite direction with reference to the direction in which they act.

(b) No, centrifugal force is not the force of reaction of the centripetal force.

(c) The magnitudes of centripetal and centrifugal force is 1: 1

Question: 11

Is centrifugal force a real force?

Solutions:

No, centrifugal force is a fictitious force.

Question: 12

A small pebble tied at one end of a string is placed near the periphery of a circular disc, at the center of which the other end of the string is tied to a peg. The disc is rotating about an axis passing through its centre.

(a)What will be your observation when you are standing outside the disc? Explain.

(b)What will be your observation when you are standing at the centre of the disc. Explain.

Solutions:

(a) When we are standing outside the disc, we observe that the pebble is moving on a circular path.

(b) When we are standing inside the disc, we observe that the pebble is stationary placed in front of us.

Question: 13

Solutions:

A piece of stone tied at the end of a thread is whirled in a horizontal circle with uniform speed with the help of hand. Answer the following questions.

a. Is the velocity of stone uniform or variable?

b. Is the acceleration of stone uniform or variable?

c. What is the direction of acceleration of stone at any instant?

d. What force does provide the centripetal force required for circular motion?

e. Name the force and its direction which acts on the hand.

Solutions:

(a) The velocity of stone is variable

(b) The acceleration of stone is variable

(c) The direction of acceleration of stone is towards the centre of the circular path.

(d) Force of tension in the string provides the centripetal force required for circular motion.

(e) The reaction of tension away from the centre of the circular path.

Question: 14

State two differences between the centripetal and centrifugal force.

Solutions:

Centripetal force	Centrifugal force
Acts towards the centre of the circle	Acts away from the centre of the circle
A real force	fictitious force

<u>Assignment</u> :

Selina book Exercise work.

Solve last 12 years Board Question Papers related to the concerned chapter 1.