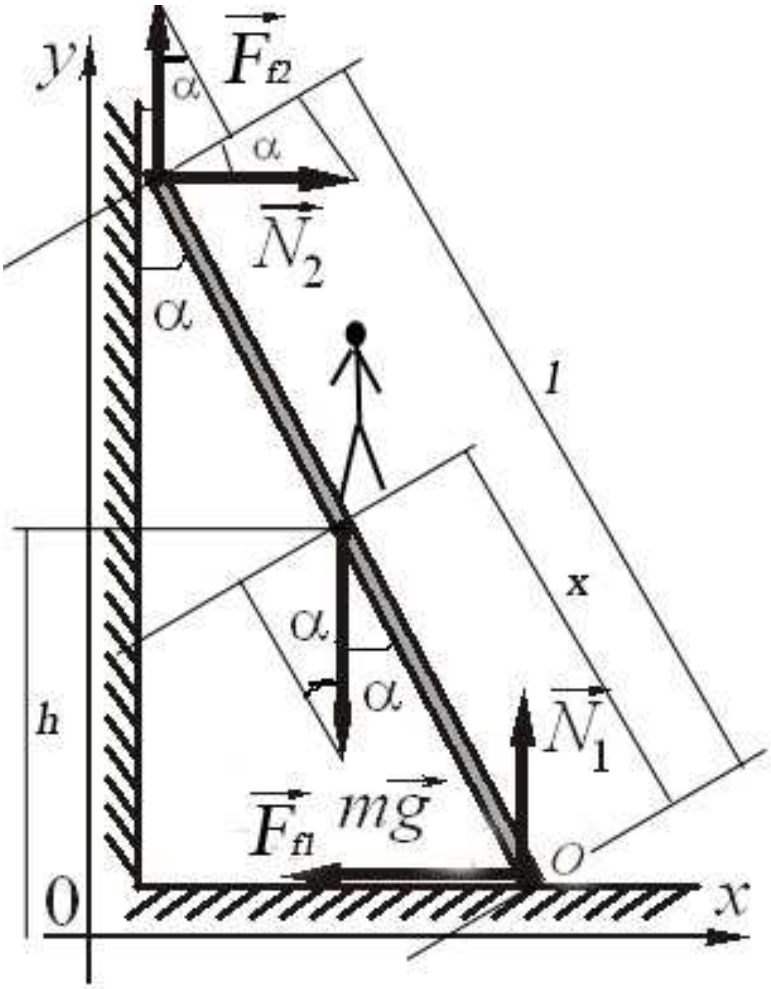
A light ladder is supported on a rough floor and leans against a rough wall. How far up the ladder can a man climb without slipping taking place?

**Solution.**




The necessary conditions for mechanical equilibrium for a system of particles.

The vector sum of all external forces is zero:

Projection on OX:

$$F_{f1} = N_2;$$

Projection on OY:

$$mg = N_1 + F_{f2};$$

The forces of friction:

$$F_{f1} = \mu_1 N_1;$$

$$F_{f2} = \mu_2 N_2;$$

$\mu_1$ is the coefficient of friction between the ladder and the floor;

$\mu_2$ is the coefficient of friction between the ladder and the wall.

$$\mu_1 N_1 = N_2;$$

$$N_1 = \frac{N_2}{\mu_1};$$

$$mg = N_1 + \mu_2 N_2;$$

$$mg = \frac{N_2}{\mu_1} + \mu_2 N_2;$$

$$N_2 = \frac{\mu_1 mg}{1 + \mu_1 \mu_2}.$$

The sum of the moments of all external forces about line O is zero:

$$N_2 cos\alpha l + F_{f2} sin\alpha l - mgcos\alpha x = 0;$$

$$mgcos\alpha x = N_2 cos\alpha l + F_{f2} sin\alpha l;$$

$$mgcos\alpha x = N_2 cos\alpha l + \mu_2 N_2 sin\alpha l;$$

$$mgcos\alpha x = N_2 l(cos\alpha + \mu_2 sin\alpha);$$

$$mgcos\alpha x = \frac{\mu_1 mgl}{1 + \mu_1 \mu_2}(cos\alpha + \mu_2 sin\alpha);$$

$$x = \frac{\mu_1 mgl}{1 + \mu_1 \mu_2} \cdot \frac{(cos\alpha + \mu_2 sin\alpha)}{mgcos\alpha};$$

$$x = \frac{\mu_1 l}{1 + \mu_1 \mu_2} \cdot \frac{(cos\alpha + \mu_2 sin\alpha)}{cos\alpha};$$

$$h = xcos\alpha;$$

$$h = \frac{\mu_1 l}{1 + \mu_1 \mu_2} \cdot \frac{(cos\alpha + \mu_2 sin\alpha)}{cos\alpha} cos\alpha;$$

$$h = \frac{\mu_1 l(cos\alpha + \mu_2 sin\alpha)}{1 + \mu_1 \mu_2}.$$

**Answer:**

$$h = \frac{\mu_1 l(cos\alpha + \mu_2 sin\alpha)}{1 + \mu_1 \mu_2}.$$