ROHININ COLLEGE OF ENGINEERING AND TECHNOLOGY
Approved by AICTE & Affliated to anna university
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DEPARTMENT OF MECHANICAL ENGINEERING

NAME OF THE SUBJECT: ENGINEERING MECHANICS

SUBJECT CODE : ME3351

REGULATION 2021

UNIT V: FRICTION

TYPES OF FRICTION

The friction force is the resisting force developed at the contact surface of two bodies due to their roughness and when the surface of one body moves over the surface of an another body.

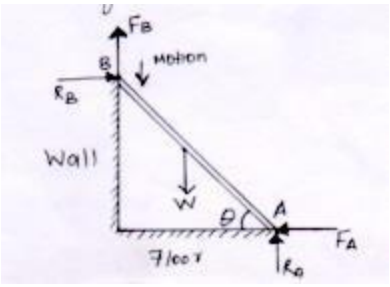
Some of important Engg application of simple contact friction are,

- Ladder friction
- Wedge friction
- Screw friction
- Belt friction

1. Ladder friction:

A ladder is a device used for climbing on roof or wall

Consider a ladder AB of length 'l' and weight 'w' resting on the ground at A and leaning against a rough wall at B as shown in fig.



Let the angle of ladder with horizontal be θ when the angle θ exceeds angle of friction (or) when the weight of the man on the ladder makes instability to the ladder, the ladder slips down.

During sliding the upper end of the ladder tends to slip downwards, hence the friction force at B, F_B will act upwards. If the coefficient of friction of wall surface B is μ_B

Then $\mu_B = \frac{F_B}{N_{RB}}$ (or) $F_B = \mu_B N_{RB}$

At the same time the lower end of the ladder A tends to slip away from the wall, hence the frictional force at A, F_A will act towards the wall if the coefficient of friction of floor surface A is μ_A

$$\mu_A = \frac{F_A}{N_{RA}} \quad \text{(or) } F_A = \mu_A \, N_{RA}$$

Condition:

$$\Sigma F_X = 0$$

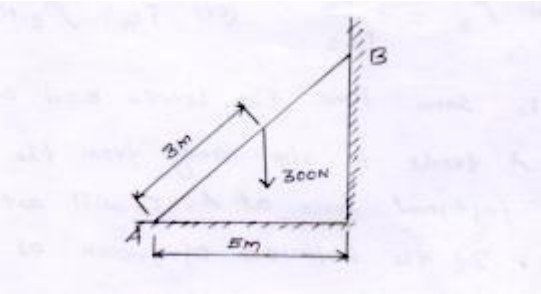
$$\Sigma F_Y = 0$$

$$\Sigma M = 0$$

$$F = \mu N_R$$

Problem 1:

A ladder is 8m long and weight 300N. The center of gravity of the ladder is 3m along the length of from the bottom end. The ladder rests against a vertical wall at B and on the horizontal floor at A as shown below. Determine the safe height upto which a man weighting 900N can climb without making the ladder slip. The coefficient of friction b/w ladder and floor is 0.4 and ladder top and wall is 0.3



Given:

Length of ladder l=8m

Weight of ladder w= 300N at 3m length from lower end

$\mu_A = 0.4$

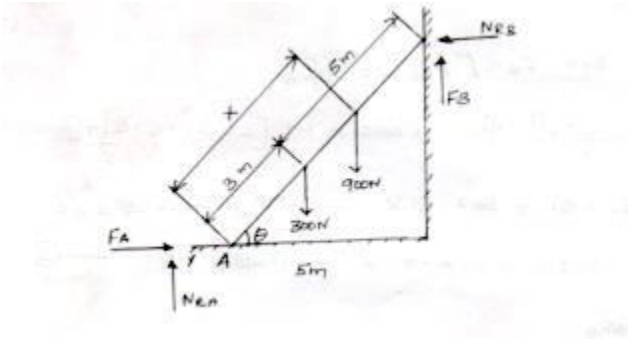
μ_B=0.3

To find

Safe height ‘H’

Soln:

Free body diagram



Sum of X direction force $\Sigma F_X = 0$

$F_A - N_{RB} = 0$

$F_A - N_{RB}$---------- (1)

Sum of Y direction force $\Sigma F_y = 0$

$N_{RA} + F_B - 300 - 900 = 0$

$N_{RA} + F_B = 300 + 900 = 0$

$N_{RA} + F_B = 1200$---------- (2)

$\Sigma M_A = 0$ Moment about ‘A’

Now find out the θ

$\theta = cos^{-1}(\frac{5}{8})$

$\theta = 51°19'$

$\Sigma M_A = 0$ ↑ - ↓ +

$(300 \times 3cos\theta) + (900 \times cos\theta) + [F_B \times 5] + [-N_{RB} \times 8sin\theta] = 0$

$[300 \times 3cos51°19'] + [900 \times cos51°19'] + [-F_B \times 5] + [-N_{RB} \times sin51°19' = 0$

Sub $F_B = \mu N_{RB} = 0.3N_{RB}$

$$[300 \times 3cos51°19'] + [900 \times cos51°19'] + [-0.3NR_B \times 5] + [-N_{RB} \times 8sin51°19' = 0$$

$$562.51 + 562.51 \times -1.5N_{RB} - 6.24N_{RB} = 0$$

$$562.51 + 562.21 \times -7.74N_{RB} = 0$$---------- (3)

To find N_{RB}

From eqn (2)

$N_{RA} + F_B = 1200$---------- (2)

$\frac{F_A}{0.4} + 0.3 \times N_{RB} = 1200$

$\frac{N_{RB}}{0.4} + 0.3 \times N_{RB} = 1200$

$N_{RB} = F_A \quad F_A = \mu \times N_{RA}$

$F_A = 0.4 \times N_{RA}$

$N_{RA} = \frac{F_A}{0.4}$

$2.5N_{RB} + 0.3\,N_{RB} = 1200$

$2.8N_{RB} = 1200$

$$N_{RB} = \frac{1200}{2.8}$$

$N_{RB} = 428.57N$

N_{RB}value sub in Eqn(3)

$$562.51 + 562.51 \times -7.74N_{RB} = 0$$

$$562.51 + 562.51 \times -7.74 \times 428.57 = 0$$

$$562.51 \times = [7.74 \times 428.57] - [562.51]$$

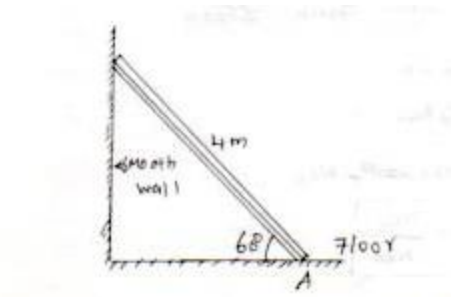
$$562.51 \times = 2754.63$$

$$X = \frac{2754.63}{562.51}$$

Ans $X = 4.89m$from the floor of Ladder

Problem 2

A ladder of weight 1000 N and length 4m rest as shown in fig. if the 750 n weight is applied at distance of 3m from the top of ladder, it is at the point of sliding. Determine the coefficient of friction b/w ladder and the floor.



Given:

Length of Ladder l = 4m

Weight of ladder w = 1000N

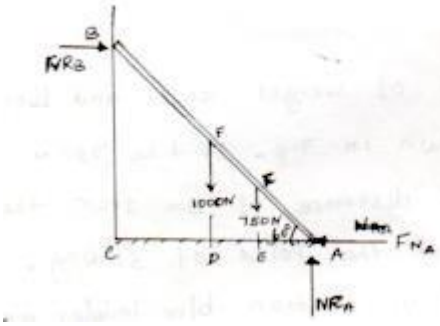
Weight of man = 750 N at 3m from toped

To find:

Coefficient of friction

Soln:

Free body diagram



Sum of X direction force $\Sigma F_X = 0$

$N_{RB} - F_{NA} = 0$

$N_{RB} - \mu_A N = 0$

$-\mu_A N_{RA} = -N_{RB}$

$\mu_A = \frac{N_{RB}}{N_{RA}}$-------- (1)

Sum of all Y direction force

$N_{RA} - 1000 - 750 = 0$

$N_{RA} - 1750 = 0$

$N_{RA} = 1750N$

Take moment about 'A' ↓ +↑ -

$\Sigma M_A = 0$

$\Sigma M_A = [N_{RB} \times BC] + [-1000 \times AD] + [-750 \times AE] = 0$

$BC = 4\ sin6 \qquad AD = 2\ cos60 \quad AE = -1 \cos 60$

$[N_{RB} \times 4 \sin 60] + [-1000 \times 2 \cos 60] + [-750 \times -1cos60] = 0$

$3.46N_{RB} - 1000 - 375 = 0$

$3.46N_{RB} - 1375 = 0$

$$N_{RB} = \frac{1375}{3.46}$$

$N_{RB} = 397.39\ N$

N_{RA} & N_{RB} value sub in Eqn (1)

$$\mu = \frac{N_{RB}}{N_{RA}} = \frac{397.39}{1750}$$

$ans\ \mu = 0.22$