CLASS - X

FORCE

* Types of motion :

1. Linear or translational motion : When a force acts on a stationary rigid body, free to move, the body starts moving in a straight path in the direction of force.

2. Rotational motion : If a body is pivoted at a point and the force is applied on the body at a suitable point, it rotates the body about the axis passing through the pivoted point.

Moment of a Force (Torque).

The moment of a 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.

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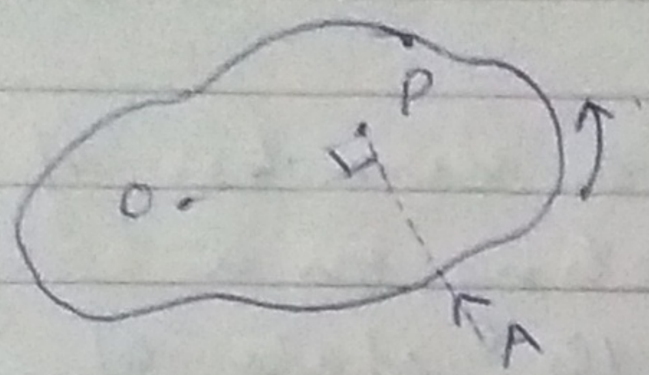
Moment of force = Force × Perpendicular distance of force from the point O

= F × OP.



* Unit of moment of force -

S.I unit = newton × metre.
= Nm.

C.G.S unit = dyne × cm.

Relation

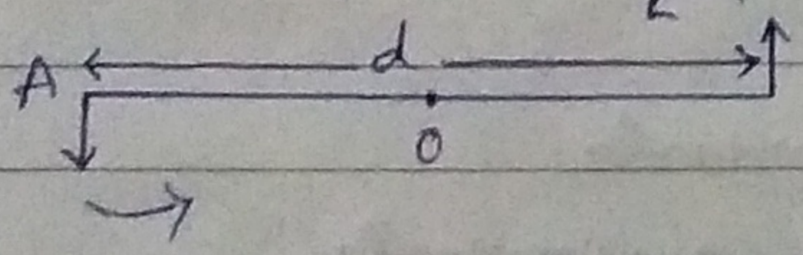
→ 1 Nm = 10^7 dyne cm.

* Clockwise and anticlockwise moments :

1. If the effect on the body is to turn it anticlockwise, moment of force is anticlockwise moment and it is taken positive.

2. If the effect on the body is to turn it clockwise, moment of force is clockwise moment and it is taken negative.

* <u>COUPLE</u> : Two equal and opposite parallel forces not acting along the same line form a couple. A couple is always needed to produce a rotation.



Moment of force F at A
= F × OA (anticlockwise)

Moment of force F at B
= F × OB (anticlockwise)

Total moment of couple
= F × OA + F × OB
= F × (OA + OB)
= F × AB = F × d. (anticlock)

∴ Moment of couple = Either force × perpendicular distance between the two forces.

* Equilibrium of Bodies : 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.

→ Kinds of equilibrium -

(1) Static equilibrium - When a body remains in the state of rest under the influence of several forces.

(2) Dynamic equilibrium - When a body remains in the same state of motion under the influence of the several forces.

→ Conditions of equilibrium :-

1. The resultant of all the forces acting on the body should be zero.
2. The algebric sum of moments of all the forces acting on the body about the point of rotation should be zero.

* Principle of moments :-

In equilibrium condition

Sum of the anticlockwise moments = Sum of clockwise moments.

—x—

5. When does a body rotate ? State *one* way to change the direction of rotation of the body. Give a suitable example to explain your answer.
6. Write the expression for the moment of force about a given axis.
7. What do you understand by the clockwise and anticlockwise moment of force ? When is it taken positive ?
8. State *one* way to reduce the moment of a given force about a given axis of rotation.
9. State *one* way to obtain a greater moment of a force about a given axis of rotation.
10. Why is it easier to open a door by applying the force at the free end of it ?
11. The stone of a hand flour grinder is provided with a handle near its rim. Give reason.
12. It is easier to turn the steering wheel of a large diameter than that of a small diameter. Give reason.
13. A spanner (or wrench) has a long handle. Why ?
14. A jack screw is provided with a long arm. Explain why ?
15. A, B and C are the three forces each of magnitude 4 N acting in the plane of paper as shown in Fig. 1.26. The point O lies in the same plane.

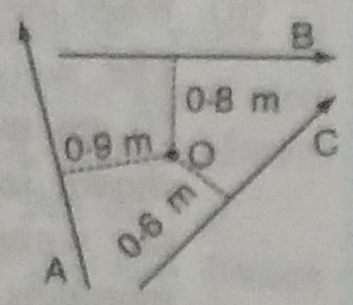


Fig. 1.26

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

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

(iii) Name the forces producing (a) clockwise, (b) anticlockwise moments.

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

Ans. (i) C, because the force C is nearest to O
(ii) A, because the force A is farthest from O.
(iii) (a) A and B, (b) C (iv) 4·4 N m (clockwise).

16. The adjacent diagram (Fig. 1.27) 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.

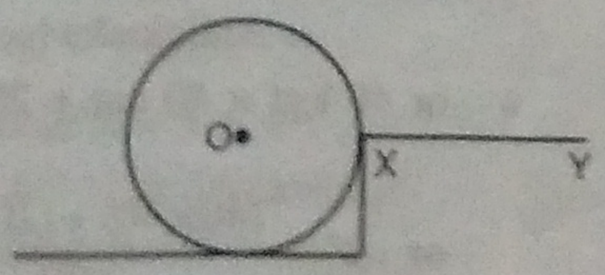


Fig. 1.27

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.

Ans. (a) Resultant force = 0, moment of forces = 0, no motion (ii) Resultant force = 0, moment of forces = Fr. The forces tend to rotate the body about the mid-point between the two forces,

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.
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.
20. Define moment of couple. Write its S.I. unit.
21. Prove that
Moment of couple = Force × couple arm.
22. What do you mean by equilibrium of a body ?
23. State the condition when a body is in (i) static, (ii) dynamic, equilibrium. Give *one* example each of static and dynamic equilibrium.
24. State *two* conditions for a body, acted upon by several forces, to be in equilibrium.
25. State the principle of moments. Name *one* device based on it.
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.
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.

Ans. (i) N m (ii) zero (iii) static (iv) dynamic

MULTIPLE CHOICE TYPE

1. 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.

Ans. (d) 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 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.

Ans. (d) the body will have rotational as well as translational motion

NUMERICALS

[*Note :* For a uniform rod, its weight acts at its mid-point.]

1. The moment of a force of 10 N about a fixed point O is 5 N m. Calculate the distance of the point O from the line of action of the force. **Ans.** 0·5 m

2. A nut is opened by a wrench of length 10 cm. If the least force required is 5·0 N, find the moment of force needed to turn the nut. **Ans.** 0·5 N m

3. A wheel of diameter 2 m is shown in Fig. 1.28 with axle at O. A force $F = 2$ N 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.

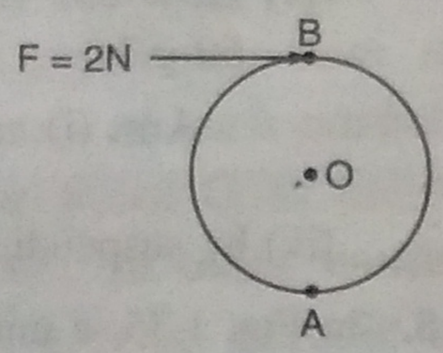


Fig. 1.28

Ans. (i) 2 N m (clockwise), (ii) 4 N m (clockwise)

4. The diagram in Fig. 1.29 shows two forces $F_1 = 5$ N and $F_2 = 3$ N acting at points A and B of a rod pivoted at a point O, such that OA = 2 m and OB = 4 m.

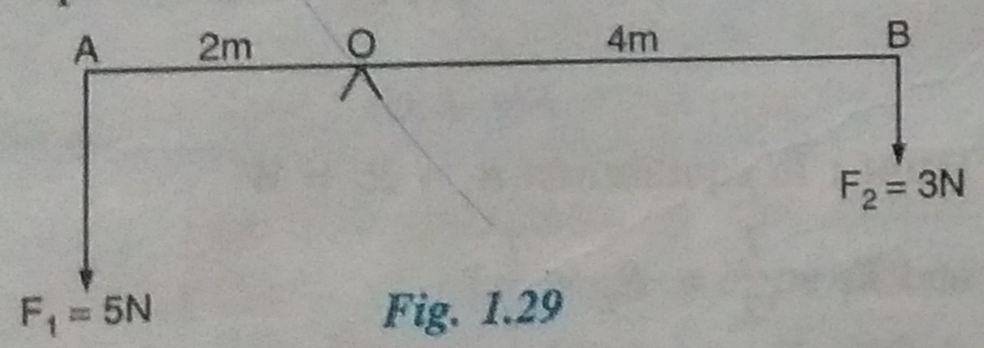


Fig. 1.29

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.

Ans. (i) 10 N m (anticlockwise), (ii) 12 N m (clockwise), (iii) 2 N m (clockwise).

5. Two forces each of magnitude 10 N act vertically upwards and downwards respectively at the two ends A and B of a uniform rod of length 4 m which is pivoted at its mid point O as shown in Fig. 1.30. Determine the magnitude of resultant moment of forces about the pivot O.

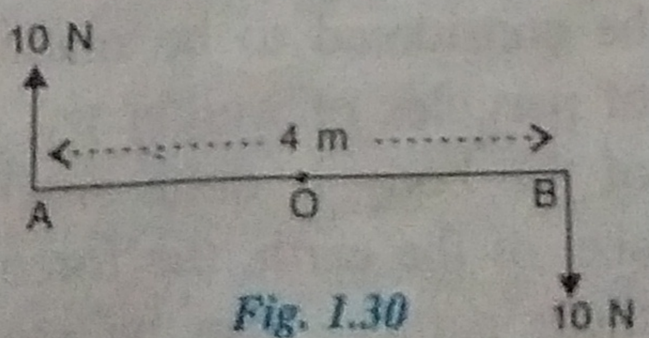


Fig. 1.30

Ans. 40 N m (clockwise)

6. Fig. 1.31 shows two forces each of magnitude 10 N 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.

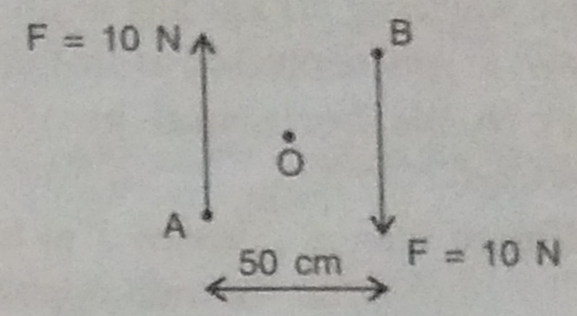


Fig. 1.31

Ans. (i) 5 N m clockwise, (ii) 5 N m clockwise, (iii) 5 N m clockwise

7. A steering wheel of diameter 0·5 m is rotated anticlockwise by applying two forces each of magnitude 5 N. Draw a diagram to show the application of forces and calculate the moment of the forces applied. **Ans.** 2·5 N m

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

Ans. At distance 25 cm from the other end.

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

(i) Draw a diagram of the arrangement.

(ii) What is the weight of the rule ?

Ans. (ii) 105 gf

10. The diagram below (Fig. 1.32) shows a uniform bar supported at the middle point O. A weight of 40 gf is placed at a distance 40 cm to the left of the point O. How can you balance the bar with a weight of 80 gf ?

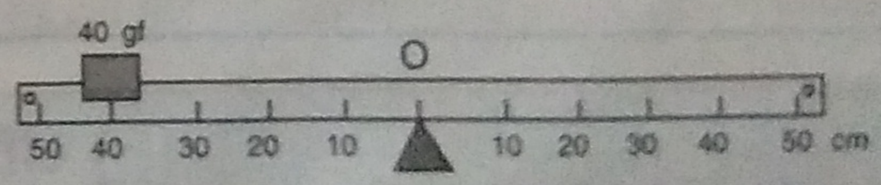


Fig. 1.32

Ans. By placing the weight of 80 gf at a distance 20 cm to the right of the point O.

11. Fig. 1.33 shows a uniform metre rule placed on a fulcrum at its mid-point O and having a weight 40 gf 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