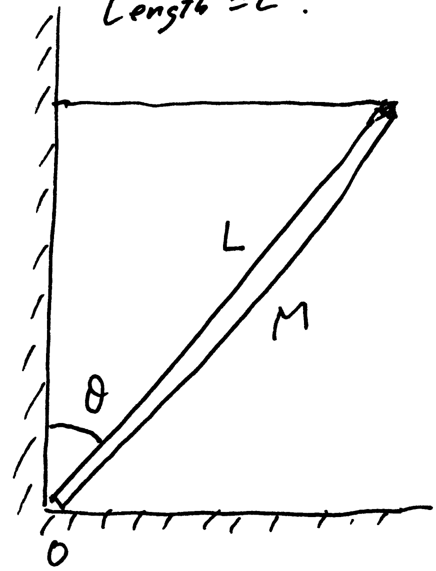
phys 101 . Lecture ~~23~~ 23

Examples (statics and Rotation).

mass = M.

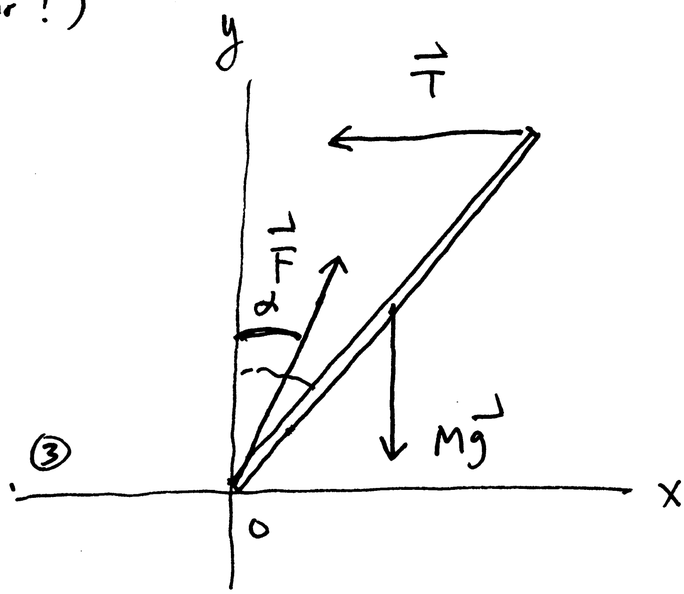
Length = L.



e.g: A bar is held against a wall, by a horizontal wire. The bottom of the bar is wedged against the wall, with an angle θ.

Find: Force on bar at the corner.

FBD. ($\vec{F}$ is not along the bar!)



$\Sigma \vec{F} = 0$: $\quad F_x - T = 0 \quad$ ①

$\qquad\qquad F_y - Mg = 0 \quad$ ②

$\Sigma \tau = 0$. (about O).

$$T L \cos\theta - Mg \frac{L}{2} \sin\theta = 0 \quad ③$$

Solve ①, ②, ③ for T, F_x, F_y:

③: $\quad T = \frac{Mg}{2} \frac{\sin\theta}{\cos\theta} = \frac{Mg}{2} \tan\theta$.

①: $\quad F_x = T = \frac{Mg}{2} \tan\theta$

②. $\quad F_y = Mg$.

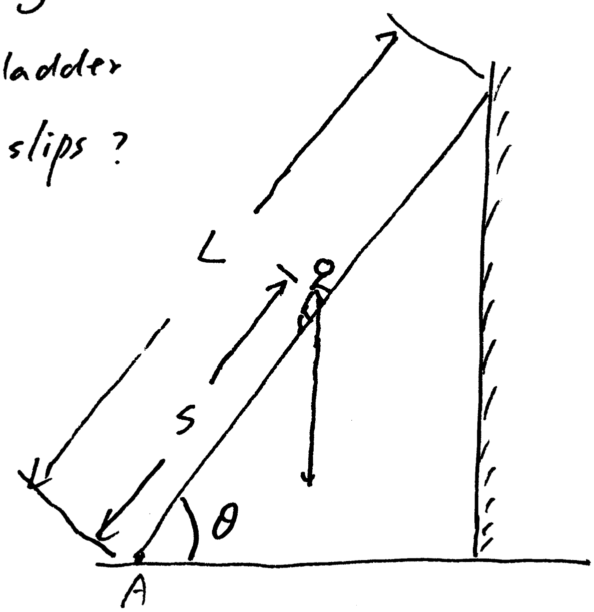
$$F = \sqrt{F_x^2 + F_y^2}.$$

$$= \sqrt{\left(\frac{Mg}{2}\right)^2 \tan^2\theta + (Mg)^2}$$

$$= Mg \sqrt{1 + \left(\frac{\tan\theta}{2}\right)^2}$$

$$\alpha = \tan^{-1} \frac{F_y}{F_x} = \frac{2}{\tan\theta}$$

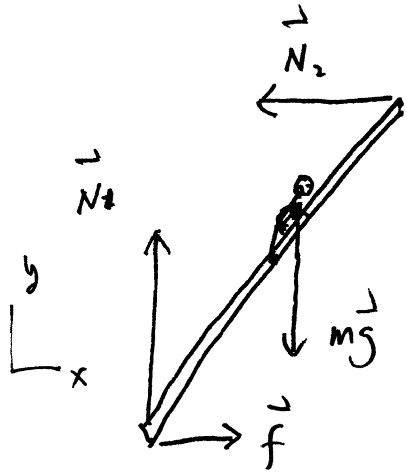
e.g. A man climbs a massless ladder against a frictionless wall. How far up the ladder can the man climb before the ladder slips ?



Given : θ , L , μ_s

Find: $s = ?$

FBD for the ladder



$f \le \mu_s N_1$.

$f = \mu_s N_1$ when it's about to slip .

$\Sigma \vec{F} = 0$: x: $\mu_s N_1 - N_2 = 0$ ①

y: $N_1 - mg = 0$ ②

$\Sigma \tau = 0$. (about A) : $N_2 L \sin\theta - mgs\cos\theta = 0$ ③ .

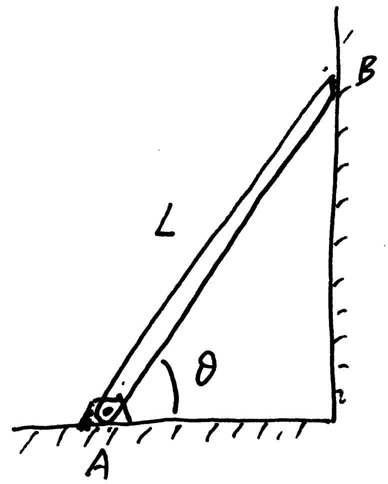
②: $N_1 = mg$. $\rightarrow$ ①: $\mu_s mg - N_2 = 0$, $N_2 = \mu_s mg$.

③: $$s = \frac{N_2 L \sin\theta}{mg\cos\theta} = \frac{\mu_s mg L \sin\theta}{mg\cos\theta} = \mu_s L \tan\theta$$

e.g. A bar leans against a smooth wall.

The bottom is held by a hinge.

(can rotate, can't slide).



Given:

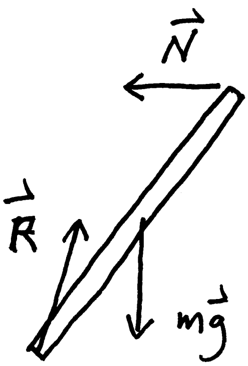
mass = m

Length = L

angle = θ.

Find the magnitude of the force that the hinge exerts on the bar.

[solution]. FBD:



$\Sigma \vec{F} = 0$:

$$R_x - N = 0$$

$$R_y - mg = 0$$

$\Sigma \tau = 0$. (About point A):

$$N L \sin\theta - mg \frac{L}{2} \cos\theta = 0$$

$$N = \frac{mg \cos\theta}{2 \sin\theta}$$

$$R_x = N = \frac{mg \cos\theta}{2 \sin\theta}$$

$$R_y = mg.$$

$$R = \sqrt{R_x^2 + R_y^2} = \sqrt{\frac{m^2 g^2 \cos^2\theta}{4 \sin^2\theta} + m^2 g^2}$$

$$= mg \sqrt{\frac{\cos^2\theta}{4 \sin^2\theta} + 1}.$$