Lesson 2.4 – Translational Equilibrium

Unit 2: Dynamics and Equilibrium

Translational Equilibrium: *When the sum of all the forces acting on an object is zero.*

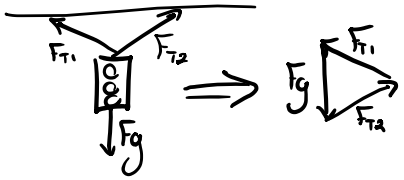
* sum of horizontal forces is zero. $\sum \vec{F}_x = 0$
* sum of vertical forces is zero. $\sum \vec{F}_y = 0$

$\sum$ ← Sigma = sum.

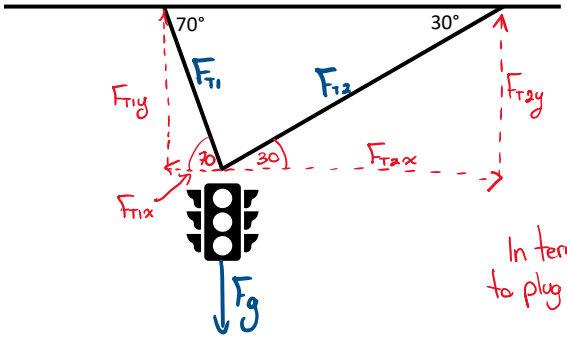
The force vectors will form a closed vector diagram

→ no resultant vector

Ex. Traffic Light



Example 1: Find the tension in the wires (m = 15 kg)



$\sum F_x = 0$

$F_{T1x} - F_{T2x} = 0$

$F_{T1x} = F_{T2x}$

$F_{T1}\cos 70 = F_{T2}\cos 30$

In terms of F_{T1} to plug into another eq: $F_{T1} = \dfrac{F_{T2}\cos 30}{\cos 70}$

$\vec{F}_{T1} = \dfrac{51.1\cos 30}{\cos 70}$

$\vec{F}_{T1} = 129\,N$

*option to simplify

$F_{T1} = 2.53F_{T2}$

$\sum F_y = 0$

Expand → $F_{T1y} + F_{T2y} - F_g = 0$

$F_{T1}\sin 70 + F_{T2}\sin 30 - mg = 0$

$\dfrac{F_{T2}\cos 30\sin 70}{\cos 70} + F_{T2}\sin 30 = mg$

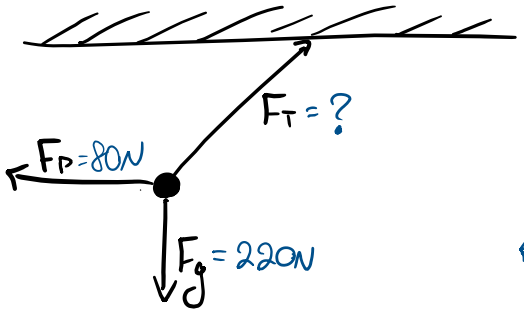
$F_{T2}\left(\dfrac{\cos 30\sin 70}{\cos 70} + \sin 30\right) = mg$ (tan 70)

$F_{T2} = \dfrac{mg}{\cos 30\tan 70 + \sin 30}$

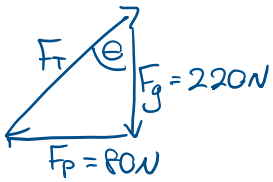
$F_{T2} = \dfrac{15(9.8)}{\cos 30\tan 70 + \sin 30}$

$F_{T2} = 51.1\,N$

Example 2: A 220. N mass is hanging from a vertical rope. A person pulls the mass horizontally with a force of 80.0 N. Find the tension in the rope and the angle created.



Use a vector diagram (will sum to 0).



$F_T = \sqrt{220^2 + 80^2}$

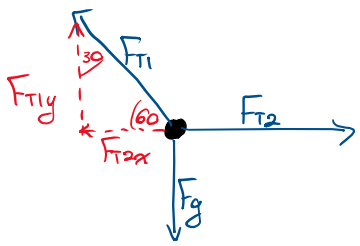
$= 234\,N$

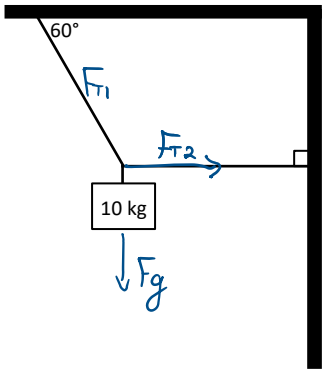
$\theta = \arctan\left(\dfrac{80}{220}\right)$

$= 20.0°$ from vertical

or $80.0°$ from horizontal.

Example 3: Find the tension in each wire:





$\sum F_x = 0$

$F_{T1x} - F_{T2} = 0$

$F_{T1x} = F_{T2}$

$F_{T1}\cos 60 = F_{T2}$

$\sum F_y = 0$

$F_{T1y} - F_g = 0$

$F_{T1}\sin 60 = mg$

$F_{T1} = \frac{mg}{\sin 60}$

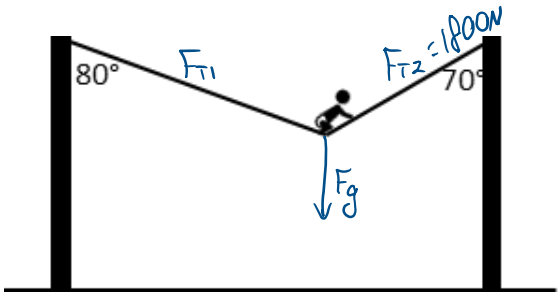
$F_{T1} = \frac{10(9.8)}{\sin 60}$

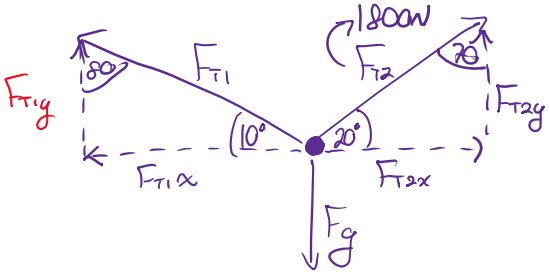
$F_{T1} = 113\,N$

$F_{T2} = 113\cos 60$

$F_{T2} = 56.6\,N$

Example 4: A circus performer (who is a baby) crawls the tightrope as shown. If the tension in the short length is 1.8×10^3 N, find the mass of the performer.





$\sum F_x = 0$

$F_{T1x} - F_{T2x} = 0$

$F_{T1x} = F_{T2x}$

$F_{T1}\cos 10 = 1800\cos 20$

$F_{T1} = \frac{1800\cos 20}{\cos 10}$

$F_{T1} = 1717.54\,N$

$\sum F_y = 0$

$F_{T1y} + F_{T2y} - F_g = 0$

$F_{T1}\sin 10 + F_{T2}\sin 20 - mg = 0$

$m = \frac{F_{T1}\sin 10 + F_{T2}\sin 20}{g}$

$m = \frac{1717.54\sin 10 + 1800\sin 20}{9.8}$

$m = 93\,kg.$

Assignment: WS 2.4 – Translational Equilibrium Practice