MAHARASHTRA STATE BOARD OF TECHNICAL EDUCATION

(Autonomous)
(ISO/IEC-27001-2005 Certified)

WINTER-12 EXAMINATION

Subject Code: 12015 Model Answer Page No: 01/

Q1- Any ten (2x10=20)

a) Characteristics of force-

i. Magnitude of force
ii. Direction of force
iii. Point of application
iv. Nature of force

01/2 each

b) **Kinetics**-It is branch of dynamics which deals with study of effect of forces with considering mass of body and forces causing motion. (01)

Kinematics- It is branch of dynamics which deals with study of effect of forces with out considering mass of body and forces causing motion. (01)

c) Varignon's theorem of moments- It state that sum of moments of all forces about a point is equal to moment of resultant force about the same point. (02)

d) Law of parallelogram of forces- If two concurrent forces are acting as sides of parallogram then diagonal passing through intersection point of forces will represent resultant force in magnitude and direction. (02)

e) Free body diagram-The diagram by which two or more bodies in contact can be separated from their surrounding is called free body diagram. (02)

f) Equilibrant: It is the force equal in magnitude and opposite in direction and collinear with resultant force. (02)

g) **Advantages of friction**-

i. Side slipping can be easily avoided.
ii. One can move on ground easily
iii. By applying breaks vehicles can stop.
iv. A nail can be driven into wall.

½ EACH

h**) Angle of repose**- it is the angle made by inclined plane with horizontal such that the body placed on it just starts sliding down the plane, due to its own weight.

i) **Centroid:** It is the point on plane figure where whole area is supposed to be concentrated. (01)

Centre of gravity-It is the point on solid body where whole weight is supposed **to** be concentrated. (01)

j)

Simple machine	**Compound machine**
1. A m/c which can lift heavy load with minimum effort.	A m/c which is made up of no. of simple machines.
2. e.g .simple screw jack, simple axle and wheel	e.g.-crane

k) Ideal effort – The effort required to lift a load, when there is no friction is called ideal effort.

Ideal load- The load which can be lifted when there is no friction is called ideal load.

l) Significance of law of machine- Once the law of machine for a particular m/c is known then we can easily find efforts required for any know load lifted by that m/c.

e.g. if law of m/c is P=0.2 W+1.2 N

Then for, W= 5N P=0.2x5+1.2=2.2 N

Q2: Solve any four (4 x 4 = 16)

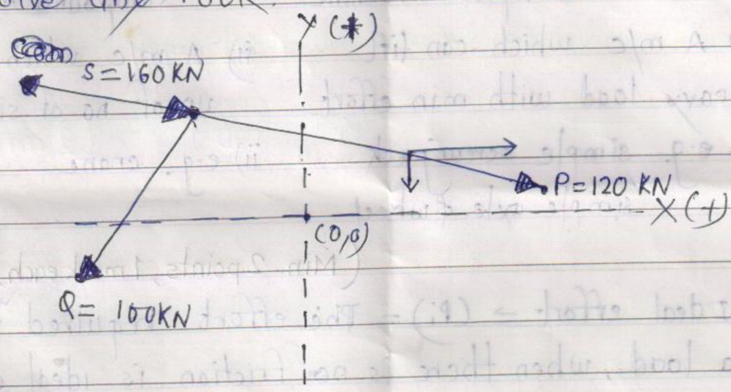
Q 2

a)

(4)

Q. 2 Solve any FOUR.

a)



For $P = 120\,KN$

Points $A(\underset{x_1}{-3}, \underset{y_1}{5})$ & $B(\underset{x_2}{5}, \underset{y_2}{1})$

$$\theta = \tan^{-1}\left|\frac{y_2 - y_1}{x_2 - x_1}\right| = \tan^{-1}\left|\frac{1-5}{5-(-3)}\right| = \tan^{-1}\left|\frac{-4}{8}\right|$$

$$\theta = 26.56^\circ$$

$\therefore F_x = F\cos\theta = 120\cos 26.56^\circ = 107.335\ KN$

$F_y = F\sin\theta = 120\sin 26.56^\circ = 53.656\ KN$

For $Q = 100\ KN$

Points $A(-3,5)$ & $Q = (-5,-3)$

$$\theta = \tan^{-1}\left|\frac{-3-5}{-5-(-3)}\right| = \tan^{-1}\left|\frac{-8}{-2}\right| = 75.96^\circ$$

$F_x = F\cos\theta = 100\cos 75.96 = 24.259\ KN$

$F_y = F\sin\theta = 100\sin 75.96 = 97.012\ KN$

For $S = 160$ KN

Points $D(-7, 6)$, $A(-3, 5)$

$$\theta = \tan^{-1}\left|\frac{5-6}{-3-(-7)}\right| = \tan^{-1}\left|\frac{-1}{4}\right| = 14.036^\circ$$

$$F_x = F\cos\theta = 160\cos 14.03^\circ = 155.222 \text{ KN}$$

$$F_y = F\sin\theta = 160\sin 14.03^\circ = 38.788 \text{ KN}$$

Q.2. b)

$\alpha = \tan^{-1}\frac{2}{3} = 33.69° \simeq$
$\simeq 33.7°$

$\theta = 90 - 33.7 = 56.3°$

$\Sigma Fx = 0$ $\underset{-ve}{\leftarrow} \rightarrow +ve$

$= +60 \cos 56.3° - 85 \cos 56.3° + 55 \cos 56.3° - 95 \cos 56.3°$

$\Sigma Fx = -36.064$

$\Sigma Fy = 0$ $\uparrow +ve$ $\downarrow -ve$

$= +60 \sin 56.3° - 85 \sin 56.3° + 55 \sin 56.3° - 95 \sin 56.3°$

$\Sigma Fy = -54.077$

$R = \sqrt{(\Sigma Fx)^2 + (\Sigma Fy)^2} = \sqrt{(36.064)^2 + (54.077)^2} = 64.999 \simeq 65\,N$

$\theta = \tan^{-1}(\Sigma Fy / \Sigma Fx) = \tan^{-1}\left(\frac{-54.077}{-36.064}\right) = 56.3°$

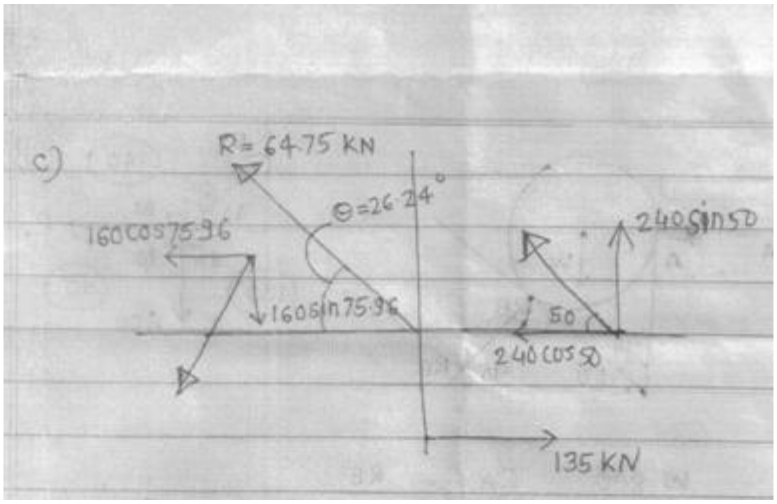
x = Apply Varignon's theorem, @ pt. O

$+85 \sin 56.3 \times 1.4 - 55 \sin 56.3 \times 3 + 95 \sin 56.3 \times 3.9 = (65 \sin 56.3 \times x)$

$99 - 137.27 + 308.23 = 54.077 \times x$

$269.96 = 54.077 \times x$

Q2 c)



For F_1 =160 KN

A (-3,2) =(X_1,Y_1) AND B(-4,-2)= (X_2,Y_2)

$$\Theta = \tan^{-1}\left|\frac{y2-y1}{x2-x1}\right| = \tan^{-1}\left|\frac{-2-2}{-4-(-3)}\right| = 75.96^0$$

$\sum$ Fx=0 -ve $\longleftarrow$ $\longrightarrow$ +ve

= +135 -240cos 50 -160cos 75.96= -58.08 KN

$\sum$ Fy= 0 $\uparrow$ + ve

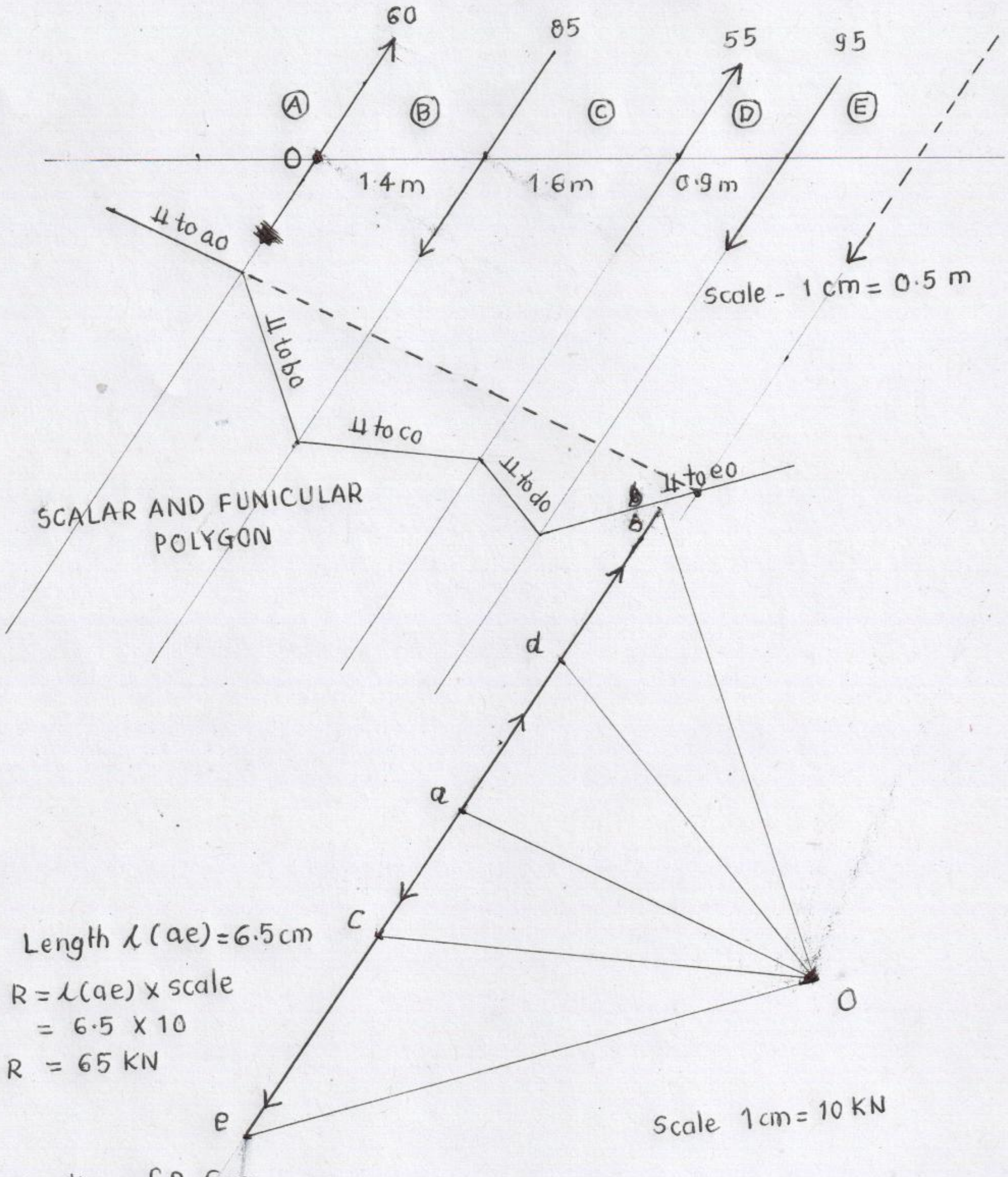
$\downarrow$ - Ve

= +240 sin 50 -160 sin 75.96= +28.63 KN

R= $\sqrt{58.08^2 + 28.63^2}$ = 64.75 KN

$\Theta = \tan^{-1}$ (28.63/58.08)= 26.24^0 W.R.T. POINT “O”

Que: 2 (d)



Length $l(ae) = 6.5\,cm$

$\therefore R = l(ae) \times \text{scale}$

$= 6.5 \times 10$

$R = 65\ KN$

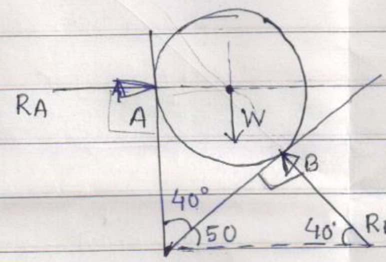
Position of R from point O i.e. x

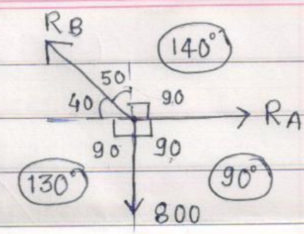
$x = 10\,cm \times 0.5$

$x = 5\,m$

7

e)



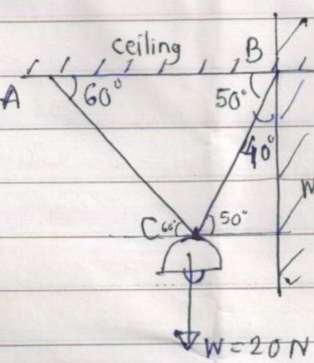


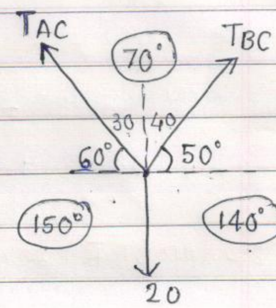
$$\frac{800}{\sin 140} = \frac{R_A}{\sin 130} = \frac{R_B}{\sin 90}$$

$$R_A = \frac{800}{\sin 140} \times \sin 130 = 953.402 \text{ N}$$

$$R_B = \frac{800}{\sin 140} \times \sin 90 = 1244.579 \text{ N}$$

f)





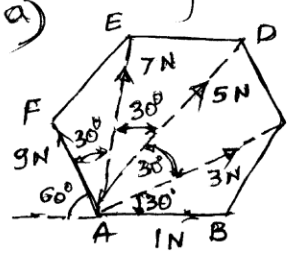
$$\frac{20}{\sin 70} = \frac{T_{AC}}{\sin 140^\circ} = \frac{T_{BC}}{\sin 150^\circ}$$

$$T_{AC} = \frac{20}{\sin 70} \times \sin 140^\circ = 13.680 \text{ N}$$

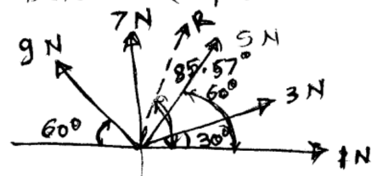
$$T_{BC} = \frac{20}{\sin 70} \times \sin 150^\circ = 10.641 \text{ N}$$

Q.3. Solve any four of the following —

a)



Determine Resultant R = ?



$\Sigma F_x = 1\cos 0^\circ + 3\cos 30^\circ + 5\cos 60^\circ - 9\cos 60^\circ = +1.598$ N

$\Sigma F_y = +3\sin 30^\circ + 5\sin 60^\circ + 7 + 9\sin 60^\circ = +20.624$ N

$$R = \sqrt{(\Sigma F_x)^2 + (\Sigma F_y)^2}$$

$$= \sqrt{(1.598)^2 + (20.624)^2}$$

$$= 20.686 \text{ N}$$

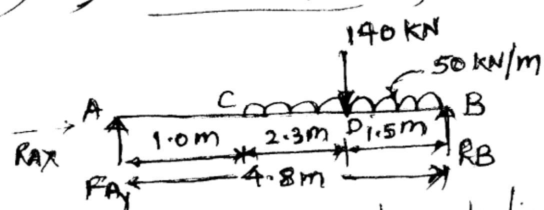
ΣF_x & ΣF_y, both are +ve, R lies in first quadrant.

Direction of Resultant.

$$\tan\alpha = \frac{\Sigma F_y}{\Sigma F_x} = \frac{+20.624}{1.598} = 12.906$$

$$\alpha = \tan^{-1}(12.906) = 85.57^\circ$$

c) Determine Reactions—



$\Sigma F_x = 0$ already satisfied.

$\Sigma F_y = R_A - 140 - 50 \times 3.8 + R_B = 0$

$R_A + R_B = 330$ KN

$\Sigma M @ A = 0$ $\quad 140 \times 3.3 + 50 \times 3.8 \times 2.9 - R_B \times 4.8 = 0$

$462 + 551 - R_B \times 4.8 = 0$

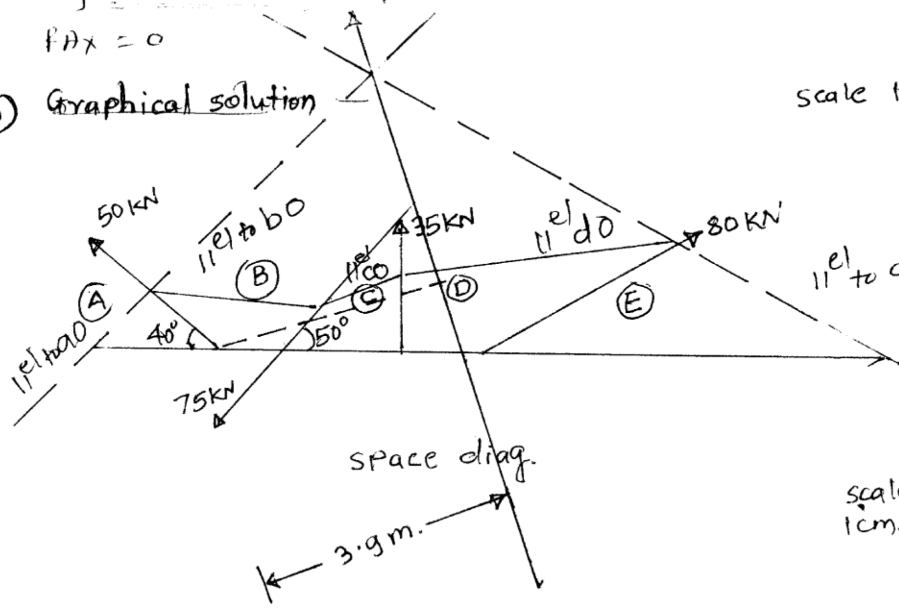
$R_B = 211.04$ KN

$R_{A_y} = 115.96$ kN

$R_{Ax} = 0$

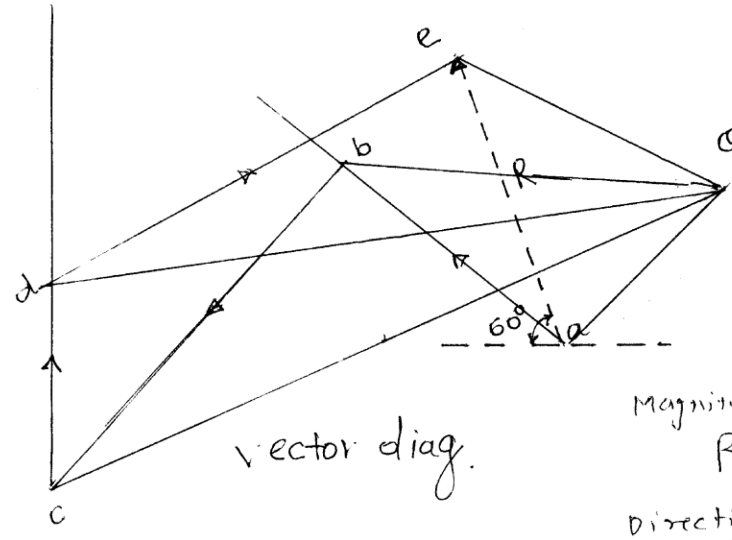
Q.3 b) <u>Graphical solution</u>

scale 1:100



space diag.

scale 1cm=10KN



R= 56 KN

θ = 60°

vector diag.

Magnitude of Resultant

R = <u>56 KN</u>

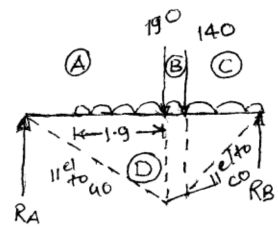
<u>Direction</u> = <u>60°</u> from -ve x-axis

II quad.

position of Resultant is 3.9 m from pt.A

Graphical method

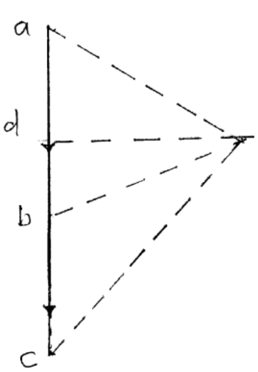
Q.3. d)



scale
1cm = 1m

Space diag. with
funicular polygon

1cm = 50 KN



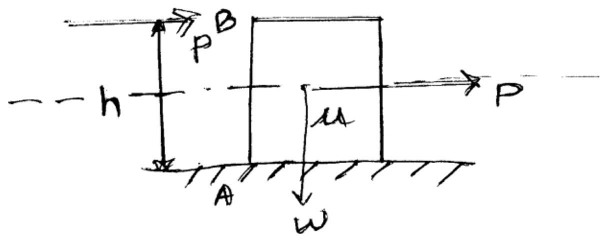
dist. cd = 4.2 × 50 KN
RB = 210 KN

dist. da × 50 KN
i.e.
RA = 2.4 × 50 KN
120 KN

vector diag. with
Polar diag.

RA = 120 KN
RB = 210 KN

Q3 e)



for sliding, the block, P reqd

$P = \mu R = \mu W$

when load is applied at pt. 'B' block will overturns & reaction at 'A' is zero.

$W \times \frac{2b}{2} = P \times h$

$h = \frac{Wb}{P}$

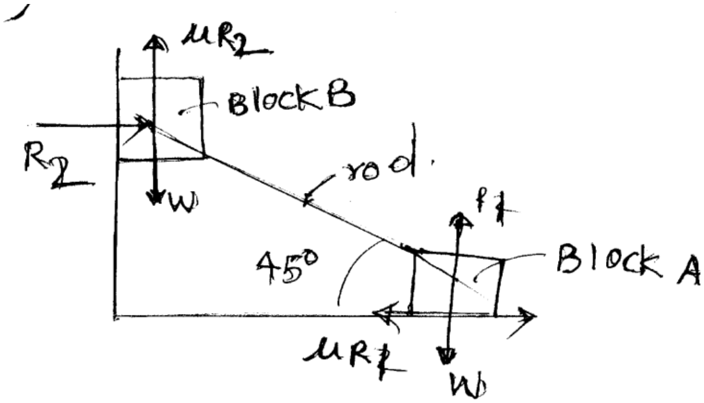
for sliding $P = \mu R = \mu W$

when $h = 2b$ it is equal to the force reqd to overturn. but it make to slide without overturning

$h =$ Half the width i.e $\frac{2b}{2}$

$\boxed{h = \frac{2b}{2} = b}$

Q3 f)



consider FBD of Block B

$\Sigma F_x = 0$ $\quad R_2 + T\cos45^0 = 0$

$$R_2 = -T\cos45^0$$

$\Sigma F_y = 0$

$$\mu R_2 - w - T\sin45^0 = 0$$

$$w = \mu R_2 - T\sin45^0$$

$$w = \mu \times (-T\cos45^0) - T\sin45^0 \quad \text{--- (I)}$$

F.B.D of block A.

$$\Sigma F_x = -\mu R_1 - T\cos45^0 = 0$$

$$-\mu R_1 = T\cos45^0$$

$$\boxed{R_1 = \frac{-T\cos45^0}{\mu}}$$

$\Sigma F_y = 0$ $\quad R_1 - w + T\sin45^0 = 0$

$$-\frac{T\cos45^0}{\mu} - w + T\sin45^0 = 0$$

$$\boxed{w = T\sin45^0 - \frac{T\cos45^0}{\mu}} \quad \text{--- (II)}$$

equating I & II

$$T\sin45^\circ - \frac{T\cos45^\circ}{\mu} = -\mu T\cos45^\circ - T\sin45^\circ$$

$$T\left[\sin45^\circ - \frac{\cos45^\circ}{\mu}\right] = \cancel{T}\left[-\mu\cos45^\circ - \sin45^\circ\right]$$

$$0.71 - \frac{0.71}{\mu} = -\mu \times 0.71 - 0.71$$

$$\frac{0.71\mu - 0.71}{\mu} = 0.71\left[-\mu - 1\right]$$

$$0.71\left[\mu - 1\right] = 0.71 \times \mu(-\mu - 1)$$

$$\mu - 1 = -\mu^2 - \mu$$

$$-\mu^2 - \mu - \mu + 1 = 0$$

$$+\mu^2 + 2\mu - 1 = 0$$

$a = 1$, $b = 2$ $c = -1$

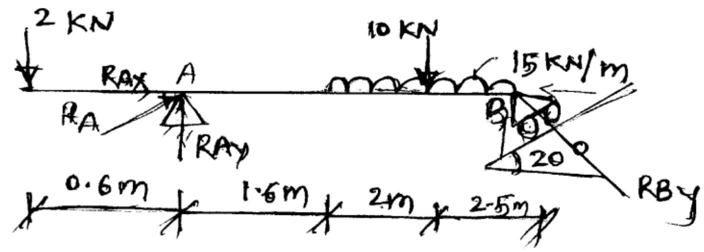
$$\frac{-2 \pm \sqrt{4 - 4 \times (1) \times (-1)}}{2 \times 1}$$

$$\boxed{\mu = 0.415}$$

Q. 4. Solve any two of the following (2 x 8 =16)

Q.4

a)



$\Sigma M @ A = 0$ $\quad -2\times0.6 + 10\times3.6 + 15\times4.5\times3.85$

$- R_{By}\times6.1 = 0.$

$R_B = 48.31\ kN$

$\Sigma f_y = 0$

$-2 + R_A \sin\theta - 10 - 15\times4.5 + R_B \sin70^\circ = 0$

$-34.10 + R_A \sin\theta = 0$

$R_A \sin\theta = 34.10$ ——— (1)

$\Sigma f_x = 0$

$R_A \cos\theta - 48.31 \cos70^\circ = 0$

$R_A \cos\theta = 16.52$ ——— (2)

Divide 1 by (2)

$$\frac{R_A \sin\theta}{R_A \cos\theta} = \frac{34.10}{16.52}$$

$\tan\theta = 2.06$

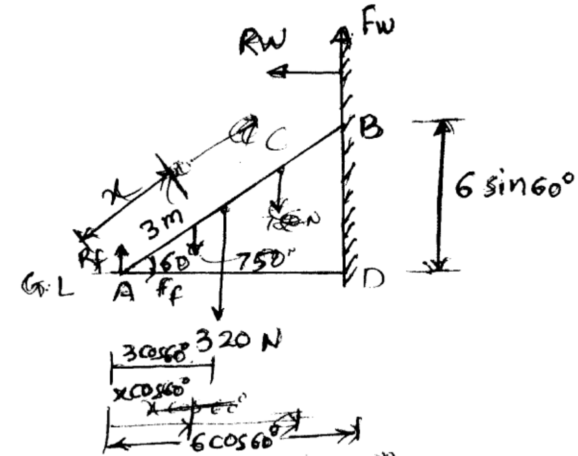
$\theta = 64.11^\circ$

Substitute value θ in eq^n (1)

$R_A \sin 64.11^\circ = 34.10$

$R_A = 37.90\ kN$

Q. 4. b)



$\cos 60° = \frac{x}{3}$

$\sin 60° = \frac{x}{6}$

Applying cond^n of eq^m.

$\underline{\Sigma F_x = 0}$

$$f_f - R_w = 0$$

$$\mu_f R_f - R_w = 0$$

$$0.2\,R_f - R_w = 0$$

$$R_w = 0.2\,R_f \quad \text{or} \quad R_f = \frac{R_w}{0.2} \qquad (1)$$

$\underline{\Sigma F_y = 0}$

$$F_w + R_f - 320 - 750 = 0$$

But $\quad F_w = \mu_w \times R_w = 0.2\,R_w$

$$R_f + 0.2\,R_w - 1070 = 0$$

$$R_f + 0.2\,R_w = 1070 \quad \text{———} \quad (2)$$

$\underline{\Sigma M @ A = 0}$

$$320 \times 3\cos 60° - R_w \times 6\sin 60° - F_w \times 6\cos 60° + 750 \times x\cos 60° = 0$$

$$480 - R_w \times 5.20 - F_w \times 3 + 375\,x = 0$$

$$480 - 5.20\,R_w - 3F_w + 375\,x = 0 \quad \text{———} \quad (3)$$

Put value of R_f from eq^n (1) in eq^n (2)

$$\frac{R_w}{0.2} + 0.2\,R_w = 1070$$

$5R_w + 0.2R_w = 1070$

$5.2R_w = 1070$

$R_w = \underline{205.77\ kN}$

eq^n (3) becomes,

$480 - 5.20R_w - 3 \times \mu_w \times R_w + 375x = 0$

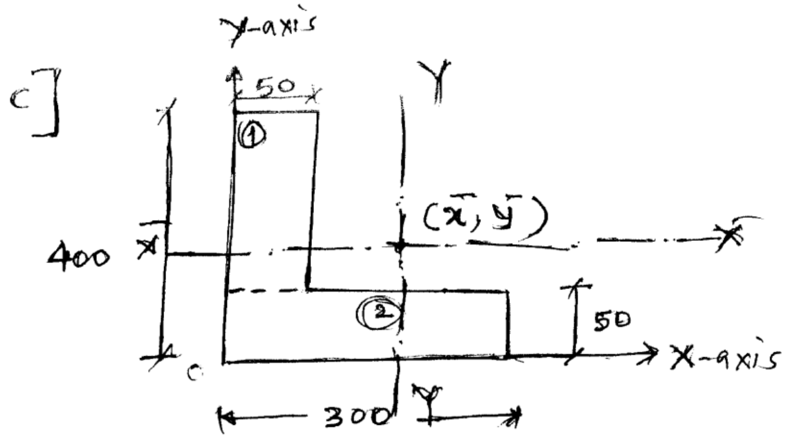
$480 - 5.20(205.77) - 3 \times 0.2 \times 205.77 + 375x = 0$

$480 - 1070 - 123.462 + 375x = 0$

$-713.462 + 375x = 0$

$x = \underline{1.902\ m}$ along ladder.

c]



$A_1 = 50 \times 350 = 17500\ mm^2$

$A_2 = 300 \times 50 = 15000\ mm^2$

distance of centroid from OX axis.

$Y_1 = 50 + \frac{350}{2} = 225\ mm$

$Y_2 = \frac{50}{2} = 25\ mm$

distance of centroid from OY axis.

$x_1 = 25\ mm$

$x_2 = 150\ mm$

Centroid. $\bar{x} = \dfrac{a_1x_1 + a_2x_2}{A_1 + A_2}$, $A = 32500$

$= \dfrac{17500 \times 25 + 15000 \times 150}{17500 + 15000}$

$\bar{x} = \underline{\underline{82.692}}$ mm from $\underline{Y\text{-axis}}$

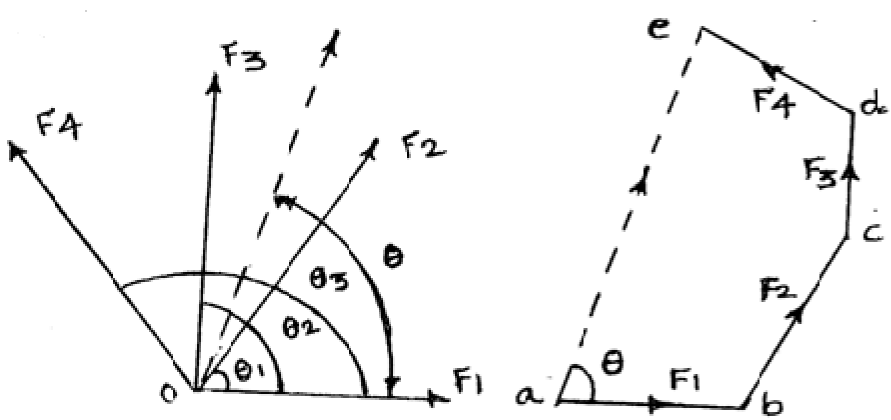
$\bar{y} = \dfrac{a_1y_1 + a_2y_2}{A_1 + A_2}$

$= 132.69$ mm from $\underline{X\text{-axis}}$ or bottom.

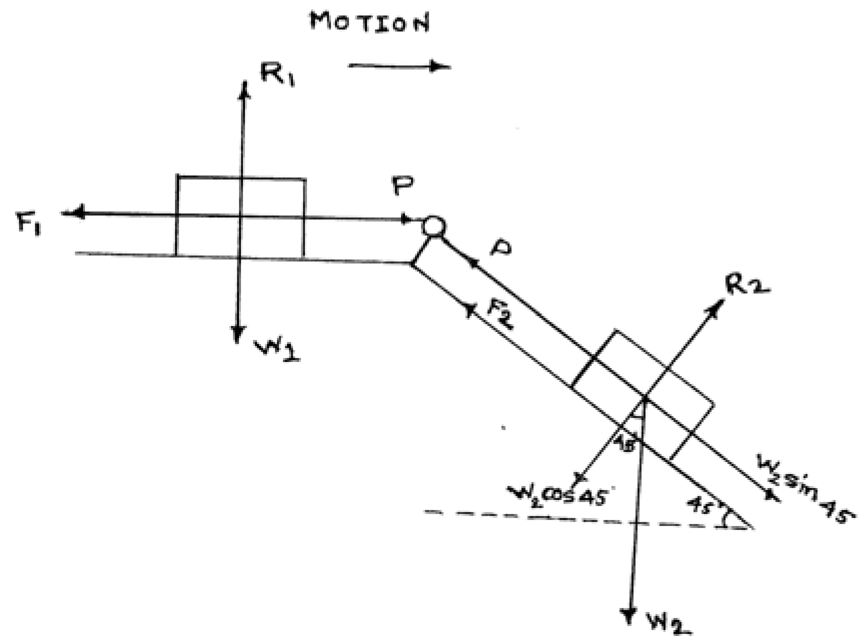
$(\bar{x}, \bar{y}) = (82.692 \text{ mm}, 132.69 \text{ mm})$

Q 5. Solve any four (4 x 4 = 16)

a) **Law of polygon of forces-** this law states that if no.of coplanar concurrent forces acting simultaneously on a body be represented in magnitude and direction by the sides of polygon taken in order, then their resultant may be represented in magnitude and direction by the closing side of polygon taken in opposite order.

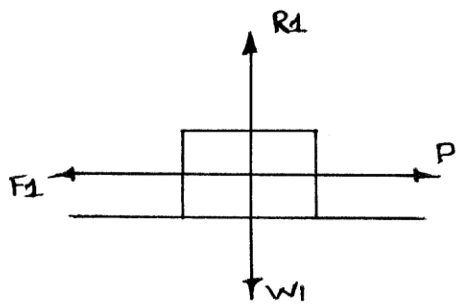


b)



Two blocks weighing W1 and W2are connected by a string passing over a frictionless pulley as shown in fig.

The tension force will be created and this tension force is equal on both the sides to maintain equilibrium.



$\Sigma FY = 0$

$R_1 - W_1 = 0$

$\boxed{R_1 = W_1}$

But

$\mu = \frac{F_1}{R_1}$

$0.25 = \frac{F_1}{W_1}$

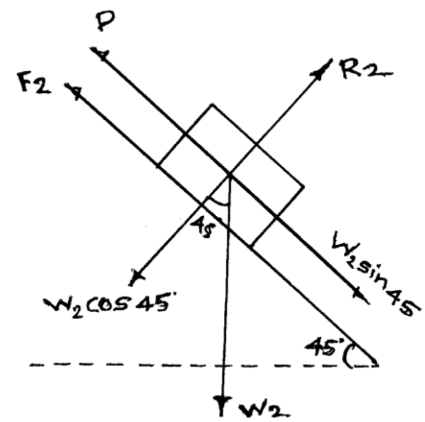
$\boxed{F_1 = 0.25\, W_1}$ - 01

$\Sigma FX = 0$

$P - F_1 = 0$

$P - 0.25\, W_1 = 0$

$\boxed{P = 0.25 W_1}$ - 01



$\Sigma FY = 0$

$R_2 - W_2 \cos 45 = 0$

$\boxed{R_2 = 0.707 W_2}$

But

$\mu = \frac{F_2}{R_2}$

$0.25 = \frac{F_2}{0.707\, W_2}$

$\boxed{F_2 = 0.176\, W_2}$

$\Sigma FY = 0$

$-P - F + W_2 \sin 45 = 0$

$-P - 0.176\, W_2 + 0.707 W_2 = 0$

$\boxed{P = 0.531\, W_2}$ 01

$$P = 0.531\ W_2$$

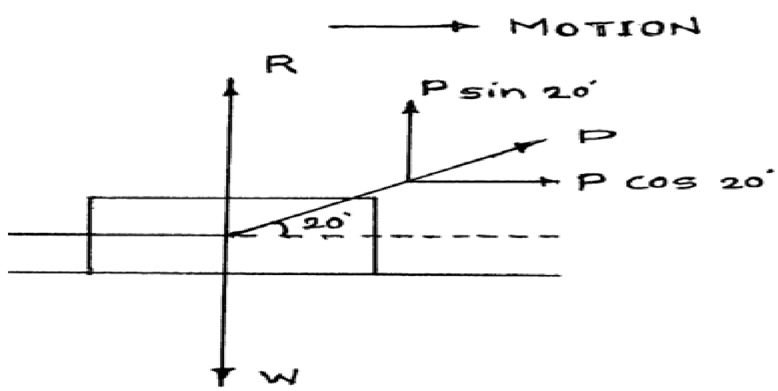
$$0.25\ W_1 = 0.531\ W_2$$

$$\frac{W_1}{W_2} = \frac{0.531}{0.25}$$

$$\boxed{\frac{W_1}{W_2} = 2.124}$$

C) Given W=1200 N

μ= 0.5



$\sum$ Fy= 0

R-W+PSin 20=0

R-1200+PSin20=0

R=1200-0.34 P----------1

$\sum$ Fx= 0

P Cos 20-F =0

PCos20 – μ R = 0

PCos20- 0.5(1200-0.34 P)=0

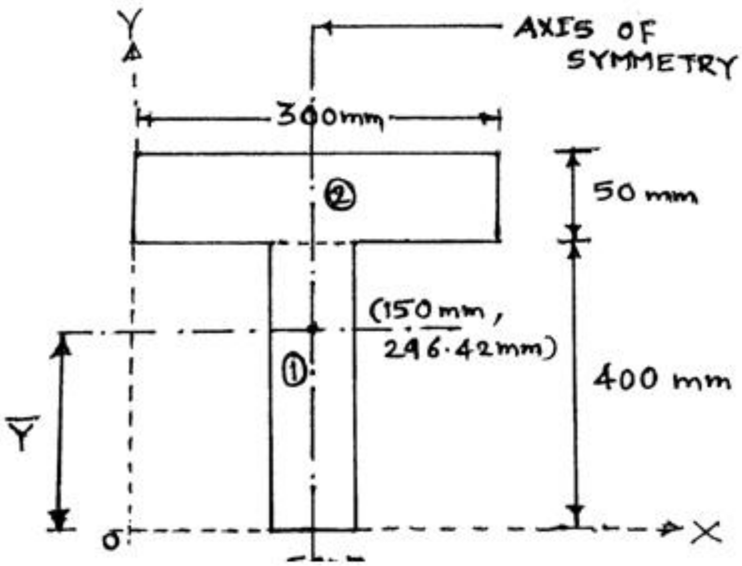
P=540.54 N

d) Given

T SECTION

FLANGE 300X50 mm

WEB 400x 50 mm



X=300/2 =150 mm

$\mathbf{A_1 = 5}0\text{x } 400 = 20000\text{mm}^2$

$A1 = 300X50 = 15000 \text{ mm}^2$

$Y_1 = 400/2 = 200$ mm

$Y_{2=}$ 400 + 50/2= 425 mm

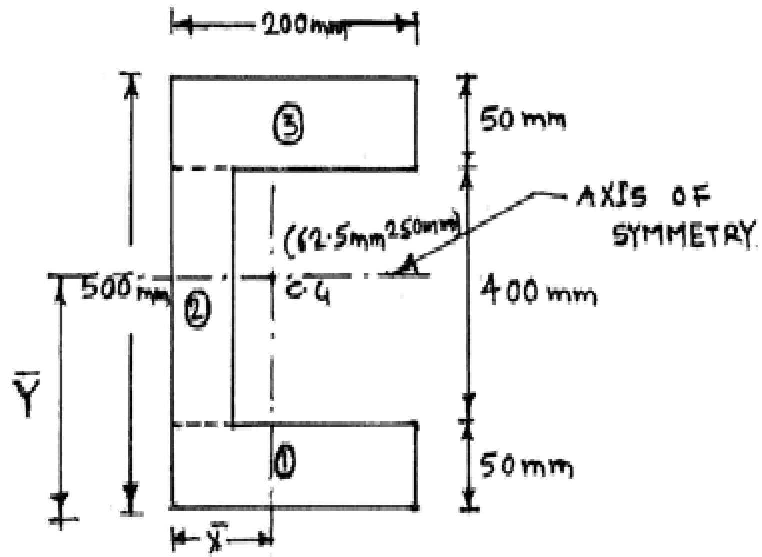
$Y = A1\ Y_1 + A2\ Y_2 / A1 + A2$

= (20000X 200)+(15000X 425)/35000

= 296.42 mm

Centroid = (150mm, 296.42mm)

e)



$$\bar{Y} = \frac{500}{2} = 250 \text{ mm}$$

$$A_1 = A_3 = 200 \times 50 = 10000 \text{ mm}^2.$$

$$A_2 = 400 \times 50 = 20000 \text{ mm}^2.$$

$$X_1 = \frac{200}{2} = 100 \text{ mm}$$

$$X_2 = \frac{50}{2} = 25 \text{ mm}$$

$$X_3 = \frac{200}{2} = 100 \text{ mm}$$

$$x_3 = \frac{200}{2} = 100 \text{ mm}$$

$$\bar{X} = \frac{A_1 x_1 + A_2 x_2 + A_3 x_3}{A_1 + A_2 + A_3}$$

$$= \frac{10000 \times 100 + 20000 \times 25 + 10000 \times 100}{10000 + 20000 + 10000}$$

$$\boxed{\bar{X} = 62.5 \text{ mm}}$$

centroid $(\bar{X}, \bar{Y}) = (62.5\text{mm}, 250\text{mm})$

Q5 f)

Given

$P1=110$ N $\qquad$ $W1=1100$N

$P2=500$ N $\qquad$ $W2=5800$N

$P= mW+C$

$P_1=mW_1+C$

$110 = m1100+C$ ----1 $\qquad$ 01/2 MARK

$P_2 = mW_2 + C$

500= m 5800+C ------2 01/2 MARK

Solving 1 and 2

m=0.083 01 MARK

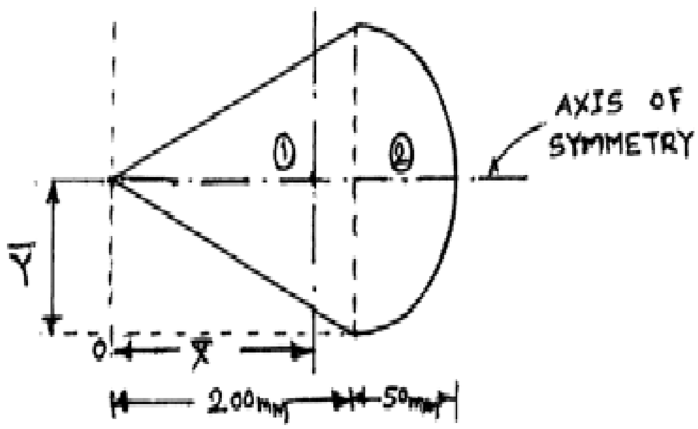
putting m in eq^n 1

C=18.7 N 01 MARK

Law of m/c is P=0.083W+18.7 N 01 MARK

Q.6. Solve any two (2 x 8 = 16)

Q. 6 a)



$\bar{Y} = \frac{100}{2} = 50 \text{ mm}$ 2

V_1 = Volume of cone

V_2 = Volume of hemisphere

$$V_1 = \frac{1}{3}\pi r^2 h$$

$$= \frac{1}{3} \times \pi \times (50)^2 \times 200$$

$$= 523.598 \times 10^3 \text{ mm}^3$$ 1

$$x_2 = 200 + \frac{3}{8} R$$ 1

$$= 200 + \frac{3}{8} \times 50$$

$$= 218.75 \text{ mm}$$

$$\bar{x} = \frac{v_1 x_1 + v_2 x_2}{v_1 + v_2}$$ 1

$$= \frac{523.598 \times 10^3 \times 150 + 261.799 \times 10^3 \times 218.7}{523.598 \times 10^3 + 261.799 \times 10^3}$$

$$\boxed{\bar{X} = 172.9 \text{ mm}}$$ C.G $(\bar{x}, \bar{y})$ = (172.9 mm, 50 mm) 1

b) given

VR=250

P=0.01W+5 N

W=1000N

P=0.01X 1000 +5=15 N 1 ½ mark

MA=W/P=1000/15=66.67 1 ½ mark

η = (MA/VR) X100= 26.67% 1 ½ mark

Pi=W/VR=1000/250=4 N 1 ½ mark

P_f= P-P_i = 15-4=11 N 1 mark

The efficiency of the m/c is less than 50%, so the m/c is nonreversible. 1 mark

c) Given-

P=50N η=70%

VR=N_1xN_3/N_2xN_4 2 mark

=60x90/10x15

VR =36 2 mark

η %= (MA/VR) X100

MA= (70X36)/100

MA = 25.2 2 mark

But, MA=W/P

25.2=W/50

W=1260N 2mark