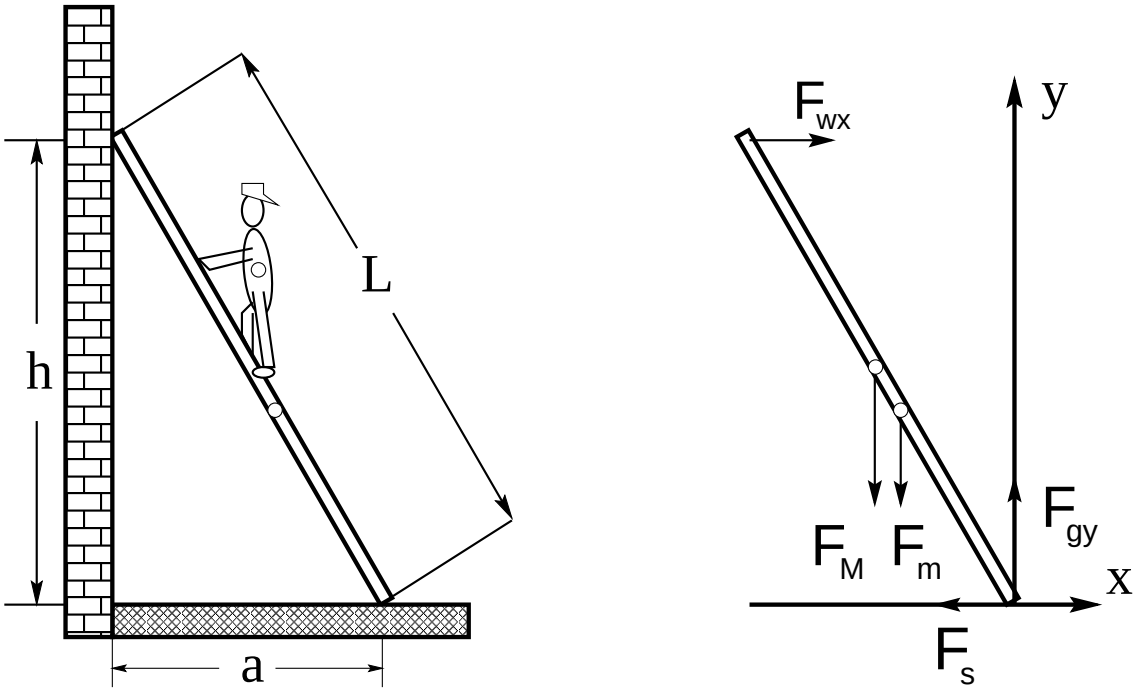
Ex : A ladder of **L=12.0 m** and **m=45 kg** rests against a wall. Its upper end is **h=9.3 m** above the ground. The CM of the ladder is one-third of the way up the ladder. A firefighter of **M=72 kg** climbs the ladder until her CM is halfway up the ladder. Assume that the wall, but not the ground is frictionless. What forces are exerted on the ladder by the wall and ground?



∘ Begin by drawing a free-body diagram of our system.

Note:

i). As the wall is frictionless, no F_{wy} is present.

ii). F_{gx} points to the left as it represents f_s.

iii). F_{gy} is the normal force of the ground on the ladder.

◦ Begin by calculating the weight forces of the ladder and firefighter.

$$F_m = mg = 441.5\ N \qquad F_M = Mg = 706.32\ N$$

◦ To proceed, use our equilibrium equations for the balance of forces and the balance of torques.

$$\Sigma F_{x,y} = 0, \qquad \Sigma \tau_z = 0$$

◦ From our balance of force equations:

$$\Sigma F_x = F_{wx} - F_s = 0 \qquad \Sigma F_y = F_{gy} - Mg - mg = 0$$

$$F_{gy} = F_m + F_M = 1148\ N$$

◦ Use our balance of torques equation, defining the origin as the rotation point.

$$\Sigma \tau_z = -F_{wx}h + F_M(a/2) + F_m(a/3) + F_s(0) + F_{gy}(0) = 0$$

$$F_{wx} = \frac{a(F_M/2 + F_m/3)}{h} = 408\ N = F_{gx}$$