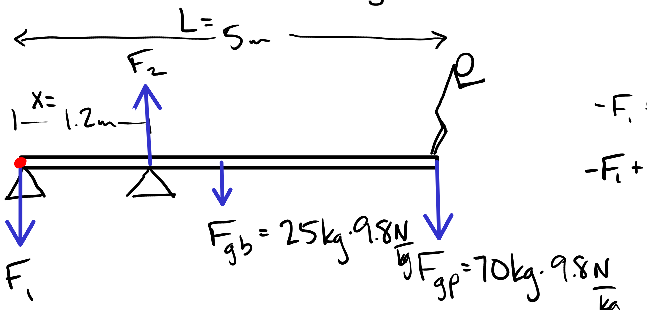
At the end of this worksheet you should be able to

- have more practice at working equilibrium problems.
- work more complicated examples of equilibrium problems.

1. A 5 m long diving board is supported by two connections to the ground. One at the end and another at a point 1.2 m from that end. The board has a mass of 25 kg and a diver with a mass of 70 kg is at the far end. What are the forces exerted by the two supports?



$$\Sigma F = 0$$

$$-F_1 + F_2 - 245N - 686N = 0$$

$$-F_1 + 3369N - 245N - 686N = 0$$

$$F_1 = 2437\,N$$

$$\Sigma \tau = 0$$

$$+F_2 \cdot x - m_b g \cdot \frac{L}{2} - m_p g \cdot L = 0$$

$$F_2 \cdot 1.2m - (245N \cdot 2.5m) - (686N \cdot 5m) = 0$$

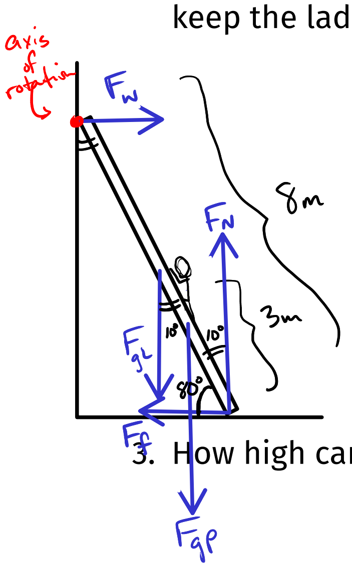
$$F_2 \cdot 1.2m - 612.5Nm - 3430Nm = 0$$

$$F_2 \cdot 1.2m - 4042.5Nm = 0$$

$$F_2 \cdot 1.2m = 4042.5Nm$$

$$F_2 = 3369N$$

2. A painter is standing on a ladder that is 8 m long. The painter has a mass of 75 kg and the ladder has a mass of 10 kg. The painter is standing 3 meters along the ladder. The wall is friction-less, but the floor is friction-full. What force of friction must there be to keep the ladder stable?



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

$$\Sigma F_x = 0 \qquad +F_w - F_f = 0$$

$$\Sigma F_y = 0 \qquad -F_{gL} - F_{gp} + F_N = 0$$

$$-98N - 735N + F_N = 0$$

$$F_N = 833N$$

$$\Sigma \tau = 0$$

$$-98N\sin(10°)4m - 735\sin 10° \cdot 5m + 833\sin 10° \cdot 8m - F_f \sin 80° \cdot 8m = 0$$

$$-68.1Nm - 638Nm + 1157 - 7.88 \cdot F_f = 0$$

$$F_f = 57.2\,N$$

$$\mu_s \le \frac{F_f}{F_N} \qquad \mu = \frac{F_f}{F_N} = 0.06$$

3. How high can this person climb the ladder if the coefficient of static friction is ~~0.3~~ 0.15?

$$\mu_s = \frac{F_f}{F_N} \qquad F_N \mu = F_f = 125\,N$$

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

$$\Sigma F_x = 0 \qquad +F_w - F_f = 0$$

$$\Sigma F_y = 0 \qquad -F_{gL} - F_{gp} + F_N = 0$$

$$-98N - 735N + F_N = 0$$

$$F_N = 833N$$

$$\Sigma \tau = 0$$

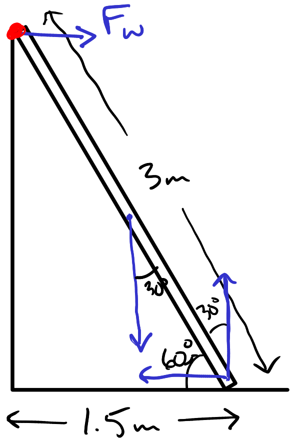
$$-98N\sin(10°)4m - 735\sin 10° \cdot X + 833\sin 10° \cdot 8m - 125 \cdot \sin 80° \cdot 8m = 0$$

$$-68.1Nm - 127.6X + 1157 - 985 = 0$$

$$X = 0.81$$

$8 - 0.81 = 7.2$ m from the bottom

4. If a uniform ladder has a mass of 10 kg, a length of 3 m, and its base is 1.5 m from the wall, what is the minimum coefficient of friction to keep the ladder up?



$\cos\theta = \frac{1.5}{3}$

$\theta = 60°$

$\Sigma \vec{F} = 0$

$\Sigma F_x = 0$

$+F_W - F_f = 0$

$\Sigma F_y = 0$

$-9.8\frac{N}{kg} 10kg + F_N = 0$

$F_N = 98N$

$\Sigma \tau = 0$

$-98 \cdot \sin 30° \cdot 1.5m - F_f \sin 60° \cdot 3m + 98N \sin 30° \cdot 3m = 0$

$F_f = 28.3N$

$\mu = \frac{F_f}{F_N} = 0.29$

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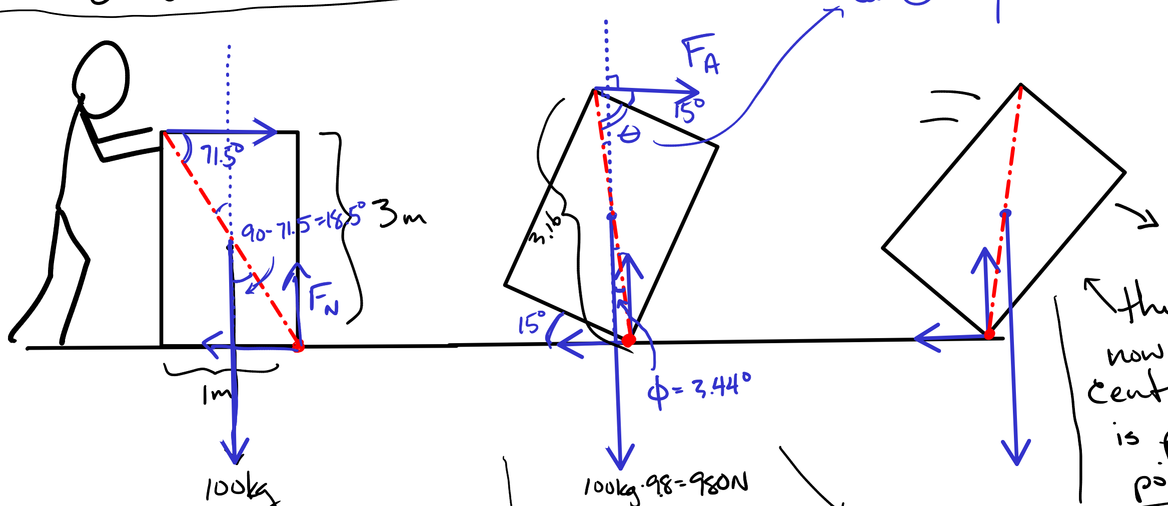
$\tan\theta = \frac{3}{1} \Rightarrow \theta = \tan^{-1}(3) = 71.5°$

$+15°$

$86.56°$

$90 - 86.56° = 3.44°$



↖ the box will fall now that the center of gravity is past the pivot point!

What F_A in this position?

$+980N \cdot \sin 18.5° \cdot 1.58 - F_A \sin 71.5° \cdot 3.16 = 0$

$F_A = 163.8N$

What about the minimum coefficient of friction

$\mu = \frac{F_f}{F_N} = \frac{F_A}{F_G} = \frac{163.8}{980} = 0.16$

↖ it could be higher but this is the minimum

What F_A is necessary in this position?

$\Sigma \tau = 0$

$+980 \cdot \sin 3.44° \cdot 1.58m - F_A \cdot \sin 86.56° \cdot 3.16 = 0$

$F_A = 29.5N$