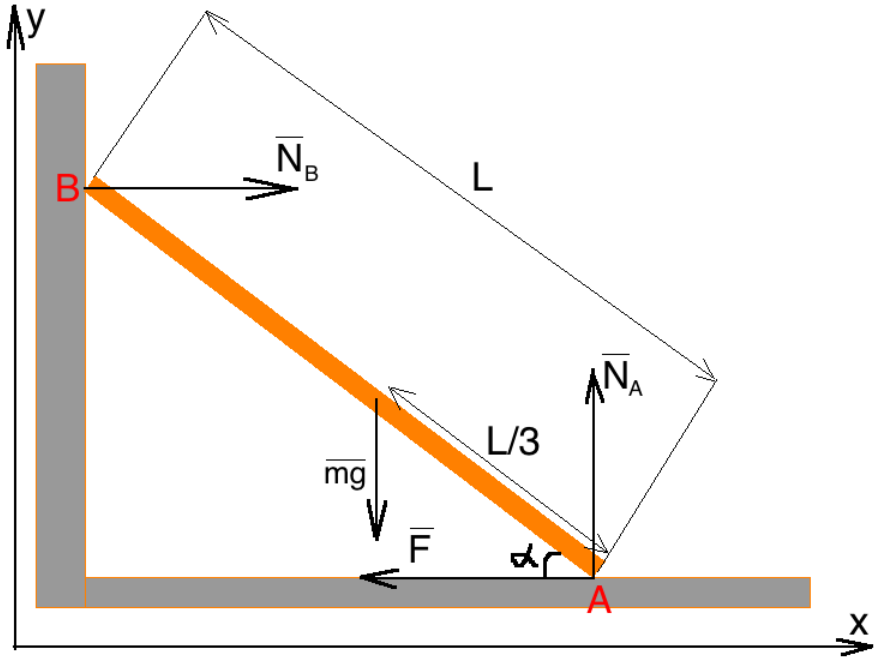
Answer on Question #41193 – Physics – Mechanics

A 150-kg ladder leans against a smooth wall, making an angle of 30 degrees with the floor. The centre of gravity of the ladder is one-third the way up from the bottom. How large a horizontal force must the floor provide if the ladder is not to slip?

Solution:



$\alpha = 30^o -$ angle which ladder makes with the wall

$N_A -$ reaction force from the floor

$N_B -$ reaction force from the wall

$m = 150kg -$ mass of the ladder

$L -$ length of the ladder

Newton's second law for the ladder (the first law of equilibrium):

$$\vec{F} + m\vec{g} + \overrightarrow{N_A} + \overrightarrow{N_B} = \vec{0}$$

Projection of the law on the X-axis:

$$x: N_B - F = 0 \Longrightarrow N_B = F \qquad (1)$$

Momentum equation for point A (the second law of equilibrium):

$$A: M_{mg} + M_F + M_{N_A} + M_{N_B} = 0 \qquad (2)$$

$(M_{N_A} = M_F = 0, \text{because moment arm of this forces is zero})$

$$M_{mg} = -mg \cdot \frac{L}{3}\cos\alpha \text{ (minus sign because of the direction of force)}$$

$$M_{N_B} = N_B \cdot L \sin\alpha = |\text{using (1)}| = F \cdot L \sin\alpha$$

$\rightarrow$ (3):

$$F \cdot L \sin\alpha - mg \cdot \frac{L}{3}\cos\alpha = 0$$

$$F = \frac{mg}{3} \cdot \frac{\cos\alpha}{\sin\alpha} = \frac{mg}{3\tan\alpha} = \frac{mg}{3\tan\alpha} = \frac{150\text{kg} \cdot 9.8\frac{\text{N}}{\text{kg}}}{3 \cdot \tan 30^\circ} = 849\text{N}$$

Answer: horizontal force that the floor provide is equal to 849N.