$\frac{3000}{\sin(30+\theta)} = \frac{2000}{\sin(120-\theta)} = \frac{P}{\sin(90+\theta)}$

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UNIT-I

Introduction :-

Mechanics is a branch of physical science which deals with the motion of bodies under the action of forces.

Kinematics :-

kinematics deals with the problems related to determination of the nature of motion of bodies.

Kinetics :-

Kinetic deals with the problems which requires the determination of the effect of forces on the motion of bodies.

or

Conversely the forces causing a certain motion.

statics :-

Static deals with the problems concerning the equalibrium of bodies under the effect of forces

Basic Concepts

Space :-

Space is a region which extend in all direction and contains everything in it.

for ex- Sun & stars, planets.

By:

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Time :-

Time is the measure of duration between successive events.

Displacement :-

When a body occupied a fixed position or any length of time it is said to be Statics or at rest during the time interval.

Mass of Body :-

The mass of a body is defined as the quantity of matter contained by it.

Weight of Body :-

This is the force with which the earth attracts a body.

mathematically $w = mg$;

the body with doesn't undergo any change in its dimensions or Slope even after application of forces is called as rigid body.

Scalar Quantity :-

The scalar quantity is one which can be completely specified by it's numerical value

Ex- length, mass, time, temp

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Vector Quantity :-
A vector quantity processes both direction and magnitude
ex- displacement.

Force ⇒
Force is that which changes the state of motion of body.

Equilibrium :-
A body acted upon by a system of forces is said to be in equalibrium if it either remains in a state of rest or continue to move in a straight line with a uniform velocity.

Principle of Equalibrium :-

(1) Two forces principle :-
If a body in equalibrium is acted upon by two forces the must be equal and opposite and colineas.

(2) Three forces principle :-
If the body are acts two forces P & Q that resultant of (R) mathemetic

$$R = \sqrt{P^2 + Q^2}$$

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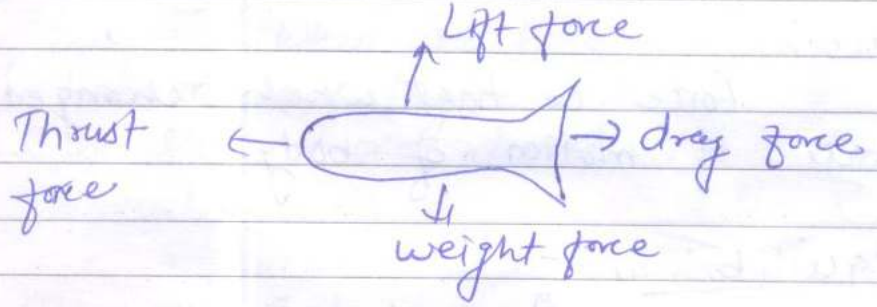
(iii) Fourth force principle :-

It states if a body in equilibrium is acted upon by four force.



Principle of mechanics

(i) Newton's first Law of motion :-

If the any particle will continue move in a straight line with uniform velocity or remain in a state of rest if there is no unbalance force acting on it.

(ii) Newton's second law of motion :-

The acceleration of a given particle is proportional to the impressed force.

mathmetically $f = ma$

(iii) Newton's third law of motion :-

To every action there is an equal and opposite reaction

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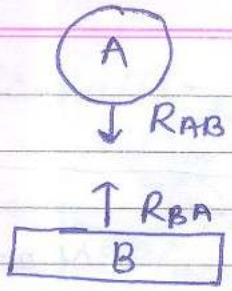


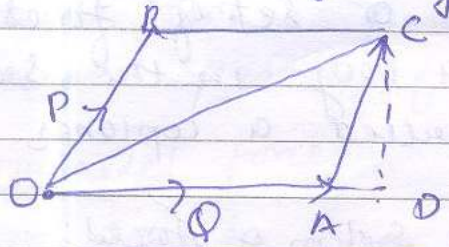
Where R_{BA} reaction on body B by body A
R_{AB} reaction on body A by body B.

(IV) principle | Law of conversion of energy

The principle of conservation of energy states that any Rxn with a system are in a process no energy is either created or destroyed.

(V) Parallelogram Law:-

The parallelogram law is use for the summation of any two vector quantity



$$R = \sqrt{P^2 + Q^2 + 2PQ\cos\theta}$$

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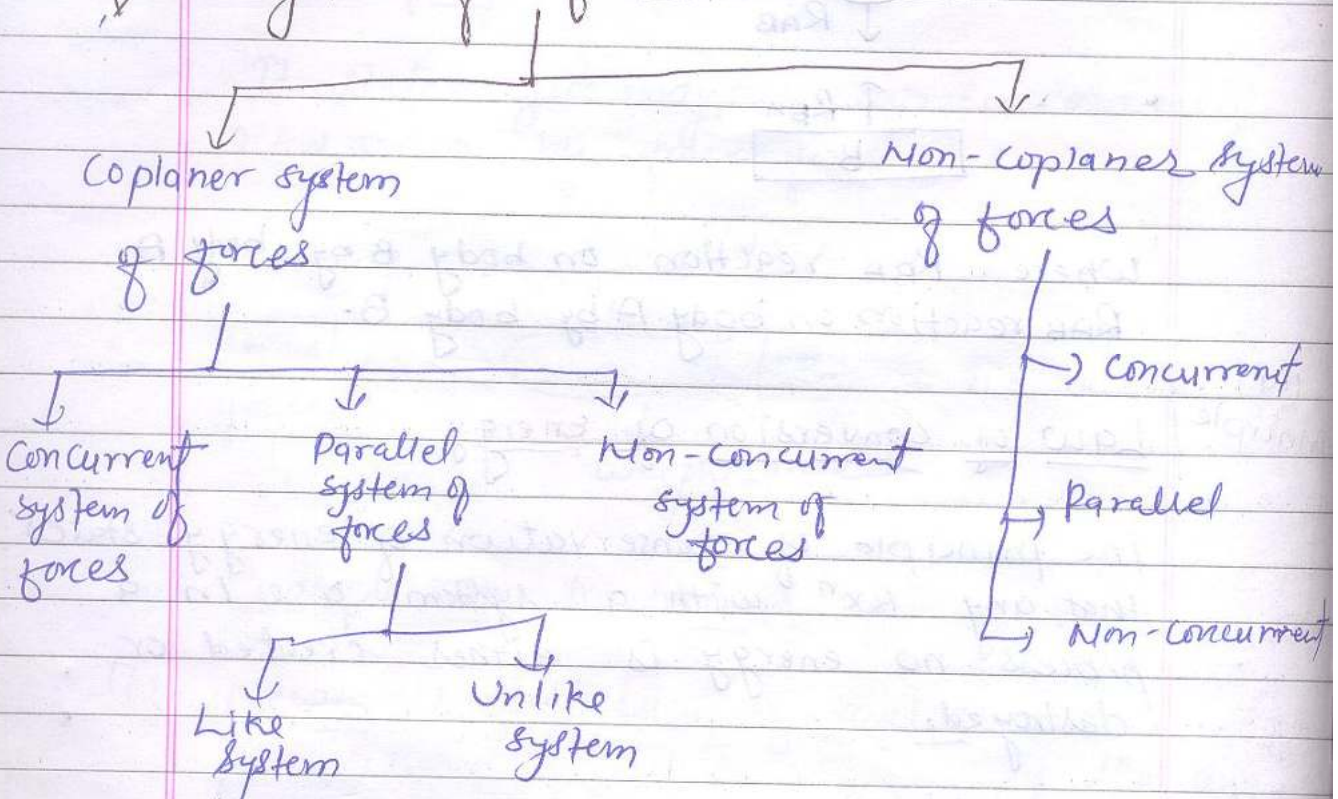
UNIT - 1

System of forces :-



(1) Coplanear System of forces :-
The system in which two or more forces or set of forces acting simultaneously on a body in the same plane then it is called a coplanar forces.

(2) Non-coplanar system of forces :-
The system in which two or more forces or set of forces acting simultaneously on a body don't lie in one plane.

(3) Concurrent forces system :- The system in which forces act at the same

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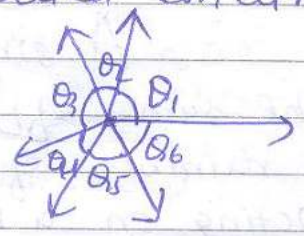
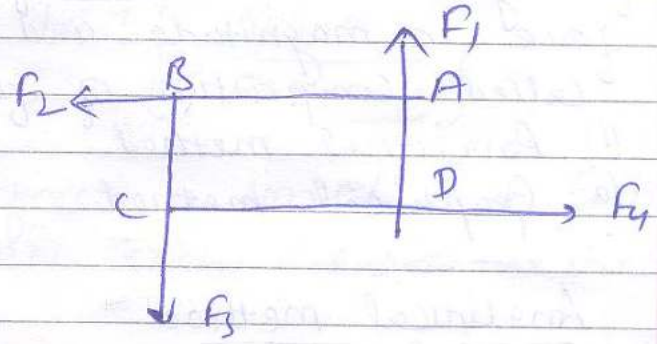
point is called concurrent system of forces



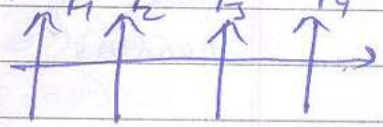
(b) Non-concurrent system of forces:—

The system in which the forces act at a different points is called Non-concurrent forces



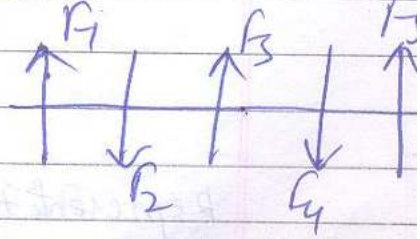
(c) Parallel forces :-

The system in which all the forces remain parallel to each other is called parallel forces.



Like parallel forces

all force act on same direction



unlike parallel forces

All forces doesn't act in same direction

All forces act in opposite direction.

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Resultant force (R) :-

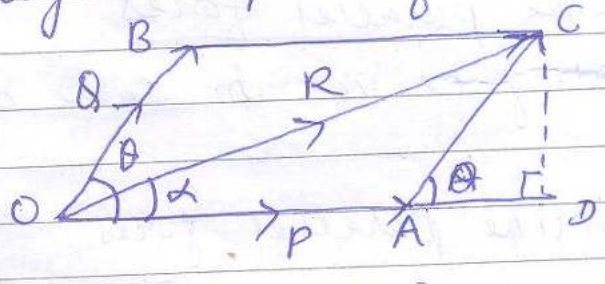
A single force which can produce the same effect as it is produce by the numbes of forces ; The forces system acting on a body is called Resultant forces.

✡ Composition of forces :- method of finding the resultant force or a single force in magnitude and direction is called composition of force

① Analitical method
② Graphical method

① Analytical method

② Law of parallelogram :- If two force acting at a point represented in a magnitude and a direction by the adjeet side of a parallelogram then the diagonal passing through the point of intersection.



Represent the Resultant Both in magnitude and direction $\angle COA = \alpha$

Now $OD = OA + AD$

$OD = P + Q\cos\theta$

$DC = Q\sin\theta$

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$$OC^2 = OD^2 + CD^2$$
$$OC^2 = (P+Q\cos\theta)^2 + (Q\sin\theta)^2$$
$$OC^2 = P^2+Q^2\cos^2\theta + 2PQ\cos\theta + Q^2\sin^2\theta$$
$$OC = \sqrt{P^2+Q^2+2PQ\cos\theta}$$

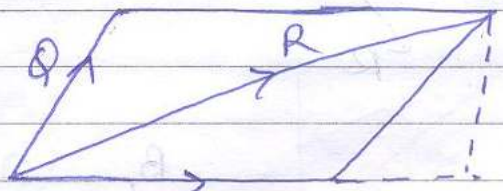
direction of Resultant

$$\tan\alpha = \frac{CD}{OD} = \frac{Q\sin\theta}{P+Q\sin\theta}$$

$$\alpha = \tan^{-1}\left\{\frac{Q\sin\theta}{P+Q\sin\theta}\right\}$$

Q. Resolve a force of 100 N into two component of 200 N each draw the sketch.

Sol Given



$$R^2 = P^2+Q^2+2PQ\cos\theta$$
$$(100)^2 = (200)^2+(200)^2+2(200)(200)\cos\theta$$
$$10{,}000 = 40000+40000+80000\cos\theta$$
$$80000\cos\theta = -70000$$
$$\cos\theta = -7/8$$
$$\theta = \cos^{-1}(-7/8)$$
$$\theta = 151.04$$
$$\alpha = \tan^{-1}\left\{\frac{200\sin\theta}{200+200\cos\theta}\right\}$$
$$= \tan^{-1}\left\{\frac{200\times 0.48}{200(1-0.87)}\right\}$$
$$\alpha = \tan^{-1}\left\{\frac{0.48}{0.13}\right\} = \tan^{-1}\{8.7\}$$

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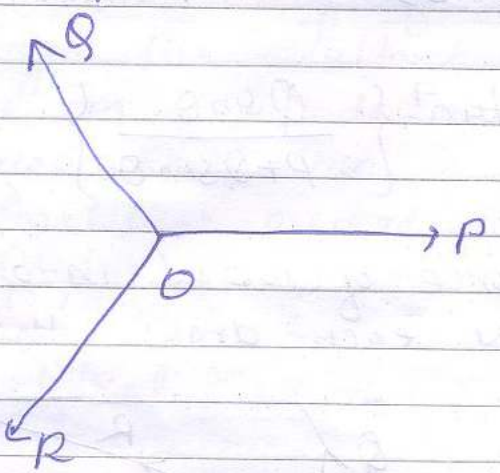
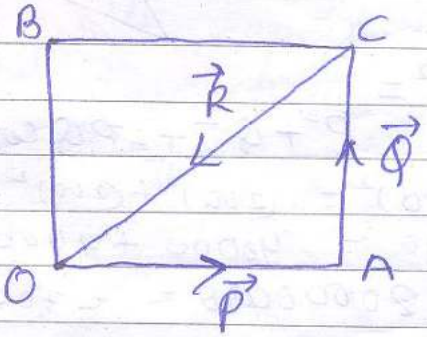
Law of Triangle of forces:-

If 3 forces acting at a point O can be represented in a magnitude and direction by side of a triangle taken in order then they will be in equilibrium





Let on same scale

$\vec{P} = \vec{OA}$

$\vec{Q} = \vec{AC}$

$\vec{R} = \vec{CO} = -\vec{OC}$

$$\vec{P} + \vec{Q} + \vec{R} = \vec{0}$$

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(b) Method of Resolution :-

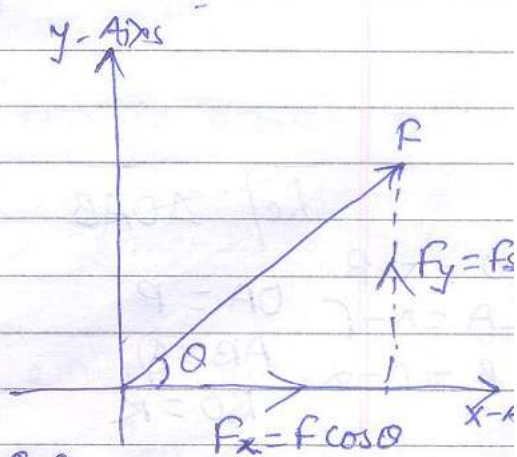
"The method of splitting a force in to its compo without changing the effect on the body is called as resolution of force or method of resolution."

USE :- This method is used to find resultant in magnitude and direction of more than two concurrent forces. A force may be resolved in any two directions.

e.g. 'F' be the force makes an angle 'θ' with horizontal or X-axis

Then

Horizontal Component (F_x)
& Vertical Component (F_y)



$\therefore \sin\theta = \frac{F_y}{F} \quad \therefore F_y = F\sin\theta$

$\cos\theta = \frac{F_x}{F} \quad \therefore F_x = F\cos\theta$

Note Sign convention : For horizontal Components i.e. F

Right = +ve → +
Left = -ve ← -

for vertical Components

upward = +ve + ↑
Downward = -ve ↓

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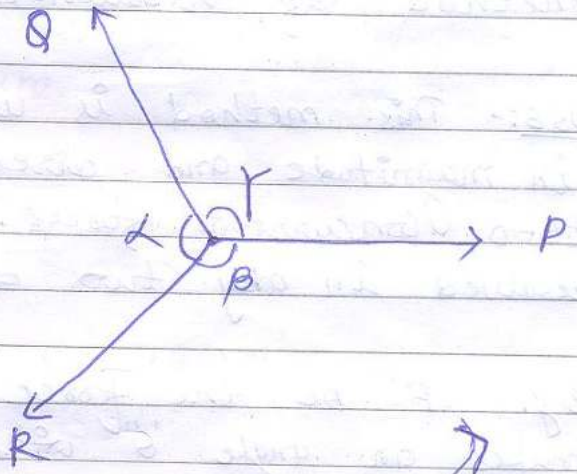
Lamis theorem :-

If three forces active on a particle or an a body kept in equilibrium then each force as proportional to the sine of the angle between the other two forces.

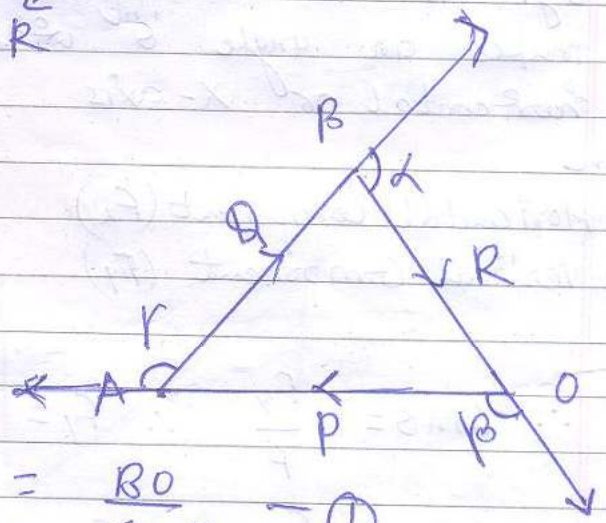


$$\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}$$

Let ΔOAB

$\angle O = \pi - \beta$
$\angle A = \pi - \gamma$
$\angle B = \pi - \alpha$

$OA = P$
$AB = Q$
$BO = R$



$$\frac{OA}{\sin\beta} = \frac{AB}{\sin O} = \frac{BO}{\sin A} \quad \text{--- (1)}$$

Now

$$\frac{P}{\sin(\pi-\alpha)} = \frac{Q}{\sin(\pi-\beta)} = \frac{R}{\sin(\pi-\gamma)}$$

$$\boxed{\frac{P}{\sin\alpha} = \frac{Q}{\sin\beta} = \frac{R}{\sin\gamma}}$$

Hence proved

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Limitations of Lami's theorem :-

① Theire should be three ~~known~~ non-parallel forces acting on a body.

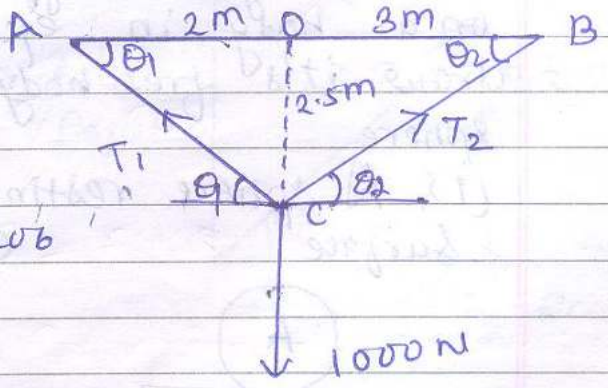
② There three forces acting on a body should be keep the body in equalibrium. (साम्यावस्था)

(3) Three forces are con-current / ~~acting~~ at a point on a body.

(4) The force act away from the point of concourence

(5) The angle between any two forces is less the 180°.

ex- Find the tension in the strings which are supporting a load of 1000N hanging vertically and where the dimensions are given in figure



$AC = \sqrt{4 + 6.25}$

$= \sqrt{10.25} = 3.206$

$CB = \sqrt{9 + 6.25}$

$= 3.905$

$\sin\theta_1 = \frac{2.5}{3.206}$

$\theta_1 = 51.24°$

$\sin\theta_2 = \frac{2.5}{3.905}$, $\theta_2 = 39.81°$

$\angle A = 51.24$

$\angle B = 39.81$

$\angle C = 88.9$

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$$\frac{T_1}{\sin\theta_2} = \frac{T_2}{\sin\theta_1} = \frac{S}{\sin C} \quad \frac{1000}{\sin(\theta_1+\theta_2)}$$

$$\frac{T_1}{\sin(39.86)} = \frac{T_2}{\sin 51.24^\circ} = \frac{S}{\sin 88.9} = \frac{1000}{.999}$$

$$T_1 = \frac{S}{\sin\theta} \quad \frac{1000}{.999} \times .64$$

$$T_1 = 646.46 \text{ N}$$

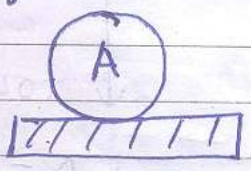
$$T_2 = \frac{1000}{.999} \times .779$$

$$= 787.65 \text{ N}$$

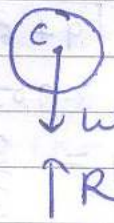
Free Body Diagram :-

If the system containing many bodies is an equalibrium then each body of the system is en equalibrium. To clearly identify the various forces acting on a body in equalibrium we have to draw it's free body diagram. Such as a sphere

(1) A sphere resting on friction less plane surface



(a)



Force W equal to the weight of the sphere

(b) Reaction R at the point of contact with the surface.

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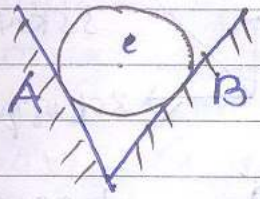
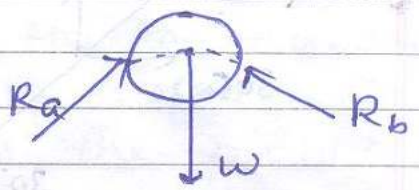
(11) A sphere resting on the grove of V-shap

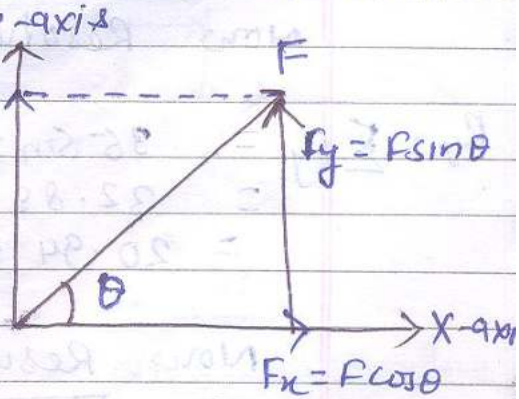




(a) weight of the sphere acting vertically downward direction through it's centre C.
(b) Reaction Ra acting normally to the inclined plane at the contact A and Reaction Rb at the contact B.

Resolution's of forces :→

The method of splitting a force into it's component without changing the effect on the body is called resolution of force



Fx = horizontal compon
Fy = vertical

Fy = FsinΘ

$\sin\theta = F_y/F$

$\cos\theta = F_x/F$

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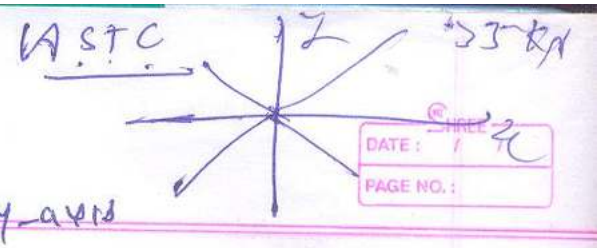
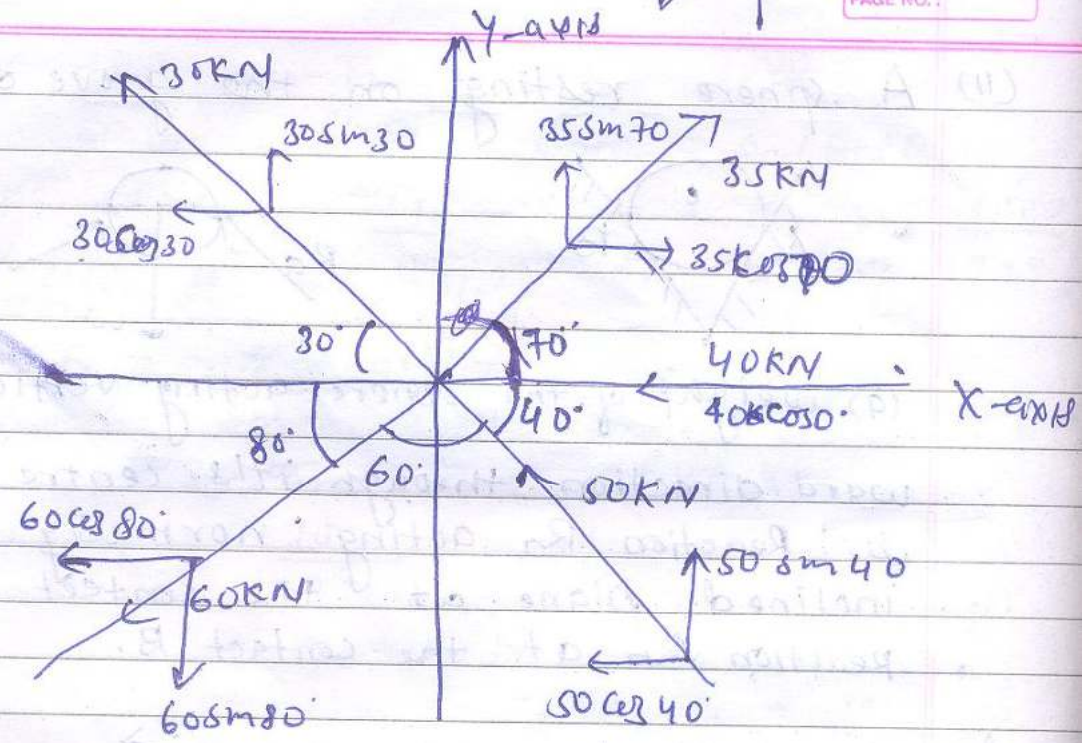
Q solution of the q^n





Horizontal component

$R_x = \Sigma F_x = -40 + 35\cos 70 + 30\cos 30 - 60\cos 80 - 50\cos 40$

$= -40 + 11.97 - 25.98 - 10.41 - 38.30$

$= -102.72$ KN

Now Resolving the vertical component

$R_y = \Sigma F_y = 35\sin 70 + 30\sin 30 - 60\sin 80 + 50\sin 40$

$= 32.88 + 15 - 59.08 + 32.139$

$= 20.94$ KN

Now Resultant

$R = \sqrt{R_x^2 + R_y^2}$

$= \sqrt{(-102.72)^2 + (20.94)^2} = 104.12$ KN

$\tan\alpha = \frac{20.94}{-102.72}$

$\alpha = -11.52°$

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Moment and Couple:-

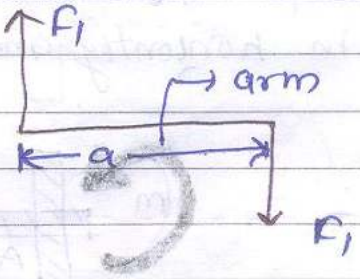
Moment of a force is the measure of turning effect of the force about an axis. Moment "M" of a force F about an axis is defined as the product of the force 'F' and prependicular distance d from the axis of rotation to the lying of action of the force.

$$M = F \cdot d$$

Couple :- A pair of ~~forces~~ two equal and unlike parallel forces i.e. force equal in magnitude with lines of action pasallel of each other and acting in opposite direction is known as couple.

$F_1 = f_1$ for magnitude

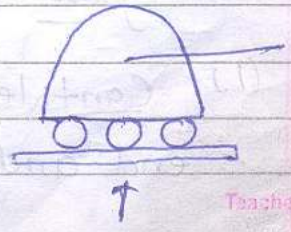
$f_1 = -F_1$ for direction.



Types of ~~Spt~~ supports :-

① Roller supports :-

In such a case the end of beam is supported on rollers and the reaction on such an end is always normal to the support.



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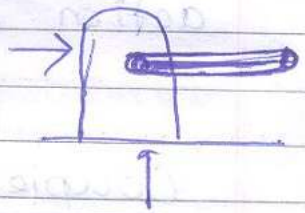
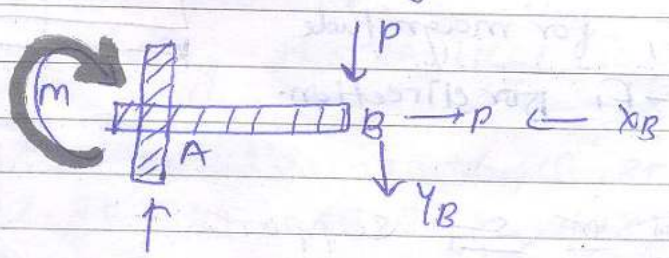
(2) Hinged supports:-

In such a case the end of a beam is hinged to the supports. Supports of this types prevents translation of body but they can't prevent the body from rotating about the connection.



(3) Built in supports:-

If the end A of a beam AB is embeded (rigidly) in the concerent. it restricts the motion of the end A in horizontly and vertically direction.

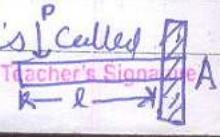


Beam ⇒ A horizontly structure member carrying transverse load is known as Beam.

Column - Compresn membes

Types of Beam:-

(1) Cantilever Beam:- A Beam fixed at one end and free other end is called cantilever beam.



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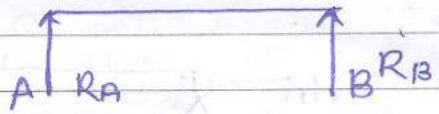
(2) Simply Supported Beam :-

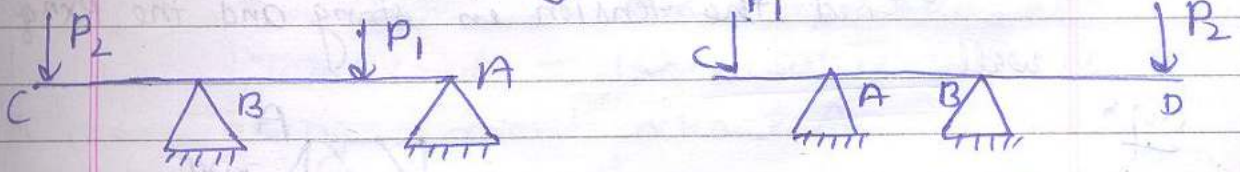
In this types of beam both ends are simply supported ; there is one reaction components at each end (R_A & R_B Rxn) they acts at right angle to the supports.



(3) Overhanging beam :-

If a beam is projecting beyond the supports it is called an overhanging beam.

The overhang may be on only one side or may be both sides.

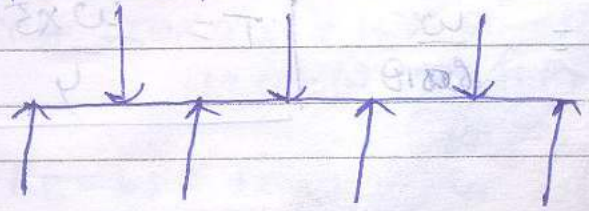


One side over hanging beam

Both sides over hanging beam

(4) Contenuous Beam :-

A beam having three or more supports is called continuous beam. In such beam three or more reactions components exist.



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$\sin(A+B) = \sin A \cos B + \cos A \sin B$

$\sin(30+\theta) = \sin 30 \cos\theta + \cos 30^\circ \sin\theta$

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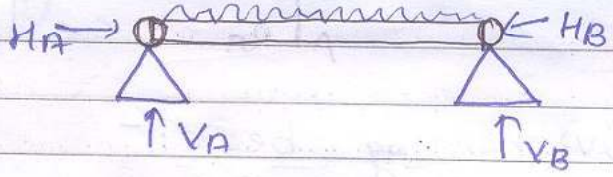
(5) Hing Beam :-

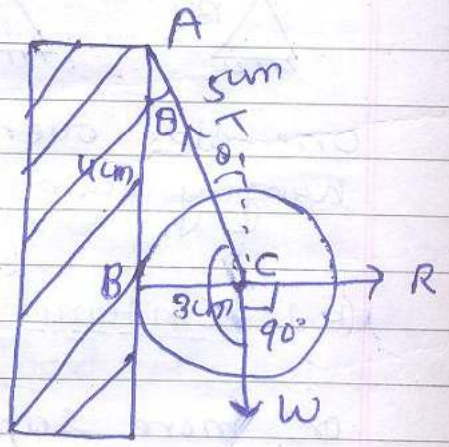
As the name suggest both ends of the beam are hinged. There are two reaction components at each end Hence total reaction components are four



Q A sphere of weight W and radius 3cm is supported against a smooth wall surface by a string length of 5cm. tied to its centre & point 'A' of the wall vertically about B.

Find the tension in string and the Rxn of wall

Sol"



$\sin\theta = \frac{3}{5}$

$\cos\theta = 4/5$

Applying the Lamis theorem

$$\frac{T}{\sin 90} = \frac{R}{\sin(\pi-\theta)} = \frac{W}{\sin(90+\theta)}$$

$$\frac{T}{1} = \frac{W}{\cos\theta}$$

$$\boxed{T = \frac{W \times 5}{4}}$$

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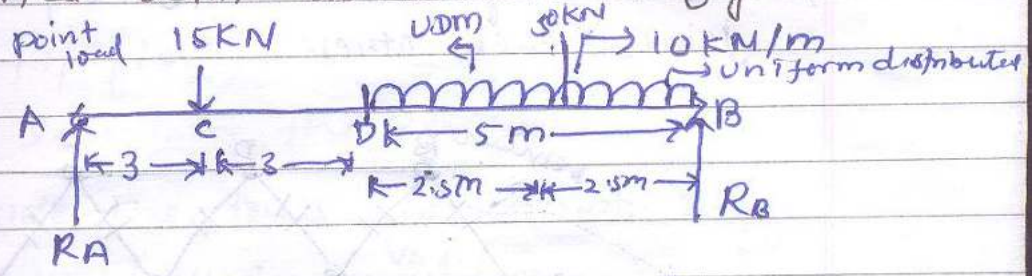
$$\frac{R}{\sin\theta} = \frac{W}{\cos\theta}$$

$$R = \frac{W}{\cos\theta} \times \sin\theta = \frac{W}{4/5} \times \frac{3}{5} = \frac{3}{4}W$$

Q. Find out the Rxn or supports of a simply supported beam as shown in figure



Uniform DL = Point Load / distance

Point Load = UDL X distance

= 10KN/m X 5m

PL = 50KN

$R_A + R_B = 65KN$

Total Load = 15KN + 50KN = 65KN

Taking moment about A

moment = F X Prependicular distance

$$-R_A \times 0 + 15 \times 3 + 8.5 \times 50 - R_B \times 11 = 0$$

$$470 - R_B 11 = 0$$

$$R_B = \frac{470}{11} = 42.72\,KN$$

$$R_A = 65 - 42.72$$

$$= 22.28KN$$

Taking moment about B

$$-R_B \times 0 + 50 \times 2.5 + 15 \times 8 - R_A \times 11 = 0$$

$$125 + 120 - 11R_A = 0$$

$$R_A = 22.27KN$$

$$R_B = 65 - 22.27 = 42.72KN$$

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M, C, E

Ans

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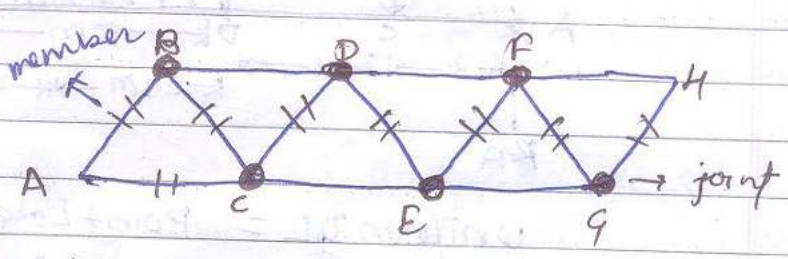
Trusses OR Framed structure :-

A Frame may be define as the structure made up of several bass connected to each other by ribeting or welding.

The simplest stabel frame is a triangle consisting of three ~~members~~ / angles pin jointed each other



* Relation blw number of joint and member in a perfect frame:-

Let there be n number and j joint in a perfect frame.

Suppose we remove three membess AB, BC, AC and three joints A, B & C

Studying this rembering part of the frame we find that the number of member is such that for each joint there are ~~three~~ 2 members

$$(n-3) = 2(j-3)$$

$$\boxed{n = 2j-3}$$

hence for ~~Each~~ a stable frame the minimum number of member requires = twice the no of joints − 3

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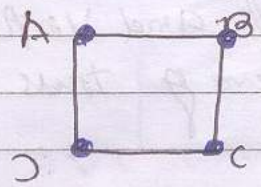
Deficient frame — If $n < 2j-3$

Perfect frame — $n = 2j-3$

Redundant frame — $n > 2j-3$



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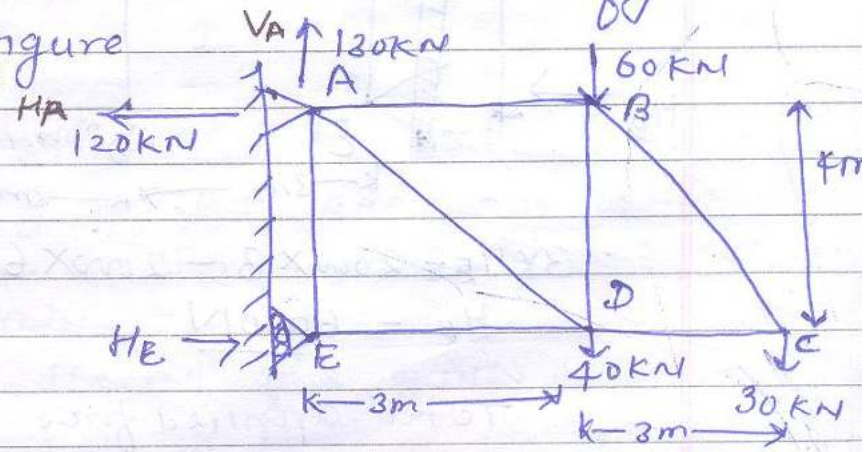
To Determine the Reactions:-

Conside the truss as shown in figure

Shown in figure



The Truss is provided with hinged support A and Roller support E. The reaction at E being vertically and the Reaction at E is horizontly. Hence there will be no verticle reaction at E.

Taking moment about A

$$H_E \times 4 - (60+40)\times 3 - 30\times 6 = 0$$

$$H_E = 120$$

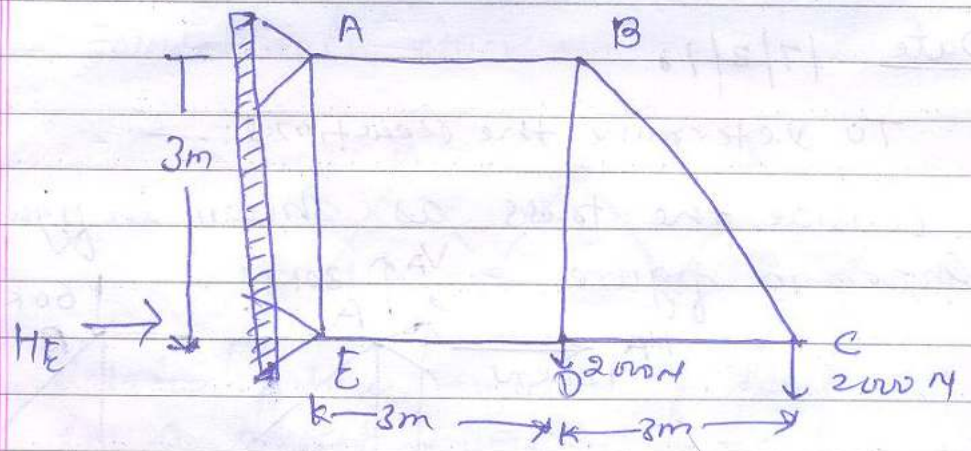
Total applied vertical force $= 60+40+30 = 130$ KN

$V_A = 130\,KN \uparrow$

$H_A = 120\,KN \leftarrow$

Q. To Determine the horizontal and Vertical Reactions in the all the members of truss shown in figure

Soln



$3 \times H_E - 2000 \times 3 - 2000 \times 6 = 0$

$H_E = 6000\,N$

Total applied force $2000 + 2000 = 4000\,N$

$V_A = 4\,KN$

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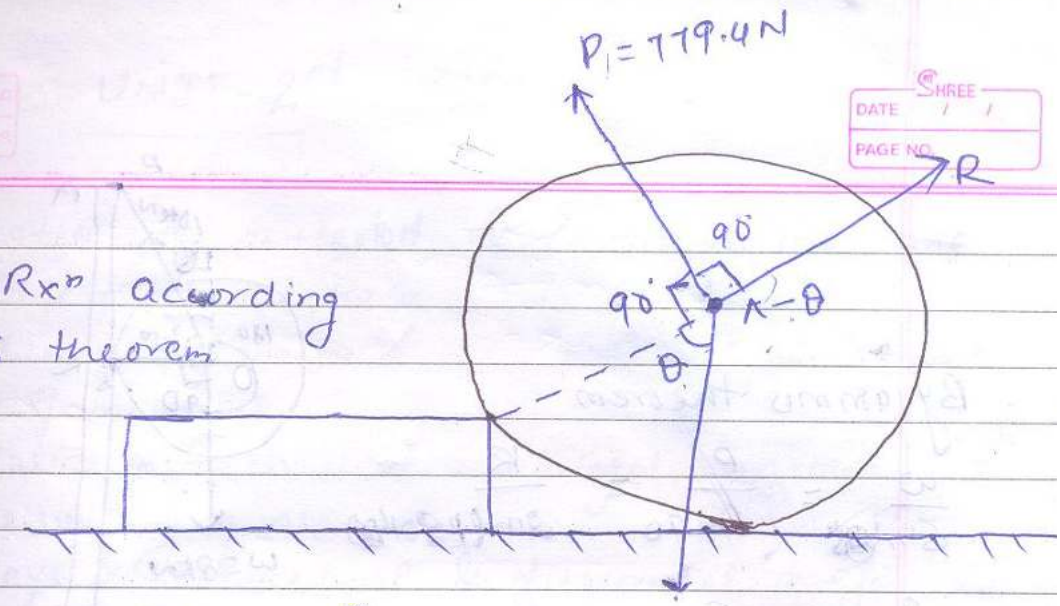
Q

Find the Rxn according to lamis theorem



$$\frac{P}{\sin(180-\theta)} = \frac{W}{\sin 90} = \frac{R}{\sin(90+\theta)}$$

$$\frac{P}{\sin\theta} = \frac{R}{\cos\theta} = \frac{900}{1}$$

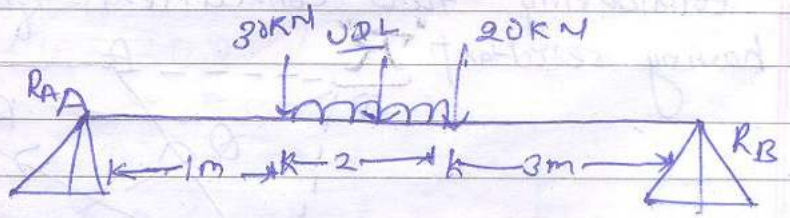
$P = 900 \sin\theta$, $R = 900 \cos\theta$

$\frac{774.9}{900} = \sin\theta$; $R = 900 \times \cos 59.42$

$R = 457.86\ N$

$\theta = 59.42$

Q2 To determine the Rxn of a given 5.5 beam



$PL = UDL \times 2$

$= 10\ KN/m \times 2\ m$

$= 20\ KN$

$R_A + R_B = 70\ KN$

$-R_A \times 0 + 1 \times 30 + \frac{2}{2} \times 2.0 + 20 \times 3 - R_B \times 6 = 0$

$\frac{130}{6} = R_B = 21.66\ KN$

$R_A = 48.34\ KN$

~~$R_B = 48.34\ KN$~~

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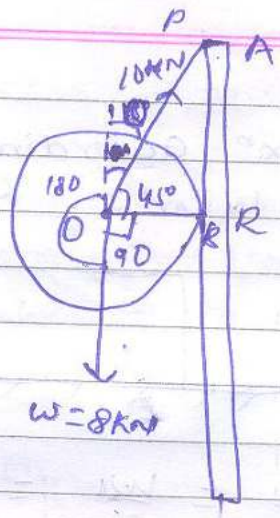


By lammis theorem

$$\frac{W}{\sin\theta} = \frac{P}{\sin 90} = \frac{R}{\sin(180+45)}$$

$$\therefore \frac{8}{1/\sqrt{2}} = \frac{P}{1} = \frac{R}{-\sin 45}$$

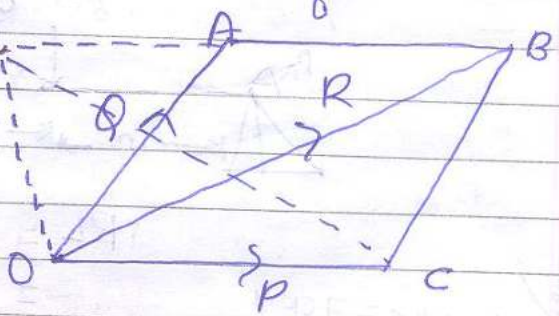
$$-8\sqrt{2} = \frac{R}{\sin\theta} \quad \frac{P}{1} \qquad R = 8N$$

* Varignon's theorem :→

It states that, "The algebraic sum of the moments of the forces about in the plane is equal to the the moment of their resultants about the same plane".

proof

we shall proove the Varignon's theorem by considering two con-current forces P and Q having resultant "R"



Let P & Q be the concurrent forces acting at point "D" Let R be the Resultant of P and Q. Now select a convennient moment centre "D". As per concept of graphical representation of moment.

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UNIT Ist

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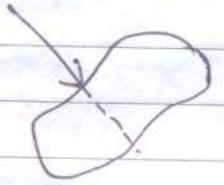
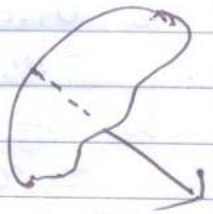
* Principle of Transmissibility :-

The effect of an external force on a rigid body remains unchanged if that force is moved along the its line of action.

NOTE :- This principle is not valid for deformable body.





Condition of Equalibrium :-

If the algebric sum of all external forces and their moment about any point on a body in their plane is zero. Then body will be in equalibrium.

Cond I^st :- The horizontal component of all forces is zero $\Sigma f_x = 0$ and vertical componet of all forces $\Sigma f_y = 0$

Cond II^nd The resultant moment of all the forces $\sum m = 0$

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Q. A uniform ~~watt~~ bar with end rollers has a mass of 50kg. And is supported by horizontal and vertical surface. And by the wire CD as shown in figure

Determine the tension T in the wire and RXn against the rollers at A & B.

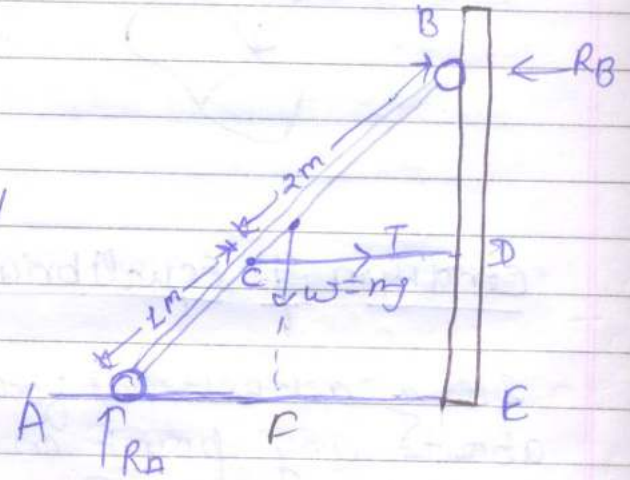
Sol^n As given

$m = 50kg$

$W = 50 \times mg$

$= 50 \times 9.81$

$W = 490.5\ N$



horizontally $\because \Sigma f_x = 0$

$T - R_B = 0$

$\boxed{T = R_B}$ — (1)

NOTE The reaction at each roller is perpendicular to the surface.

Vertically $\Sigma f_y = 0$

$R_A - W = 0$

$\boxed{R_A = 490.5N}$

Taking moment about A

$R_A \times 0 + W \times AE + T \times DE - R_B \times RE = 0$ — (2)

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$AF = 1.5 \cos 60°$

$\boxed{AF = 0.75 \text{ m}}$

$DE = AE \sin 60$

$= (XB) = 0.866$

$\boxed{DE = 0.87}$

$\boxed{BE = 2.598}$

from (1) & (2)

$0 + 490.5 \times 0.75 + R_B \times 0.866 - R_B \times 2.598 = 0$

$\Rightarrow 367.875 - 1.732 R_B = 0$

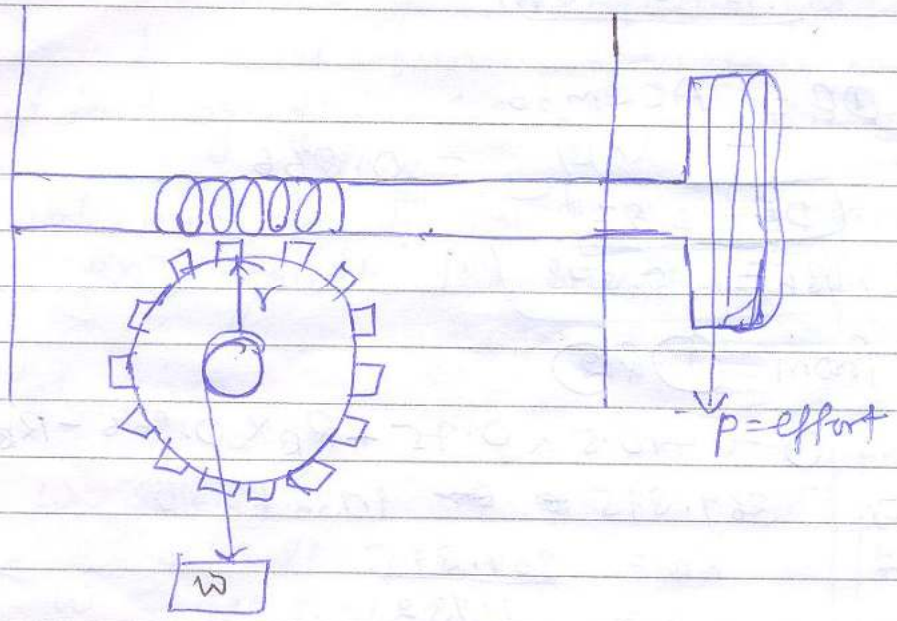
$\Rightarrow R_B = \frac{367.875}{1.732}$

$\boxed{R_B = 212.399 \text{ N}}$

$\boxed{T = R_B}$

Imp

Worm and worm wheel :-



Let R be the radius of effort wheel r be the radius of load drum (worm). T be no of teeth on the worm W be the load lifted and P be the effort applied. In one revolution of effort wheel the distance moved by the effort $= 2\pi R$.

If the worm is n threaded then for one revolution of the effort wheel the worm wheel also complete one revolution. The worm wheel push a work through n teeth. The load drum will move through $\frac{n}{T}$ revolution

Therefore distance moved by the load

$$= 2\pi r\left(\frac{n}{T}\right)$$

$$V.R. = \frac{\text{distance travelled by effort}}{\text{distance travelled by load}}$$

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V.R. = $\frac{2\pi R}{2\pi r\left(\frac{n}{T}\right)}$

$$\boxed{V.R. = \frac{RT}{nr}} \quad \because M.A. = \frac{w}{p}$$

$$\eta = \frac{M.A.}{V.R.}$$

$$\eta = \frac{w}{p} \times \frac{nr}{RT}$$

$$\boxed{\eta = \left(\frac{w}{p}\right)\left(\frac{n}{T}\right)\left(\frac{r}{R}\right)}$$

$\therefore$ V.R. $= \frac{2\pi R}{\frac{2\pi r \cdot n}{T}}$

$= \frac{2\pi RT}{2\pi rn} = \boxed{\frac{RT}{nr}}$

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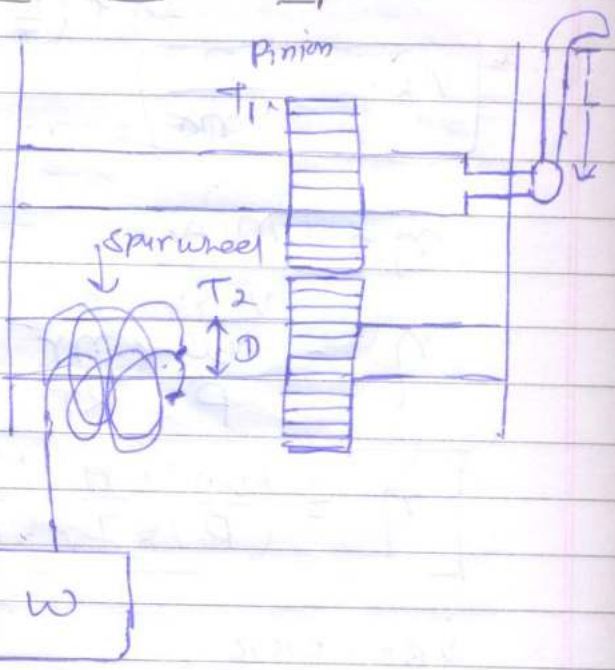
Single purchase winch crap :-



Let T_1 be the no of teeth on the Pinion T_2 be the no of teeth of spur wheel.
L be the length of handle (lever arm)
D is the diameter of load drum.
P be the effort applied and W be the load lifted.

Distance moved by the effort $= 2\pi L$

no of revolution made by pinion is 1.

no of revolution made by spur wheel $= T_1/T_2$

Distance moved by the load $= \pi D\left(\frac{T_1}{T_2}\right)$

Then V.R. $=$ $\frac{\text{distance moved by effort}}{\text{Distance moved by load}}$

$$= \frac{2\pi L}{\pi D(T_1/T_2)}$$

$$\boxed{\text{V.R.} = \frac{2LT_2}{DT_1}}$$

Then $\text{M.A.} = \frac{W}{P}$, $\eta = \frac{\text{M.A.}}{\text{V.R.}}$

$$\boxed{\eta = \frac{W}{P}\,\frac{DT_1}{2LT_2}}$$

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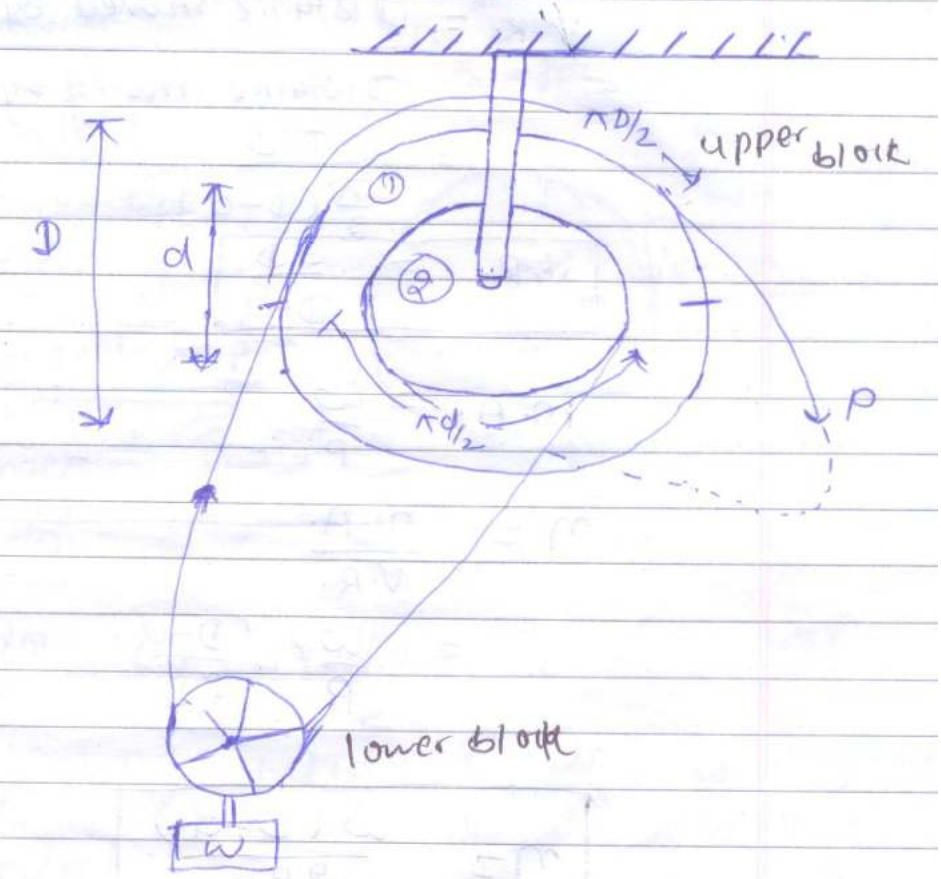
(4) Weston's differential pulley Block :-



$\pi D\left(\frac{r_1}{r_2}\right)$

$\frac{2\pi L}{\pi D\frac{r_1}{r_2}}$ $\frac{2\pi r_2 L}{2\pi D r_1}$

$= \frac{2r_2 L}{D r_1}$

Let P be the effort applied D is the dia of pulley ① and d is dia of pulley ② and W be the load lifted.

For one revolution of upper block displacement with effort is πD. This is also equal to the length of chain that is pulled over the larger pulley.

The distance through which the load will move up is $\frac{\pi}{2}D - \frac{\pi}{2}d$

$\frac{\pi}{2}(D-d)$

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The V.R. is given as.

$$V.R. = \frac{\text{Distance moved by effort}}{\text{Distance moved by load}}$$

$$= \frac{\pi D}{\frac{\pi}{2}(D-d)}$$

$$\boxed{V.R. = \frac{2D}{D-d}}$$

$$M.A. = \frac{W}{P}$$

$$\eta = \frac{M.A.}{V.R.}$$

$$= \frac{W}{P} \times \frac{(D-d)}{2D}$$

$$\boxed{\eta = \frac{W(D-d)}{2PD}}$$

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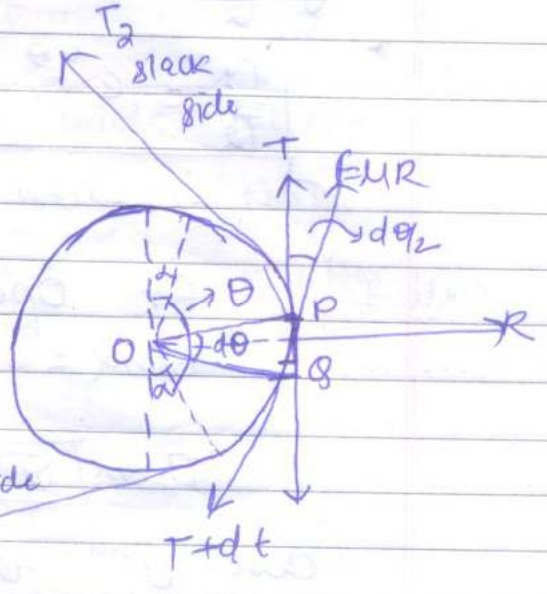
✡ Ratio of tension's for belt drive :-

Let T_1 is tension in right side and t_2 in in slack side.



Let angle of lap $= \theta$

By solving horizontal component

$$R = T\sin\frac{d\theta}{2} + (T+dT)\sin\frac{d\theta}{2}$$

$\because \frac{d\theta}{2}$ is very small

$$\sin\frac{d\theta}{2} \approx \frac{d\theta}{2}$$

$$R = T\frac{d\theta}{2} + (T+dT)\frac{d\theta}{2}$$

$$= T\frac{d\theta}{2} + T\frac{d\theta}{2} + dT\frac{d\theta}{2} \quad \left| \because \frac{dT\,d\theta}{2} \text{ is very small negligible} \right.$$

$$\boxed{R = T\,d\theta} \quad \text{(i)}$$

Now solving vertical component

$$(T+dT)\cos\frac{d\theta}{2} = T\cos\frac{d\theta}{2} + \mu R$$

$\because \frac{d\theta}{2}$ is very small so $\cos\frac{d\theta}{2} \approx 1$

$$(T+dT) = T + \mu R$$

$$\boxed{\mu R = dT} \quad \text{(ii)}$$

from (i) and (ii),

$$\mu T\,d\theta = dT$$

Take tension from T_1 to T_2 and angle 0 to θ then integrate we find

$$\int_{T_2}^{T_1} \frac{dT}{T} = \int_0^{\theta} \mu\,d\theta$$

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$$\log \frac{T_1}{T_2} = \mu\theta$$

$$\boxed{\frac{T_1}{T_2} = e^{\mu\theta}}$$

This is called ratio of tension.

Case Ist For Open Belt Drive

$$\sin\alpha = \frac{r_1 - r_2}{d}$$

Then $\boxed{\theta = 180 - 2\alpha}$

Case IInd for Cross Belt Drive

$$\sin\alpha = \frac{r_1 + r_2}{d}$$

$$\boxed{\theta = 180 + 2\alpha}$$

Q. Two pulleys of dia 300 mm (.3m) and 150mm mounted on two parallel shaft 1.5m apart and connected by the lather belt 150 mm wide. If the max^m safe tension of Belt is 1 kN/mm wide. Determine the max^m power transmitted in case

(I) Cross Belt Drive.

(II) Open Belt Drive.

Assume the speed of Belt as 540 m/min

The coefficient of friction b/w the Belt and pulley rim is 0.25

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Soln $D_1 = 300\ mm = .3m$, $r_1 = 0.15\ m$

$D_2 = 150\ mm = .15m$, $r_2 = 0.075m$

$d = 1.5m$

$T_1 = 1kN/mm$ | $\because$ wide $= 150\ mm$

$T_2 = 1 \times 150\ N = 2100\ N$

$v = 540\ m/m = \frac{540}{60}\ m/s$, $\mu = 0.25$

(i) For cross belt drive

$$\sin\alpha = \frac{r_1 + r_2}{d}$$

$$= \frac{.15 + .075}{1.5} = 0.15$$

$$\boxed{\alpha = 8.62^\circ}$$

$\therefore \theta = 180 + 2\alpha$

$= 197.25 \times \pi/180$

$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$\frac{T_1}{T_2} = e^{0.25 \times 197.25 \times \pi/180}$$

$$\boxed{T_2 = 889.8\ N}$$

$P_{cross} = (T_1 - T_2)\, v$

$= (2100 - 889.8) \times \frac{540}{60}$

$= 10891.8\ W = 10.8\ kW$

(ii) For open belt

$$\alpha = \sin^{-1}\left(\frac{.15 - 0.075}{1.5}\right) =$$

$\alpha = 2.86^\circ$

$\theta = 180 - 2\alpha$, $\boxed{\theta = 174.26}$

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$$\frac{T_1}{T_2} = e^{\mu\theta}$$

$$\mu\theta = 0.25 \times 174 \times \pi/180$$

$$\frac{T_1}{T_2} = e$$

$$= e^{.76}$$

$$T_2 = \frac{2100}{2.13}$$

$$T_2 = 985.91 \text{ N}$$

$$P_{open} = (T_1 - T_2) \times v$$

$$= (2100 - 985.91) \times 9$$

$$= 10,026.76 \text{ watt}$$

$$P_{open} = 10.026 \text{ kW}$$

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