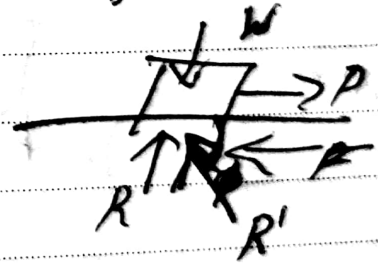


## Angle of friction: $\phi$

The angle  $\phi$  which the Resultant Reaction  $R$ , due to Normal reaction  $R$  & Friction  $F$  makes with the normal to surface is called angle of friction  $\phi$ .

$$\tan \phi = \frac{F}{R}$$



Coefficient of friction :- ( $\mu$ )

It is ratio of the limiting friction  $F$  to the normal reaction  $R$  between 2 surfaces.  
This is equal to tangent of angle of friction.

$$\mu = \frac{F}{R}$$

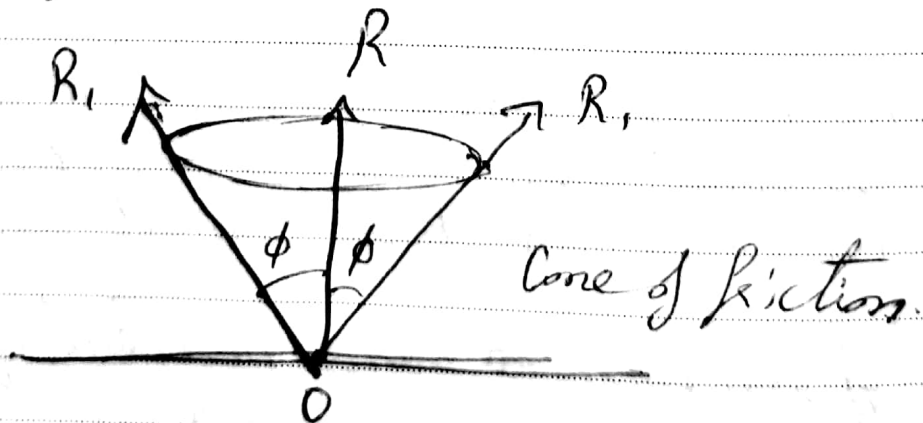
$$\therefore \tan \phi = \mu = \frac{F}{R}$$

## Cone of friction:

Whenever a body in contact with other tend to move, then normal reaction  $OR$  & friction cone into play. The normal reaction & friction can be replaced by resultant reaction  $OR_1$ . When this resultant reaction  $OR_1$  making angle  $\phi$  is revolved around point  $O$ , will form a right circular cone.

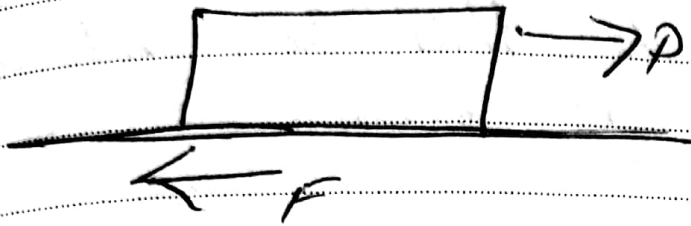
This cone having the point of contact as the vertex  $O$ , the normal  $OR$  at point of contact as its axis and  $\phi$  as the semi vertex angle is called cone of friction.

**14** Tuesday



## Laws of dry friction:-

1. The friction force always acts in the direction opposite to that in which the body tends to move.



2. Magnitude of limiting friction ( $F$ ) bears a constant ratio to the normal ~~stress~~ reaction ( $R$ ) between the 2 surfaces i.e.  $\mu = \frac{F}{R}$

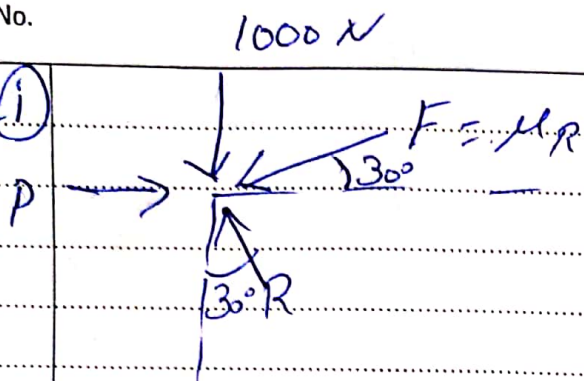
Sunday

12

3. Magnitude of force of friction is exactly equal to the force, which tends the body to move, as long as body is at rest ( $P = F$ )
4. Force of friction is independent of area of contact between 2 surfaces.
5. The force of friction depends upon the roughness of the surface in contact.



2. a) i)



Up the plane:-

$$\Sigma V = 0$$

$$-1000 - F \sin 30 + R \cos 30 = 0$$

$$R = \frac{F \sin 30 + 1000}{\cos 30} \quad \text{--- (1)}$$

1 Mark

1 Mark

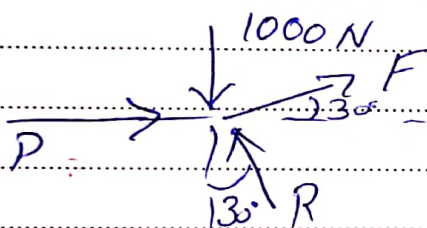
$$\Sigma H = 0$$

$$-F \cos 30 - R \sin 30 + P = 0 \quad \text{--- (2)}$$

Solving (1) & sub in (2)  $P = 968.29 \text{ N.}$

2 Marks

ii)



Down the plane:-

$$\Sigma H = 0$$

$$+P + F \cos 30 - R \sin 30 = 0$$

$$\text{--- (1)}$$

1 Mark

1 Mark

$$\Sigma V = 0$$

$$-1000 + R \cos 30 + F \sin 30 = 0$$

$$\text{--- (2)}$$

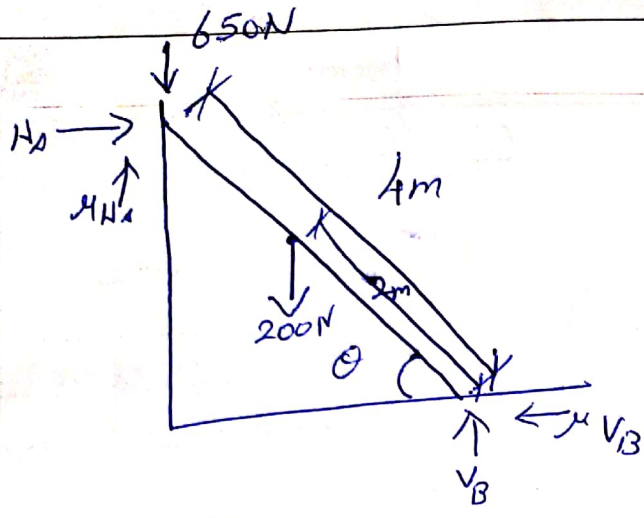
1 Mark

Solving (2) & sub in (1)

$$P = 286.36 \text{ N.}$$

2 Marks

3)



$\mu = 0.25$   
2 Marks

$$\sum H = 0$$

$$H_A - \mu V_B = 0$$

$$H_A = 0.25 V_B \quad \text{--- (1)}$$

2 Marks

$$\sum V = 0$$

$$V_B - 650 - 200 + \mu H_A = 0 \quad \text{--- (2)}$$

Sub (1) in (2)

$$V_B + (0.25 \times 0.25 V_B) - 850 = 0$$

$$V_B - 0.0625 V_B = 850 \quad \text{--- (2)}$$

$$V_B = 800 \text{ kN}$$

$$H_A = 200 \text{ N.}$$

2 Marks

$$\sum M_D = 0$$

$$200 \times 2 \cos \theta - V_B \times 4 \cos \theta + H_A \times 4 \sin \theta = 0 \quad \text{--- (3)}$$

2 Marks

Sub  $V_B$  &  $H_A$  in (3)

$$\theta = 76^\circ$$

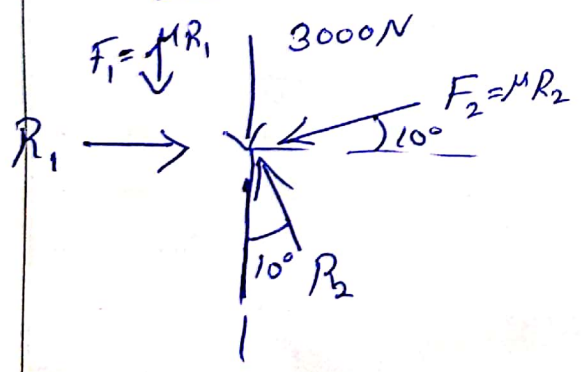
2 Marks

4)

$$\phi = 18^\circ$$

$$\mu = \tan \phi = 0.325$$

Block A



1 Mark

$$\sum V = 0$$

$$-3000 - \mu R_1 + R_2 \cos 10 = 0 \quad \text{--- (1)}$$

$$\sum H = 0$$

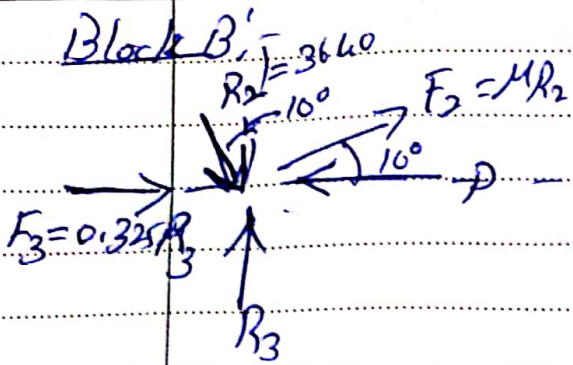
$$R_1 - R_2 \sin 10 - \mu R_2 \cos 10 = 0$$

$$R_1 = 0.493 R_2 \quad \text{--- (2) } \text{2 marks}$$

sub (2) in (1)

$$R_2 = 3640 \text{ N.}$$

2 Marks



$$\sum V = 0$$

$$-3640 \cos 10 + 0.325 \times 3640 \sin 10 + R_3 = 0$$

$$R_3 = 3380 \text{ N}$$

1 Mark

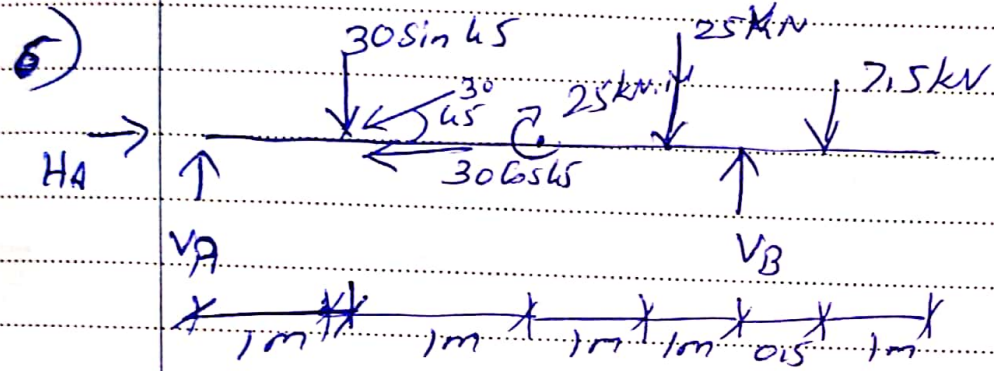
$$\sum H = 0$$

$$-P + 0.325 \times 3640 \cos 10 + 3640 \sin 10 + 0.325 R_3 = 0$$

$$P = 2281.5 \text{ N}$$

2 Marks

2 Marks



1 Mark

$$\sum V = 0, \quad V_A + V_B = 30 \sin 45 + 25 + 7.5$$

$$V_A + V_B = 35.71 \text{ kN} \quad \text{--- (1)}$$

2 Marks

$$\sum H = 0, \quad H_A = 30 \cos 45 \Rightarrow H_A = 21.21 \text{ kN}$$

2 Marks

$$\sum M_A = 0, \quad 30 \sin 45 \times 1 + 25 + 25 \times 3 + 7.5 \times 4.5 = V_B \times 4$$

$$V_B = 38.74 \text{ kN}$$

3 Marks

Sub  $V_B$  in (1)  $\therefore V_A = 14.92 \text{ kN}$

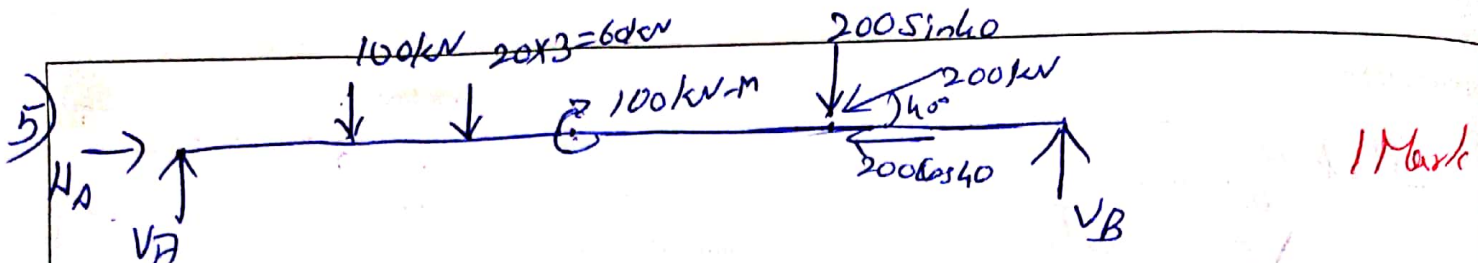
$$R_A = \sqrt{V_A^2 + H_A^2}$$

$$= 25.16 \text{ kN}$$

$$\theta = \tan^{-1} \frac{V_A}{H_A} = 35.21^\circ$$

1 Mark

1 Mark



1 Mark

$$\sum V = 0, \quad V_A + V_B = 100 + 60 + 200 \sin 40^\circ$$

2 Marks

$$V_A + V_B = 288.56 \text{ kN}$$

$$\sum H = 0, \quad H_A = 200 \cos 40^\circ$$

2 Marks

$$H_A = 153.2 \text{ kN}$$

$$\sum M_A = 0 \quad 100 \times 3 + 60 \times 6 + 100 + 200 \sin 40^\circ \times 9 = V_B \times 12$$

3 Marks

$$V_B = 152.25 \text{ kN}$$

$$V_A = 136.3 \text{ kN}$$

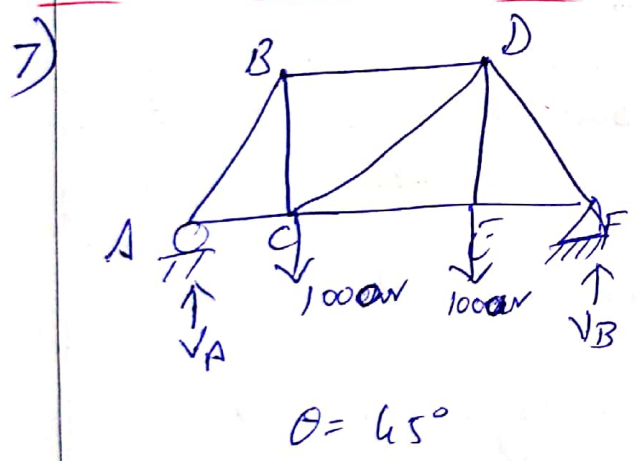
$$R_A = \sqrt{V_A^2 + H_A^2}$$

$$= 205.06 \text{ kN}$$

$$\theta = \tan^{-1} \frac{V_A}{H_A}$$

$$= 41.65^\circ$$

2 Marks



$$\sum V = 0,$$

$$V_A + V_B = 2000 \text{ N}$$

$$\sum H = 0,$$

$$\sum M_D = 0$$

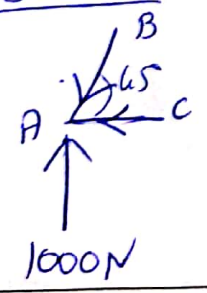
$$1000 \times 3 + 1000 \times 6 = V_B \times 9$$

$$V_B = 1000 \text{ N}$$

$$V_A = 1000 \text{ N}$$

2 Marks

Joint A:-



$$\sum V = 0$$

$$F_{AB} \sin 45^\circ - 1000 = 0$$

$$F_{AB} = 1414.2 \text{ N (C)}$$

$$\sum H = 0$$

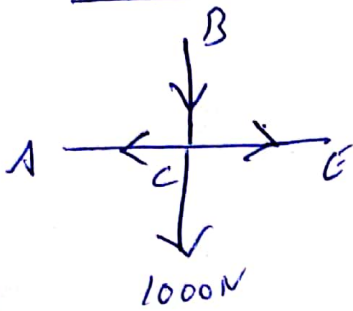
$$F_{AB} \cos 45^\circ + F_{AC} = 0$$

$$F_{AC} = -1000 \text{ N (T)}$$

2 Marks



Joint C:-



$$\sum V = 0$$

$$-1000 - F_{CB} = 0$$

$$F_{CB} = -1000 \text{ N (T)}$$

$$\sum H = 0$$

$$-F_{CA} + F_{CE} = 0$$

$$F_{CE} = 1000 \text{ N (T)}$$

2 Mark

Joint D:-



As truss is symmetric in loading & Dimension.

Joint A is ||<sup>l</sup> to Joint F  
Joint C is ||<sup>l</sup> to Joint E

$$\therefore F_{AB} = F_{DF} = 1414.2 \text{ N (C)}$$

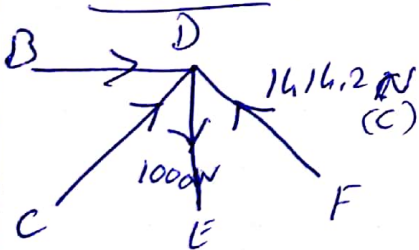
$$F_{AC} = F_{FE} = 1000 \text{ N (T)}$$

$$F_{CB} = F_{DE} = 1000 \text{ N (T)}$$

$$F_{CE} = F_{CE} = 1000 \text{ N (T)}$$

2 marks

Joint D:-



$$\sum V = 0$$

$$F_{DF} \cos 45 - 1000 + F_{DC} \cos 45 = 0$$

$$F_{DC} = 0$$

$$\sum H = 0$$

$$F_{DC} \sin 45 + F_{BD} - 1414.2 F_{DF} \sin 45 = 0$$

$$F_{BD} = 1000 \text{ N (C)}$$

$$F_{CD} = 0$$

$$F_{BD} = 1000 \text{ N (C)}$$

2 Marks