INDEX

NAME: Prabin Kumar Swain STD.: Lecturer (Mechanical Engineering) SEC.: ROLL NO.:

S. No.	Date	Title	Page No.	Teacher's Sign./ Remarks
		Sub:- Engineering Mechanics		

SYLLABUS

1. FUNDAMENTALS OF ENGINEERING MECHANICS

1.1 Fundamentals.

Definitions of Mechanics, statics, Dynamics, Rigid bodies.

1.2 Force system.

Definition, classification of force system according to plane & Line of action. characteristics of force & effect of force. principles of Transmissibility & principles of superposition. Action & Reaction forces & concept of free body diagram

1.3 Resolution of a force.

Definition, method of resolution, Types of component forces, perpendicular component & non-perpendicular components.

1.4 composition of forces

Definition, Resultant force, method of composition of forces, such as

1.4.1 analytical method such as Law of parallelogram of forces & method of resolution.

1.4.2 graphical method

introduction, space diagram, vector diagram, polygon Law of forces

1.4.3 Resultant of concurrent, non-concurrent & parallel force system by analytical & graphical method

1.5 Moment of force.

Definition, geometrical meaning of moment of a force, measurement of moment of a force & its SI units classification of moments according to direction of rotation, sign convention, Law of moments, Varignon's theorem, couple definition, SI units, measurement of couple, properties of couple.

2. EQUILIBRIUM

2.1 - Definition, condition of equilibrium, Analytic & graphical conditions of equilibrium for concurrent, non concurrent & free body diagram.

2.2 - Lami's theorem - statement, application for solving various engineering problem.

3. FRICTION

3.1 DEFINITION OF friction, frictional forces, Limiting frictional force, co-efficient of friction, angle of friction, angle of repose, Laws of friction, Advantages & disadvantages of friction.

3.2 Equilibrium of bodies on level plane - force applied on horizontal & inclined plane (UP & down)

3.3 Ladder, Wedge friction.

4. CENTROID & MOMENT OF INERTIA

4.1 centroid - Definition, moment of an area about an axis, centroid of geometrical figures such as squares, rectangles, triangles, circles, semicircle, & quarter circle, centroid of composite figure.

4.2 Moment of inertia - Definition, parallel axis & perpendicular axis Theorems. M.O.I of plane Lamina & different engineering sections.

5. SIMPLE MACHINES

5.1 Definition of simple machine, velocity ratio of simple and compound gear train, explain simple and compound Lifting machine, Define MA, VR & efficiency & state the relation between them, state Law of machine, Reversibility of machine, self Locking Machine.

5.2 Study of simple machines - simple axle & wheel, single purchase crab winch & double purchase crab winch, worm & worm wheel, screw jack.

5.3 Types of hoisting machine like derricks etc. Their use and working principle.

6. DYNAMICS

6.1 Kinematics & kinetics, principles of Dynamics, Newton's Laws of motion, Motion of particle acted upon by a constant force, Equation of motion, De-almbert's principle.

6.2 Work, power, energy & its engineering application, kinetic & potential energy & its application.

{EQUILIBRIUM}

→ Def:- A body is said to be in equilibrium if resultant of a number of forces, acting on a particle is zero.

→ The set of forces whose resultant force ~~will~~ is zero called equilibrium forces.

→ The force, which brings the set of forces in equilibrium is called an equilibrant.

→ So equilibrant is equal to the resultant force in magnitude but opposite in direction.

CONDITIONS OF EQUILIBRIUM

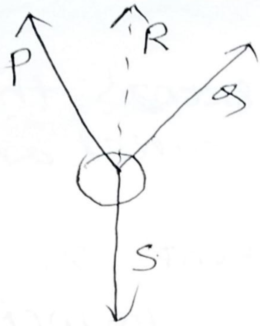
→ a body is in equilibrium if
① Net horizontal force is zero i.e. $\Sigma F_H = 0$
② Net vertical force is zero i.e. $\Sigma F_V = 0$
③ Net moment of force is zero. i.e. $\Sigma M = 0$

PRINCIPLES OF EQUILIBRIUM

ⓐ TWO FORCE MEMBER:- A body acted by two forces is said to be in equilibrium if the two forces are equal in magnitude, opposite in direction and colinear.

(b) ~~THRREE~~ THREE FORCE MEMBER

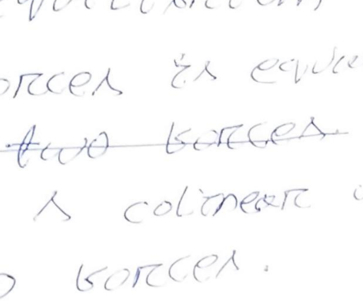
→ a body acted by three forces, is said to be in equilibrium if resultant of ~~these~~ any two forces ~~are~~ equal in magnitude, opposite in direction & colinear with 3rd force.



$$\boxed{R = S}$$

(c) FOUR FORCE MEMBER.

→ a body acted by four forces, is said to be in equilibrium if resultant of any two forces is equal ~~to resultant of other two forces~~ in magnitude, opposite in direction & colinear with resultant of other two forces.



$$\boxed{R_1 = R_2}$$

CONDITION OF EQUILIBRIUM

ⓐ For a body having translatory motion is said to be in equilibrium, if resultant force acting on them is zero i.e. net horizontal force & net vertical force is zero.

$\Sigma H = 0$ & $\Sigma V = 0$

ⓑ A body having pure rotational motion is said to be in equilibrium if resultant moment or net moment on that body is zero

$$\Sigma M = 0$$

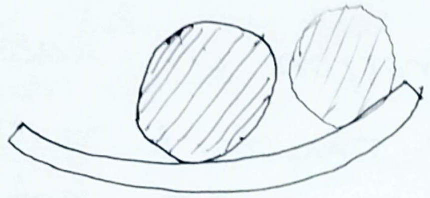
ⓒ a body having both translatory & rotational motion is said to be in equilibrium, if resultant force & resultant moment action on that body, is zero i.e.

$\Sigma H = 0$, $\Sigma V = 0$ & $\Sigma M = 0$

TYPES OF EQUILIBRIUM

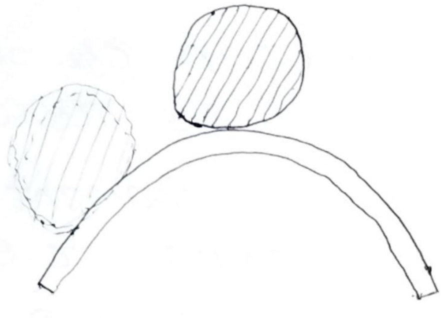
ⓐ STABLE EQUILIBRIUM

→ a body is said to be in stable equilibrium, if the body after slightly displacing from its original position/ position of rest comes back to its original position.



(b) UNSTABLE EQUILIBRIUM

→ a body is said to be in unstable equilibrium, if the body after slightly displacem-
-y from its original position/position of rest does not comes back to its original position

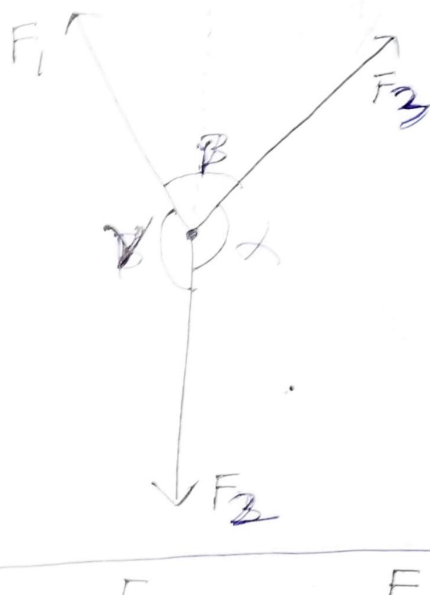


(c) NEUTRAL EQUILIBRIUM.

→ a body is said to be in neutral equilibrium, if the body after slightly displaced from its original position ~~at~~ occupy a new position of equilibrium.

LAMIS THEOREM

→ STATEMENT :- If three coplanar forces acting at a point be in equilibrium, then each force is proportional to the sine of the angle between the other two force.



$$\boxed{\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}}$$

where

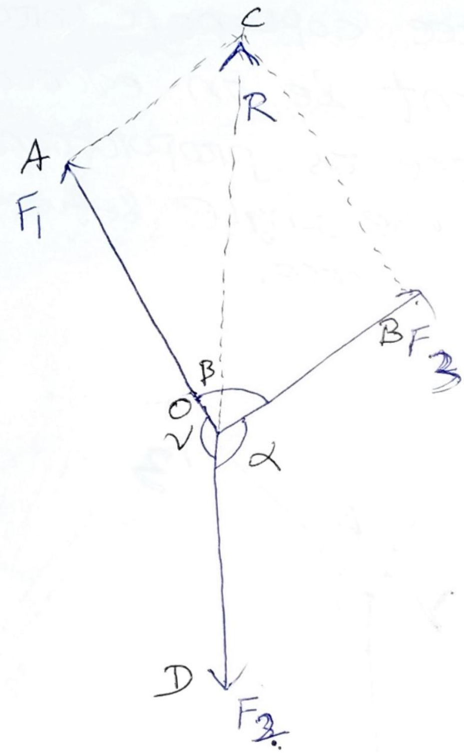
F_1, F_2 & F_3 are three forces

α = angle b/w F_2 & F_3.

β = angle b/w F_1 & F_3

γ = angle b/w F_1 & F_2

proof



→ Let three coplanar forces, F_1, F_2 & F_3 are acting at point 'O'

→ Let OACB be the ~~rector~~ parallelogram by joining OACB.

→ ~~Let~~ F_1 & F_3 are the two forces acting at two sides of parallelogram along OA & OB respectively

→ Then resultant force will be along the diagonal of the parallelogram along OC direction.

→ The point is said to be in equilibrium if

$$\boxed{R = F_2} = OC$$

→ $F_1 = OA$,
$F_2 = OB$

$\angle AOC = 180 - \gamma$

$\angle BOC = 180 - \alpha$.

Then $\angle ACO = \angle BOC$ ($\because$ opposite interior angle)

$\angle ACO = 180 - \alpha$.

so in $\triangle CAO$

$\angle ACO + \angle AOC + \angle CAO = 180^\circ$.

$\Rightarrow 180 - \alpha + 180 - \gamma + \angle CAO = 180$

$\Rightarrow 360 - \alpha - \gamma + \angle CAO = 180$

$\Rightarrow \angle CAO = 180 - 360 + \alpha + \gamma$

$\Rightarrow \angle CAO = \alpha + \gamma - 180$

→ at point "O"

$\alpha + \beta + \gamma = 360$

⇒ subtracting 180 from both sides.

$$\alpha+\beta+\gamma-180 = 360-180$$

$$\Rightarrow (\alpha+\gamma-180)+\beta = 180$$

$$\Rightarrow \angle CAD + \beta = 180$$

$$\Rightarrow \angle CAD = 180-\beta$$

From ΔCAD

~~[illegible]~~

applying sine law

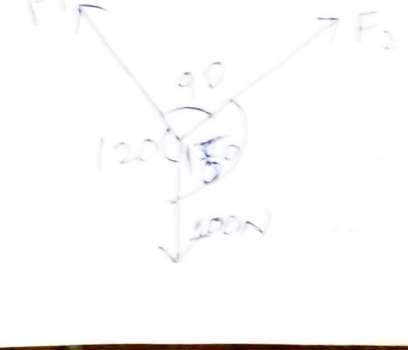
$$\frac{OA}{\sin\angle ACD} = \frac{OC}{\sin\angle CAD} = \frac{AC}{\sin\angle ADC}$$

$$\Rightarrow \frac{F_1}{\sin(180-\alpha)} = \frac{R}{\sin(180-\beta)} = \frac{F_3}{\sin(180-\gamma)}$$

$$\boxed{\frac{F_1}{\sin\alpha} = \frac{F_2}{\sin\beta} = \frac{F_3}{\sin\gamma}}$$ (proved)

problem

① calculate force from following diagram



$F_1 = ?$

$F_2 = ?$

Ans

From Lamis theorem.

$$\frac{F_1}{\sin 130} = \frac{F_2}{\sin 120} = \frac{100N}{\sin 90}$$

$$\Rightarrow \frac{F_1}{\sin 130} = \frac{100}{\sin 90}$$

$$\Rightarrow F_1 = \frac{100}{\sin 90} \times \sin 130^{\circ}$$

$$= 93.97 \text{ KN}$$

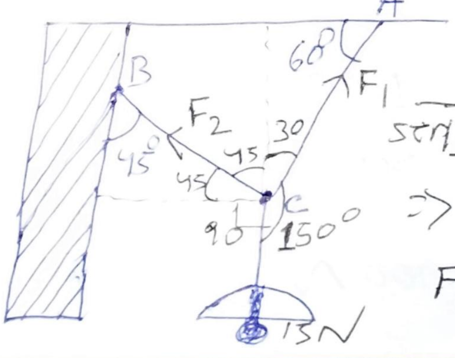
$$\frac{F_2}{\sin 120} = \frac{100}{\sin 90}$$

$$\Rightarrow F_2 = \frac{100}{\sin 90} \times \sin 120$$

$$= 86.6 \text{ N}$$

② An electric light fixture weighting 15N hangs from a point 'C', by two strings AC & BC. The string AC is inclined at 60° to the horizontal and BC at 45° to the horizontal as shown in Figure.

Ans

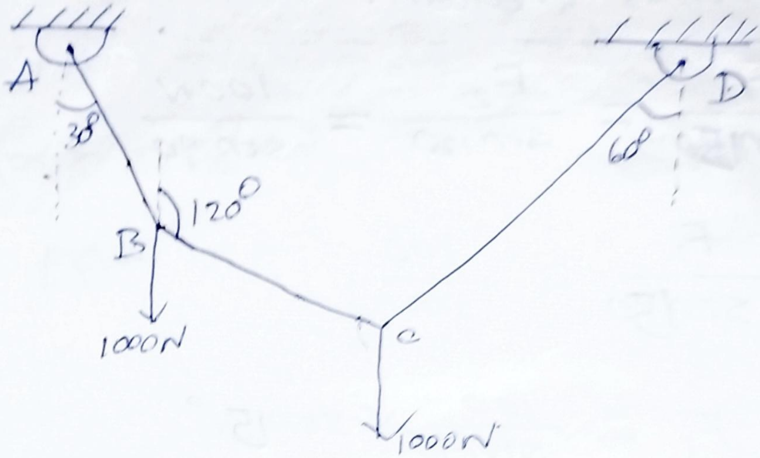


$$\frac{F_1}{\sin 135} = \frac{F_2}{\sin 150} = \frac{15N}{\sin 75}$$

$$\Rightarrow F_1 = \frac{15}{\sin 75} \times \sin 135 = 10.89 \text{ N}$$

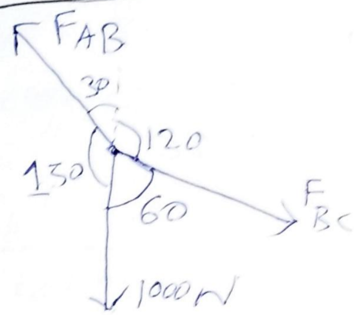
$$F_2 = \frac{15}{\sin 75} \times \sin 150 = 7.76N$$

(3)



Find F_{AB}, F_{BC} & F_{CD} ?

<u>Ans</u> <u>at point -B</u>



$$\frac{F_{AB}}{\sin 60} = \frac{F_{BC}}{\sin 150} = \frac{1000\,N}{\sin 150}$$

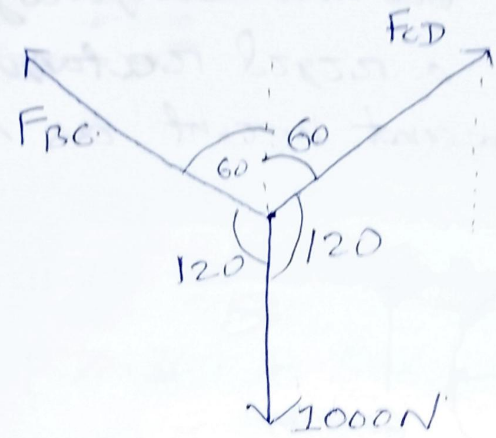
$$\Rightarrow F_{AB} = \frac{1000}{\sin 150} \times \sin 60$$

$$= 1732\ N$$

$$\frac{F_{BC}}{\sin 150} = \frac{1000\,N}{\sin 150}$$

$$\Rightarrow F_{BC} = 1000\ N$$

At point-C



$$\frac{F_{BC}}{\sin 120} = \frac{F_{CD}}{\sin 120} = \frac{1000}{\sin 120}$$

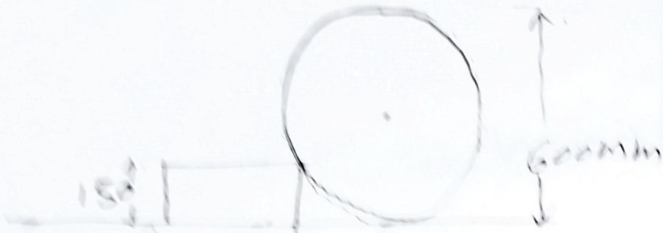
$$\Rightarrow \frac{F_{BC}}{\sin 120} = \frac{1000}{\sin 120}$$

$$\Rightarrow F_{BC} = 1000\,N$$

$$\frac{F_{CD}}{\sin 120} = \frac{1000}{\sin 120}$$

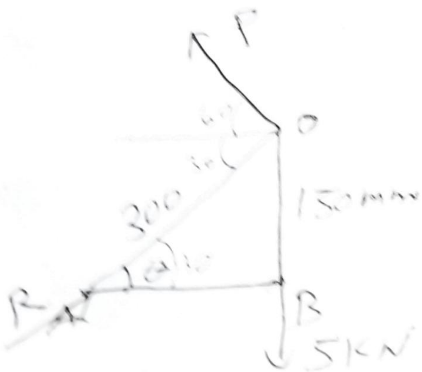
$$\Rightarrow F_{CD} = 1000\,N$$

3 A uniform wheel of 600 mm dia, weighing 5 kN rests against a rigid rectangular block of 150 mm height as shown



Find the least pull, through the centre of the wheel, required just to turn the wheel over the corner A of block. & also find the reaction on the block.

ans



$$\sin\theta = \frac{150}{300} = \frac{1}{2}$$

$$\Rightarrow \theta = \sin^{-1}\left(\frac{1}{2}\right) = 30^\circ$$

$$AB = \sqrt{OA^2 - OB^2}$$

$$= \sqrt{300^2 - 150^2}$$

$$= 260 \text{ mm}$$

Taking moment about 'A'

$$P \times 300 = 5 \times 260$$

$$\Rightarrow P = \frac{5 \times 260}{300}$$

$$= 4.33 \text{ KN}$$

Resolving force horizontally

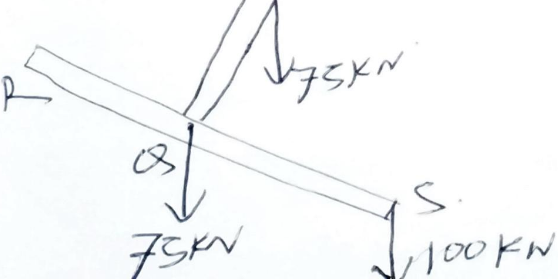
$$R \cos 30 = P \cos 60$$

$$\Rightarrow R = \frac{P \cos 60}{\cos 30} = \frac{4.33 \times \left(\frac{1}{2}\right)}{\sqrt{3}/2}$$

$$= 2.499$$

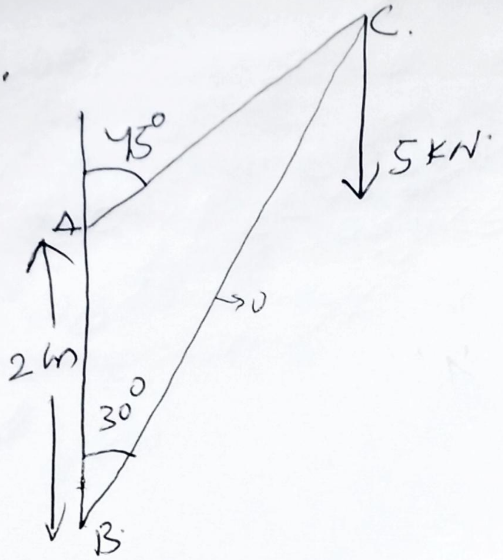
$$\simeq 2.5 \text{ KN}$$

6.



$\theta = 13.25^\circ$

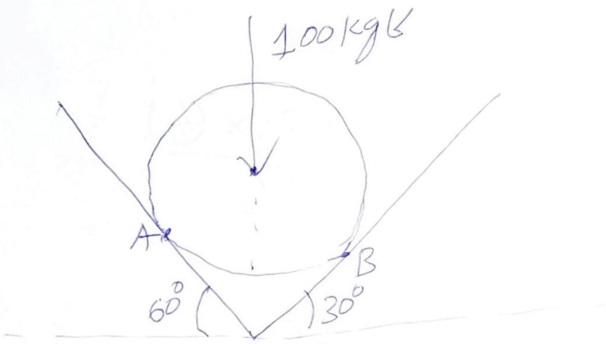
2.



$F_{AC} = ?$

$F_{BC} = ?$

3.



Find Reaction force at point A and B.