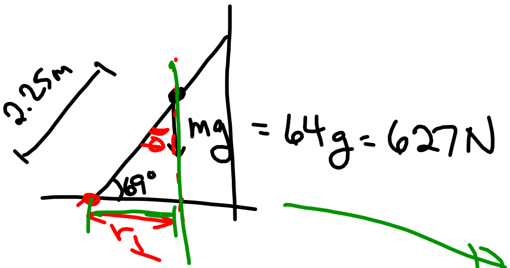
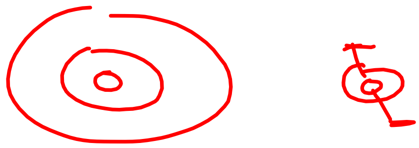
Homework Questions

p 495 #30





$\tau = rF\sin\theta$

$= (2.25)(627)\sin 21°$

$=$

$\tau = r_\perp F$

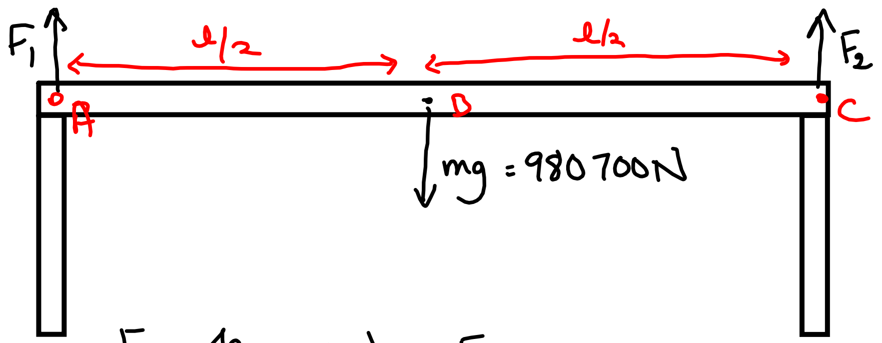
$= (2.25\cos 69°)(F_g)$

Static Equilibrium

Outcomes: Students will be able to use vector analysis to solve for forces in static equilibrium cases involving torques.

Textbook: Section 10.3

Consider a bridge whose platform (m=100 000 kg) is uniform and is 800 m long, supported by a pier on each end of the bridge. What is the force that each pier applies to keep the bridge up?



$F_1 = 490\,350N = F_2$

$\Sigma F = 0$

$F_1 + F_2 = mg$

$\Sigma \tau_B = 0$

$F_1(\ell/2) = F_2(\ell/2)$

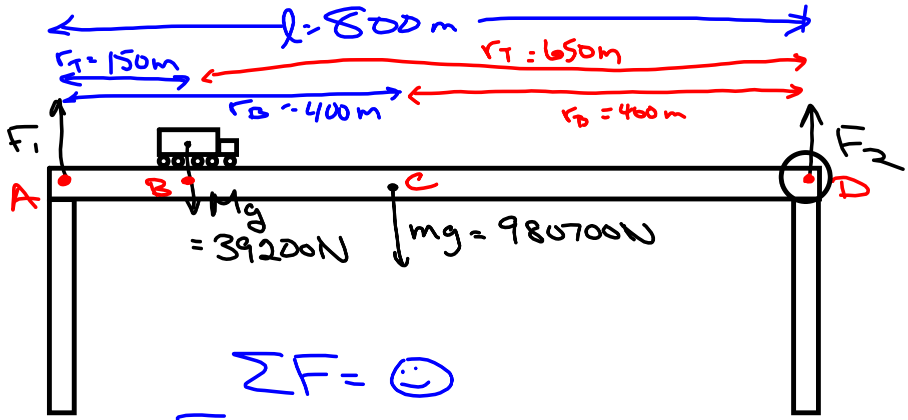
$F_1 = F_2$

$F_1 + F_1 = mg$

$2F_1 = mg$

$F_1 = \frac{mg}{2}$

Now consider the same bridge with a truck of mass 4000 kg a distance of 150 m from one end. How much force does each pier apply now?



$$\Sigma F = 0$$

$$F_1 + F_2 = mg + Mg = 1019900\,N$$

But $\Sigma \tau = 0$ around each and every point in space. (The bridge isn't rotating around ANY of them!)

If we choose point A

$$\Sigma \tau_A = 0$$

So $\Sigma \tau_{cw} = \Sigma \tau_{ccw}$

$$F_{gT} \cdot r_T + F_{gB} \cdot r_B = F_2 \cdot l$$

$$Mg \cdot r_T + mg \cdot r_B = F_2 \cdot l$$

$$\frac{39200N \cdot 150m + 980700N \cdot 400m}{800\,m} = F_2 \cdot 800m$$

$$F_2 = 497700\,N$$

$$F_1 + F_2 = 1019900\,N$$

$$F_1 = 1019900 - 497700\,N = 522200\,N$$

What if we'd chosen point D instead?

$$\Sigma \tau_D = 0$$

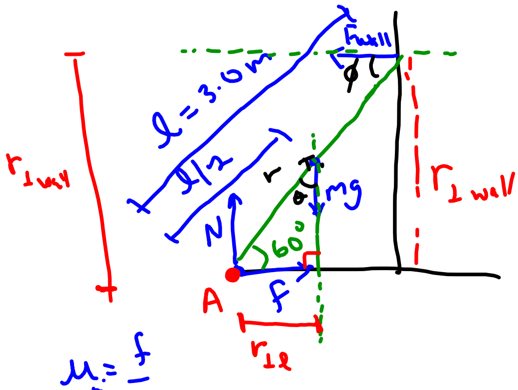
$$\Sigma \tau_{cw} = \Sigma \tau_{ccw}$$

$$F_1 \cdot l = Mg \cdot r_T + mg \cdot r_B$$

$$F_1 \cdot 800m = \frac{(39200 \cdot 650 + 980700 \cdot 400)\,Nm}{800\,m}$$

$$F_1 = 522200\,N$$

A ladder (ℓ = 3.0 m, m=10 kg) is leaned against a wall at an angle of 60°. If we assume that the friction with the wall is negligible, what coefficient of friction is required with the ground to keep it from slipping?



$\mu_{min} = \frac{f}{N}$

$\Sigma F = 0$

$\Sigma F_x = 0$

$F_{wall} = f$

$\Sigma F_y = 0$

$N = mg = 98N$

$\Sigma \tau_A = 0$ (we choose A because it eliminates N AND f)

$\tau = rF\sin\theta$ ← ∠ between F, r

$\frac{\ell}{2} mg \sin 30°$

$\tau_{wall} = rF\sin\phi$

$\ell F_{wall} \sin 60°$

recall: $r_\perp$ is the perpendicular distance from the pivot point to the line of force

$\Sigma \tau_{cw} = \Sigma \tau_{ccw}$

$mg \cdot r_{\perp \ell} = F_{wall} \cdot r_{\perp wall}$

$98N \cdot \frac{\ell}{2} \cos 60° = F_{wall} \cdot \ell \sin 60°$

$98N \left(\frac{3}{2}\right)\left(\frac{1}{2}\right) = F_{wall} \,(3) \frac{\sqrt{3}}{2}$

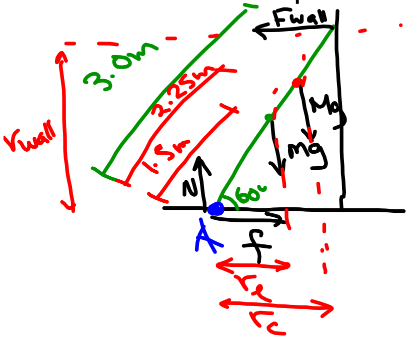
$F_{wall} = 28.3N = f$

$F_{wall} = mg \cdot \frac{r_{\perp \ell}}{r_{\perp wall}} = f$

$\mu_{min} = \frac{28.3}{98} = 0.29$

$\mu = \frac{f}{N} = \frac{mg \frac{r_{\perp \ell}}{r_{\perp wall}}}{mg}$

A person (m=70 kg) climbs 3/4 of the way up the ladder. What coefficient of friction is required with the ground now?



$\Sigma F_x =$ ☺

$f = F_{wall}$

$\Sigma F_y =$ ☺

$mg + Mg = N = 785N$

$\Sigma \tau_A =$ ☺

$\Sigma \tau_{cw} = \Sigma \tau_{ccw}$

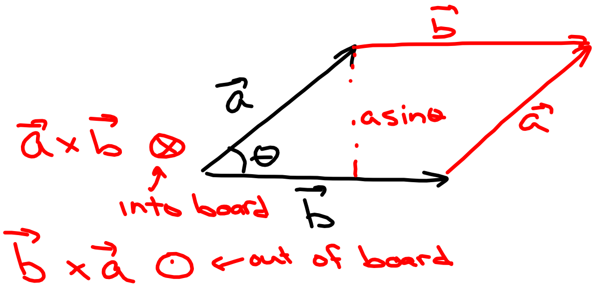
$mg \cdot 1.5\cos 60° + Mg \cdot 2.25\cos 60° = F_{wall} \cdot 3\sin 60°$

(mg = 98.1, Mg = 686.8)

$F_{wall} = 326N = f$

$\mu_{min} = \frac{f}{N} = \frac{326}{785} = 0.41$

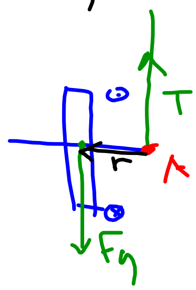
Cross Product and direction



$$|\vec{a}\times\vec{b}| = |\vec{a}||\vec{b}|\sin\theta$$

The size of the cross product is the size of the area mapped out by $\vec{a}$ and $\vec{b}$

The direction of the area is ⊥ to the surface, but which way?



Homework:
Sheet #2, 6-10