Physics Chapter:06 Equilibrium

MCQS

A body at rest or moves with uniform velocity is said to be _____

A: Motion
B: Equilibrium
C: Static equilibrium
D: Dynamic equilibrium
Answer: B

Dr.Abdus salam was awarded Nobel prize for his work on?

A: Electronics
B: radiation
C: grand unification theory
D: gravitation
Answer: A

If a body is moving with uniform velocity it is said to be in:

A: Neutral Equilibrium
B: Static Equilibrium
C: Dynamic Equilibrium
D: Unstable Equilibrium
Answer: C

Power is the product of

A: Force and velocity
B: Force and energy
C: Force and momentum
D: Fire and velocity
Answer: A

One horse power =

A: 746
B: 550
C: 672
D: 321
Answer: A

States of Equilibrium are _____

A: Stable equilibrium
B: Unstable equilibrium
C: Neutral equilibrium
D: All of them
Answer: D

The unit of a torque in SI system is _____

A: Newton
B: Meter
C: Newton-Meter
D: Pound
Answer: C

A body at rest or moves with uniform velocity is said to be _____

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The Centre Gravity of a uniform rod is _____

A: End of rod
B: Centre of rod
C: Both (a) & (b)
D: None of these
Answer: B

Torque is a _____

A: Scalar quantity
B: Vector quantity
C: Negative quantity
D: None of these
Answer: B

Clockwise torque is considered as _____

A: Positive Torque

B: Negative Torque
C: Unit Torque
D: Zero Torque
Answer: B

Fill in the Blanks

i) Torque is a **vector** quantity.

ii) Conventionally the torque producing counter clockwise rotation is taken as **positive.**

iii) Torque about a axis is the product of **force** and **moment arm**.

iv) An axis about which a body is free to rotate is called **axis of rotation**.

v) If two parallel forces have opposite directions, they are called **unlike** parallel forces.

vi) If the net forces on a body is zero it is said to be in **translational** equilibrium.

vii) In S.I. units, the unit of torque is **newton-meter.**

viii) if the net torque on a body is zero it is said to be in **rotational** equilibrium.

ix) The center of gravity of sphere lies at its **center.**

x) There are **three** states of equilibrium.

xi) A body at rest is said to be in **static** equilibrium.

Questions

Q.1) What do you understand by two like and unlike parallel forces?

Answer:

When a number of forces act on a body and if their directions are parallel, they are called parallel forces. If two parallel forces have the same direction, they are called parallel forces. If two parallel forces have opposite directions, they are called unlike parallel forces.

Q.2) Discuss torque or moment of a force in detail.

Answer:

TORQUE OR MOMENT OF A FORCE:

"The turning effect of the force is known as torque or moment of the force."

DEPENDENCE OF TORQUE:

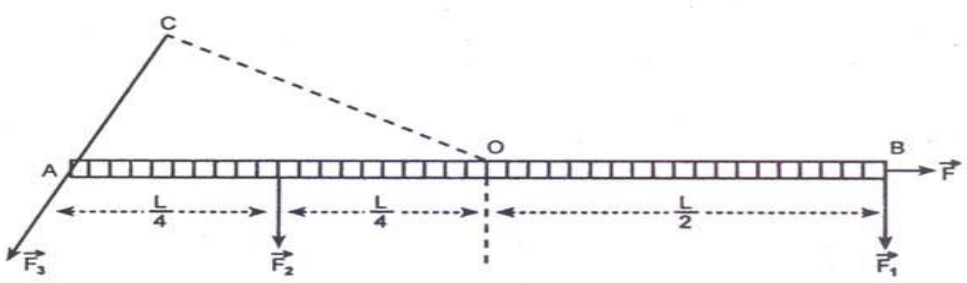
The turning effect produced by a force depends upon

i) The force of a given magnitude and direction. Greater the force, larger will be the torque and vice versa.

ii) The position of the line of action of the force. Larger the distance from axis of rotation, greater will be the torque and vice versa

EXAMPLE:

In order to study the moment arms of the forces acting on a bar AB suppose the bar is capable of rotation about its midpoint O. Let the length of the bar be L as shown in figure.



The moment arm of force F is zero as its line of action passes through the axis at O. The forces F_1 and F_2 act perpendicular to the bar, so their moment arms are L/2 and L/4

respectively. The force F_3 presents a different case. The perpendicular distance from axis of rotation O to the line of action of the force F_3 is OC. Thus OC is the moment arm of force F_3 about O.

MATHEMATICAL RELATION:

The torque or moment of a force about an axis is the product of the force and its moment arm. Thus

Torque = Force x moment arm

Its magnitude is given by

$$\tau = F \times d$$

Where symbol τ is used for torque, F for force and d for moment arm of the force.

CONVENTIONS:

i. A torque which produces a counter-clockwise rotation is considered as positive.

ii. The torque that produces a clockwise rotation is taken as negative.

UNIT:

The unit of torque in S.I. units is newton-meter i.e. N-m.

Q.3) Define Centre of gravity. How would you locate the Centre of gravity of an irregular piece of a metal sheet?

Answer:

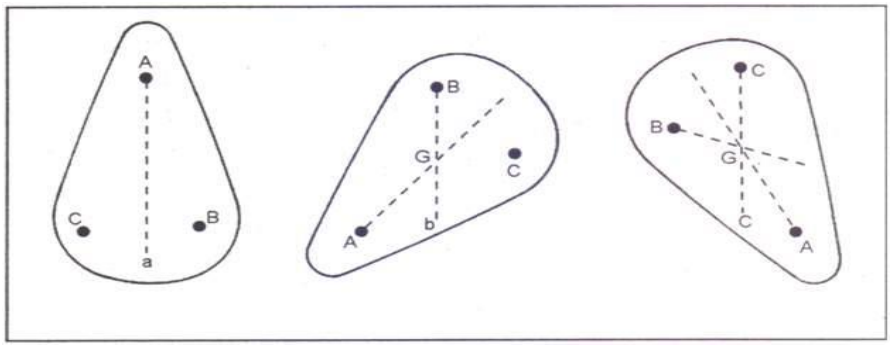
CENTRE OF GRAVITY:

Centre of gravity can be defined as

“It is the point inside or outside a body at which the whole weight of the body is acting.”

Centre of gravity of an irregular shaped body:

Drill three small holes near the edge of the plate whose Centre of gravity located



Suspend the plate from a nail fired horizontally in a wall using one of the holes, say A. When the plate is at rest, suspend a plumb line from the nail. Draw a line Aa on the plate along the plumb line. The Centre of gravity lies somewhere on the line Aa.

Repeat the above procedure with hole B on the nail. Again the Centre of gravity must lie somewhere on the line Bb. The only point common to the lines Aar and Bb is G, therefore this point must be the Centre of gravity. If the plate is suspended using third hole C, the line Cc will also pass through the point G.

Q.4) What is a couple? Calculate the moment of the couple.

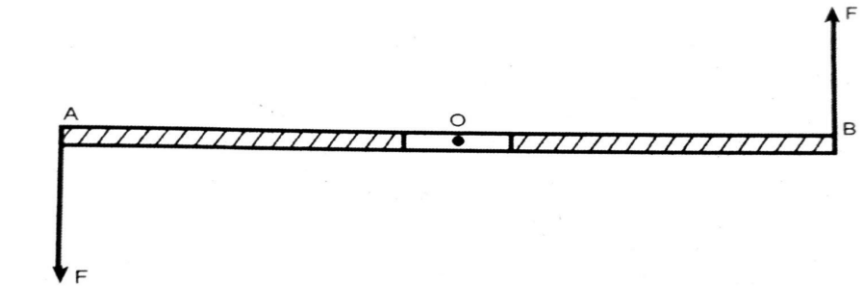
Answer:

COUPLE:

“A pair of equal, parallel and unlike forces having different lines of action, is called a couple.”

EXPLANATION:

Consider two equal, unlike parallel forces, each of magnitude F, acting at A and B, as shown in the figure.



The torques or moments of two forces are given by

The moment of the force F at A = F x OA

The moment of the force F at B = F x OB

Both these moments have the same direction i.e. counter clockwise, so the total moment of the two forces is equal to the sum of the two moments.

∴ Moment of the couple = F x OA + F x OB

= F (OA + OB)

= F x AB

Moment of the couple is equal to the product of one of the forces and perpendicular distance between the lines of action of two forces. This perpendicular distance between the two forces is called the arm of the couple.

Thus the torque or moment of a couple is equal to the product of either d arm of the couple. Whenever a couple acts on a body, there is rotation only.

Note:

It should be noted that a couple cannot be balanced by a single force. It is balanced by an equal and opposite couple.

Q.5) Define static and dynamic equilibrium.

Answer:

Static Equilibrium:

"When a body is in the state of rest then it is said to be in static equilibrium."

Dynamic Equilibrium:

"When a body is in uniform motion along the straight line then it is said to be in dynamic equilibrium."

Q.6) State and explain the two conditions of equilibrium.

Answer:

CONDITIONS OF EQUILIBRIUM:

For a body to remain in equilibrium, it must satisfy two conditions, known as

i) **First condition of equilibrium**

ii) **Second condition of equilibrium.**

First condition of equilibrium:

The first condition of equilibrium states that if a body is in equilibrium, then the vector sum of all the forces acting on the body must be equal to zero.

This can be written mathematically as

$$\Sigma F = F_1 + F_2 + F_3 + \ldots\ldots\ldots = 0 \qquad \ldots\ldots\ldots..(1)$$

The Greek letter sigma means summation. Thus Σ F represents the summation of all the forces F_1, F_2, F_3, ……. acting on the body. It follows from the above statement that the linear acceleration of a body in equilibrium is zero. In two dimensions the first condition of equilibrium leads to the following

$$\Sigma F_x = F_{1x} + F_{2x} + F_{3x} + \ldots\ldots\ldots = 0 \qquad \ldots\ldots\ldots (2)$$

$$\Sigma F_y = F_{1y} + F_{2y} + F_{3y} + \ldots\ldots\ldots = 0 \qquad \ldots\ldots\ldots (3)$$

i.e. if a body is in equilibrium, then the summation of the x-components (F_{lx},F_{2x}, F_{3x},……) of all the forces acting on the body must be equal to zero, and the

summation of the y-components (F_{1y}, F_{2y}, F_{3y},……) of the forces must be equal to zero.

In physics, the first condition of equilibrium is used to determine the magnitude and direction of unknown force acting on a body if all the other forces are known.

When the first condition of equilibrium is satisfied then the body is said to be in translational equilibrium.

Second condition of equilibrium:

The second condition of equilibrium is defined as

"The positive torques that tend to rotate a body counterclockwise must be balanced by equal magnitude negative torques that tend to rotate it clockwise."

Or

"If a body is in equilibrium, then the sum of torques acting on the body must be equal to zero."

This can be written mathematically as

$$\Sigma \tau = \tau_1 + \tau_2 + \tau_3 + \tau_4 + \ldots\ldots\ldots\ldots = 0 \qquad (1)$$

where τ_1, τ_2, τ_3, τ_4,…….. represent the torques caused by all forces F_1, F_2, F_3,…….. acting on the body. It follows from the above statement that the angular acceleration of a body in equilibrium is zero.

Note:

When the second condition of equilibrium is satisfied, the body is said to be in rotational equilibrium. The second condition of equilibrium is also used to calculate the unknown force acting on bodies in equilibrium.

Q.7) Explain three states of equilibrium.

Answer:

STATES OF EQUILIBRIUM:

There are three states of equilibrium of a body. They are (i) stable equilibrium (ii) unstable equilibrium (iii) neutral equilibrium.

i) Stable equilibrium:

A body is said to be in stable equilibrium if it comes back to its original position when it is slightly displaced. For example, a cone standing on its base, as shown in figure.

The Centre of gravity of the cone is nearer the base. When this cone is displaced, its Centre of gravity is raised. A cone in stable equilibrium should have its Centre of gravity as low as possible. The vertical line through its Centre of gravity should be within its base when the cone is disturbed. If the vertical line through the Centre of gravity is within the base, a torque due to weight of the cone brings it back to the original position.

ii) Unstable equilibrium:

A body is said to be in unstable equilibrium, if it does not come back to its original position when it is slightly displaced. A cone balanced on its apex is in unstable equilibrium, as shown in figure.

When this come is disturbed, its Centre of gravity is lowered. The vertical line through its Centre of gravity is outside the base. The torque due to weight of the cone toppled the cone down. So the cone does not regain its original position.

iii) Neutral equilibrium:

A body is said to be in neutral equilibrium if on being slightly displaced, it does not come back to its original position but occupies a new position similar to its original position. The Centre of gravity of the body remains at the same height. A cone resting on its side, as shown in the following figure, is in neutral equilibrium. If the cone is pushed slightly, its Centre of gravity is neither raised nor lowered but it remains at the same height.

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