12-17 a) $\sum F_x = -f_s + F_c \sin\theta = 0$

$$\sum F_y = F_n - F_c \cos\theta = 0$$

Solving f_s in terms of F_n

$$f_s = F_c \sin\theta = \tan\theta \; F_n$$

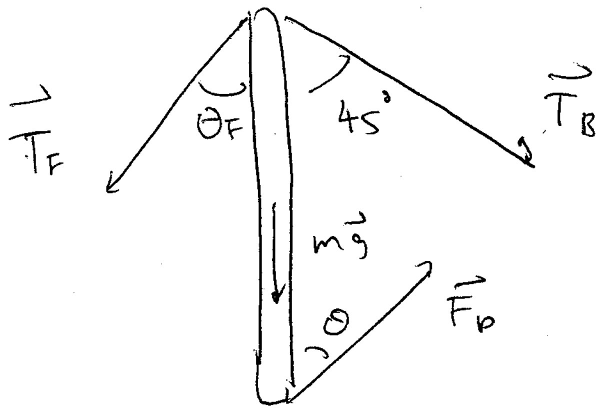
Since $f_s = f_{s,max}$, $f_s = \mu_s F_n$

$$\Rightarrow \mu_s = \tan\theta$$

b) Taking long strides requires a large coefficient of static friction because θ is large for long strides

c) If μ_s is small, i.e. there is ice on the surface, θ must be small to avoid slipping

12-23

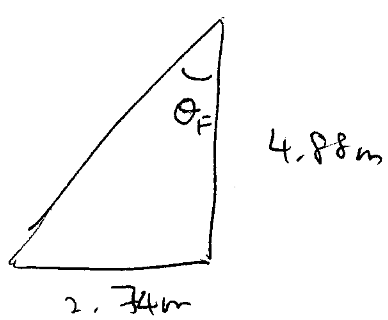


Apply $\Sigma \vec{\tau}_i$ about the foot of the mast

$$(4.88\,m)(1000\,N)\sin\theta_F = (4.88\,m)\,T_B \sin 45°$$

$$\Rightarrow \quad T_B = \frac{1000\,N \sin\theta_F}{\sin 45°}$$

To find θ_F, note that



$$\tan\theta_F = \frac{2.74}{4.88}$$

$$\theta_F = 29.3°$$

Hence $\boxed{T_B = 692\,N}$

Next, apply Newton's law

$$\Sigma F_x = F_{D,x} + T_B \sin 45^\circ - T_F \sin\theta_F = 0$$

$$\Rightarrow F_{D,x} = 1000\,N \sin 29.3^\circ - 692\,N \sin 45^\circ$$

$$\approx 0$$

$$\Sigma F_y = F_{D,y} - T_F \cos\theta_F - T_B \cos 45^\circ - mg = 0$$

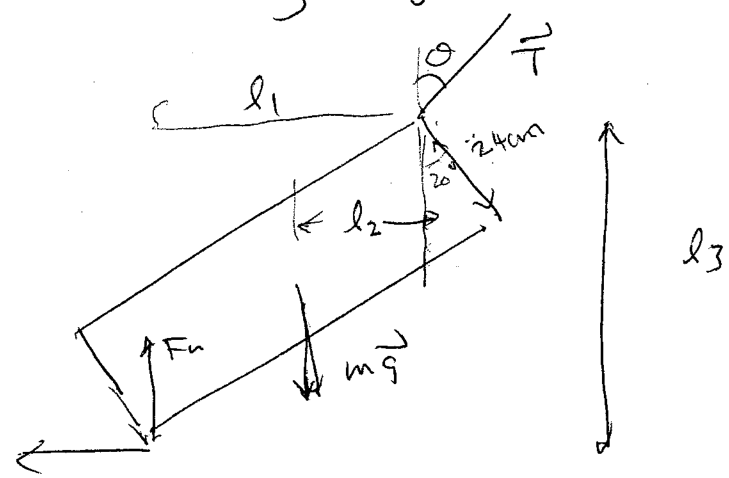
$$\Rightarrow F_{D,y} = 1000\,N \cos 29.3^\circ + 692\,N \cos 45^\circ + (120\,kg)(9.81\,m/s^2)$$

$$= 2539\,N$$

Since $F_{D,x} = 0$ $F_D = 2539\,N$ #

and no block is required to prevent mast from moving

12-39 Free body diagram

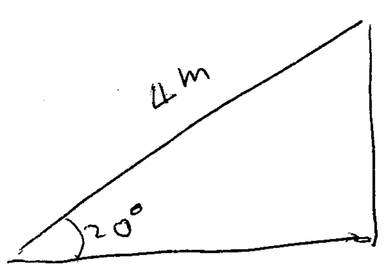


Let the pt at which the wire is attached to the log be the origin

The center of mass of log is at $(-l_2, -\frac{l_3}{2})$

the pt at contact with the floor is at $(-2l_2, -l_3)$

where



$\Rightarrow \quad l_1 + 24cm \sin 20° = 4m \cos 20°$

$\Rightarrow \quad l_1 = 3.677 \text{ m}$ or $l_2 = \frac{l_1}{2} = 1.838m$

Similarly $l_3 = 4m \sin 20° + 0.24m \cos 20°$

$= 1.594 m$

$\Rightarrow$ center of mass is at $(-1.838m, -0.797m)$

pt of contact with floor $(-3.676m, -1.594m)$

Apply $\Sigma F_x = 0$: $T\sin\theta - f_{s,max} = 0$

$\Rightarrow T\sin\theta = f_{s,max} = \mu_s F_n$ ①

$\Sigma F_y = 0$: $T\cos\theta + F_n - mg = 0$

$\Rightarrow T\cos\theta = mg - F_n$ ②

Divide ① by ②

$$\tan\theta = \frac{\mu_s F_n}{mg - F_n}$$

Apply $\Sigma \vec{\tau} = 0$ about origin

$l_2 mg - l_1 F_n - l_3 \mu_s F_n = 0$

$$\Rightarrow F_n = \frac{l_2 mg}{l_1 + l_3 \mu_s}$$

Substitute numerical values:

$$F_n = \frac{1.838\,(100\,kg)(9.81\,m/s^2)}{3.676 + 1.594(0.6)} = 389\,N$$

Therefore

$$\theta = \tan^{-1} \frac{0.6}{\frac{(100kg)(9.81\,m/s^2)}{389\,N} - 1}$$

$$= 21.5^\circ$$

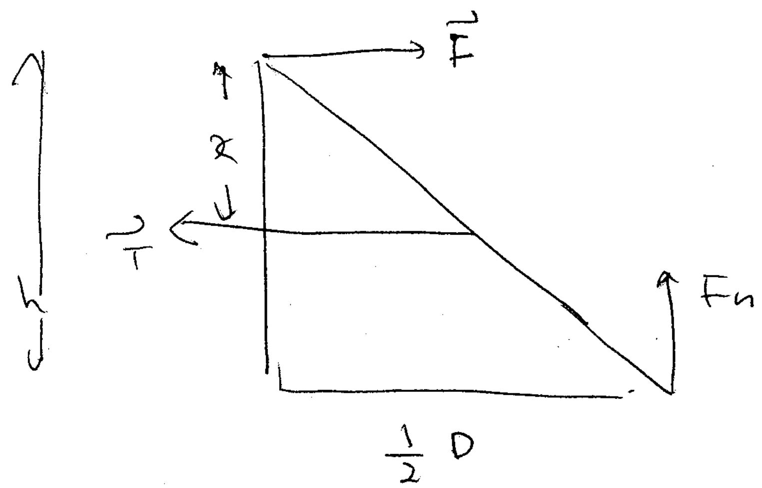
Tension $T = \dfrac{(0.6)(389\,N)}{\sin 21.5^\circ}$ from eqn ①

$$= 636\,N$$ #

12-52 (a) By symmetry, each leg carries half the total weight so force on each leg

$$\Rightarrow \quad F_n = \frac{900N}{2} = 450N$$

(b) Free body diagram



Apply $\Sigma \vec{\tau} = 0$ about the apex

$$F_n \cdot \frac{D}{2} - Tx = 0$$

$$\Rightarrow \quad T = \frac{F_n D}{2x}$$

We can calculate D in terms of h & θ

$$\frac{D}{2} = h \tan\frac{\theta}{2}$$

Hence $\quad T = \dfrac{2 F_n h \tan\frac{\theta}{2}}{2x} = \dfrac{F_n h \tan\frac{\theta}{2}}{x}$

From (a) $T = \frac{wh\tan\theta/2}{2x}$ where w = weight of man

$$= \frac{(900N)(4m)\tan 15^\circ}{2(2m)}$$

$$= 241\ N$$

(c) From $T = \frac{wh\tan\theta/2}{2x}$, we see that

T will decrease as x increases.

12-65

Express the stress on the elevator cable

$$\text{Stress}_{cable} = \frac{F}{A} = \frac{20{,}000\,N}{1.2\times10^{-6}\,m^2}$$

$$= 1.67\times10^{10}\,N/m^2$$

Then express the stress of the sample

$$\text{Stress}_{sample} = \frac{F}{A} = \frac{1000\,N}{0.2\times10^{-6}\,m^2}$$

$$= 0.5\times10^{10}\,N/m^2$$

Since $\text{Stress}_{cable} > \text{Stress}_{sample}$

$\Rightarrow$ Cable will not support elevator