

P-1

B.A./B.Sc. Part-II (sem-4) L.U.

MATHEMATICS - PAPER - II

MECHANICS

UNIT-I Topic- Forces in 3D

E-Content / Lecture - I

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# Definition - When a rigid body is being acted upon by the forces in different directions then we say that the body is under the action of forces in three dimensions.

# If a force  $F$  has components  $F_x$ ,  $F_y$  and  $F_z$  in the directions of  $x$ ,  $y$  and  $z$ -axes respectively. Then we have

$$F^2 = F_x^2 + F_y^2 + F_z^2$$

Also  $F$  acts along a line whose direction cosines are  $\frac{F_x}{F}$ ,  $\frac{F_y}{F}$ ,  $\frac{F_z}{F}$ .

Conversely if the force  $F$  acts along the line having direction cosines  $l, m, n$  then its components are  $lF, mF, nF$  along the  $x, y$  and  $z$ -axes respectively.

⊕  $M = F \cdot p$

where,  $M =$  The moment of the force  $F$  about a point  $P$

$F =$  force

$p =$  Perpendicular distance of  $P$  from the line of action of force.

Remark-

If the force has the tendency to move the body in anticlockwise then the moment of the force is positive and if it has the tendency to move in clockwise then the moment becomes negative.

In 3D, if the the forces has tendency to move the body from  $x$  to  $y$ -axis,  $y$  to  $z$ -axis and  $z$  to  $x$ -axis then the force is said to have a positive moment about the axes.

### Remark -

Any given system of forces acting at different points of a rigid body can be reduced to a single force acting through an arbitrary point and a couple whose axis passes through that point.

### Some Definitions:-

- i) Central axis:- If a system of forces reduced to a single force and a single couple in such a way that the axis of couple coincides with the line of action of the force, here the line is called the central axis.

## ii) Wrench and Pitch →

If a system of forces is reduced to a single force  $R$  and couple having moment  $K$  whose axis coincides with the direction of the force. Then  $(R, K)$  is called the wrench of the system. Hence  $R$  is called the intensity of wrench and the ratio  $K/R$  is called the pitch of the system.

## iii) Screw -

A straight line along with the acting force when considered together with the pitch, is known as screw. A screw is a definite straight line for a definite pitch.

## Remark -

Conditions of equilibrium of rigid body

$$X = Y = Z = L = M = N = 0$$

where  $X, Y, Z$  are components of  $F$ .