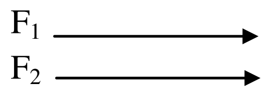
CHAPTER: 4
Turning Effect of Force

Parallel Force:-

Such forces in which point of action are different but line of action are parallel to each other are called parallel force.

Like Parallel Forces:-

Those parallel forces (in which) direction is same are called like parallel force.



Un like Parallel Force:-

A resultant force is a single force that has the same effect as the combined effect of all the forces to be added.

Addition of Forces:-

Force is a vector quantity it has magnitude as well as direction. Therefore different forces cannot be added by ordinary method.

A special method is used to add vector quantities. This method is called "Head to tail rule"

Head to tail Rule:-

According to head to tail rule first of all we will select a suitable scale then we will draw the vectors of all forces according to this scale.

Suppose we have tow vectors A and B and we want to add vector B in to vector A. For this purpose we will draw these two vectors in such a way that head of vector A joins with tail of vector B then we will join tail of vector B with head of Vector A.

A line which joins tail of vector A with head of vector B is called resultant vector.

Rectangular Components:-

Those component of a force which are mutually perpendicular to each other are called rectangular component.

Explanation:-

Consider a force ‘F’ represented by a line OA making an agle with x –axis. Draw a perpendicular AB from point ‘A’ on x-Axis.

According to head to tail rule OA is the resultant of

OB and BA

OA = Ob + BA

The component OB and BA are perpendicular to each other so they are called rectangular components of vector OA since the component OB is along x-axis so it is called x-component of the force F and its is represented by Fx.

Since the component BA is along y axis so it is called y – component of vector F and it is represented by fy

Now from eq (1)

$$OA = OB + BA$$

$$F = Fx + Fy$$

The magnitude of Fx and Fy can be found by using trigonometric ratios.

In right angle triangle OA is

We know

$$\text{Sin } \theta = \frac{P}{H}$$

$$\text{Sin } \theta = \frac{Fy}{F}$$

$$F \text{ Sin } \theta = Fy$$

$$Fy = F \text{ Sin } \theta \text{ (-)}$$

Fy = F Sin θ (-)

Now

$\cos\theta = \frac{B}{H}$

$\cos\theta = \frac{Fx}{F}$

$\cos\theta = \underline{Fx}$

$Fx = F\cos\theta$

$$Fx = F\cos\theta$$

Determination of a Force from the perpendicular components:-

By using rectangular components we can find magnitude of resultant force

Using Pythagoras theorem

$(H) \neq (B)^2 + (F)^2$

$(H) \neq (Fx)^2 + (Fy)^2$

Taking square root

$\sqrt{(F)^2} = \sqrt{(Fx)^2 + (Fy)^2}$

$F = \sqrt{(Fx)^2 + (Fy)^2}$

$F = \sqrt{(Fx)^2 + (Fy)^2}$

Direction of resultant force:-

We know

$\tan\theta = \frac{P}{B}$

$\tan\theta = \frac{Fy}{Fx}$

$\tan\theta\ \tan^{-1}\left(\frac{Fy}{Fx}\right)$

$$\theta = \text{Tan-1}\left(\frac{Fy}{Fx}\right)$$

Riged Body:-

A body is composed of large number of small particles if the distance between all pair of particles does not change by applying forces then it is called a rigid body.

OR

Such a body which retains its shape and size by applying a force is called a rigid body.

Axis of Rotation:-

A line around which a body moves or rotates is called axis of rotation.

Torque or Moment of Force:-

The turning effect of a force is called torque or moment of force. Mathematically it is defined as "The product of force and moment arm is called torque".

Formula:-

Torque = (moment arm) (force)

$T = r \times F$

Quantity:-

Torque is a vector quantity.

Dependence of Torque:-

Torque depends upon two factors.

1. Force
2. Moment arm

Moment Arm:-

Moment arm is the perpendicular distance from point of action of force to point of rotation.

Clock Wise Torque:-

If the rotation produced in a body is in clock wise direction then the torque produced in the body is called clock wise torque.

Anti Clock Wise Torque:-

If the rotation produced in a body is in anti clock wise direction then the torque produced in the body is called anti clock wise torque.

Principle of Momentum:-

If the sum of clock wise torque is equal to the sum of anti clock wise torque then a body is balanced and it is called principle of moments.

Center of Mass:-

Centre of mass of a mass of a system is such a point where an applied force causes the system to move without rotation.

Centre of Gravity:-

A point where whole weight of the body appears to act vertically downward is called centre of the gravity of the body.

Couple:-

A couple is formed by two parallel forces of the same magnitude but not along the same line.

OR

When two equal, opposite and parallel forces act at two different points of the same body then they form a couple.

Example:-

1. While driving a car the forces applied on streering wheel of the car forms a couple.

2. To open or close a water tap a couple is applied.

Equilibrium:-

A body is said to be in equilibrium. If no net force acts on it.

If a body is in equilibrium then it means that this body is at rest or moving with uniform velocity.

Condition of Equilibrium:-

There are two conditions of equilibrium.

1. First condition of equilibrium.

2. Second condition of equilibrium.

1. First Condition of Equilibrium:-

According to first condition of equilibrium if the resultant of all the forces acting on a body is zero than the body is in equilibrium

$$F1 + F2 + F3 + F4 - - - - \quad Fn = 0$$

$$\Sigma F = o$$

Here Σ (sigma) is a greek letter and it is used to find sum.

According to first condition of equilibrium the sum of all the forces acting along x-axis must be zero and the sum of all the forces acting along y-axis must be zero.

$\Sigma fx = 0$

And

$\Sigma fy = 0$

2. Second Condition of Equilibrium:-

According to second condition of equilibrium the resultant torque of all the forces acting on a body must be zero.

$\Sigma \tau = 0$

States of Equilibrium:-

There are three states of equilibrium.

1. Stable equilibrium
2. Unstable equilibrium

1. Stable Equilibrium:-

A body is said to be in stable equilibrium. If it returns to its previous position after a slight tilt.

2. Un-Stable Equilibrium:-

If a body does not return's to its previous position after a slight tilt then this state of equilibrium is called unstable equilibrium.

3. Neutral Equilibrium:-

If a body remains in its new position when it is disturb from its previous then this state of equilibrium is called neutral equilibrium.