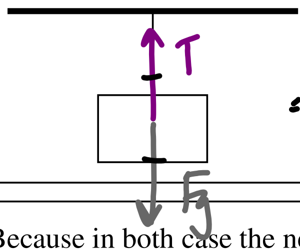
Equilibrium Notes

1 – Translational Equilibrium

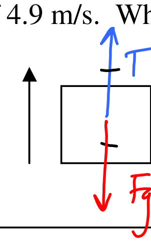
Ex.
A 20.0 kg object is suspended by a rope as shown. What is the net force acting on it?



$T = F_g$

$\therefore F_{net} = 0$

Ex.
Ok that was easy, now that same 20.0 kg object is lifted at a velocity of 4.9 m/s. What is the net force acting on it?



$a = 0$

$\therefore F_{net} = 0$

Because in both case the net force on the objects is zero they are said to be in __equilibrium__. If the object is stationary it is said to be in __static equilibrium__, while an object moving at a constant velocity is in __dynamic equilibrium__.

These are both case where the object is in __translational__ __equilibrium__.

Translational motion refers to motion along a line, therefore:

The condition of equilibrium:

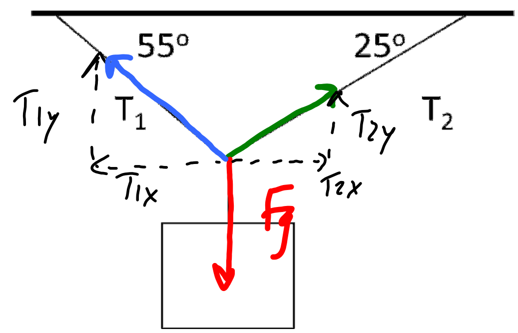
$\sum F = 0$

And so,

$\sum F_x = 0$

$\sum F_y = 0$

Ex.
A sign is suspended using ropes as shown in the diagram. If T_1 is 100 N, what is the weight of the sign?



Strategy 1: Components

1. Choose a point in the system that is in equilibrium, with all forces acting on it. In this case use __the intersection__.
2. Draw an __F__ __B__ __D__!
3. Break these forces…into components
4. Use…1st condition

$T_{1x} = T_1 \cos 55° = 57.36\ N$

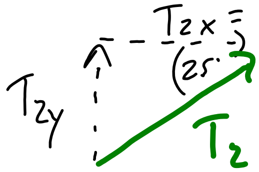
$T_1 = 100N$

$T_{1y} = T_1 \sin 55°$
$= 81.92\ N$

$\sum F_x = T_{2x} - T_{1x} = 0$

$T_{2x} = T_{1x}$
$= 57.36N$

$T_{2x} = 57.36\ N$



$\tan 25° = \frac{T_{2y}}{T_{2x}}$

$T_{2y} = T_{2x} \tan 25°$

$= 26.75N$

$\sum F_y = T_{1y} + T_{2y} - F_g = 0$

$F_g = T_{1y} + T_{2y}$
$= 81.92 + 26.75N$

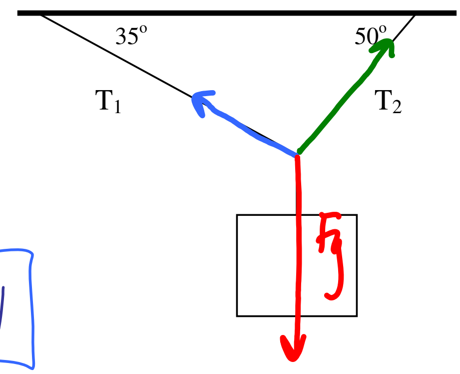
$= \boxed{109\ N}$

Strategy 2: Create a **closed vector diagram**

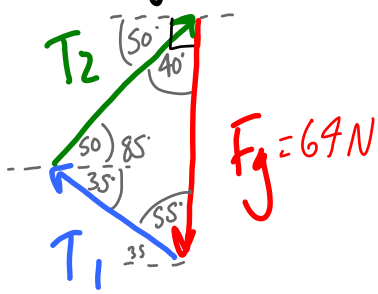
1. Since we know that $F_{net} = 0$ at any point in equilibrium, what would happen if we added if we add up all of the force vectors? They add to zero!

2. Use Sine Law, Cosine Law, or whatever means necessary to solve the triangle…
3. NEVER assume that it is a right angle unless you can prove it geometrically.

Ex.
A 64 N object is suspended using ropes as shown in the diagram. Calculate tensions T_1 and T_2 in the ropes.



$$\sum \vec{F} = \vec{F_g} + \vec{T_1} + \vec{T_2} = 0$$



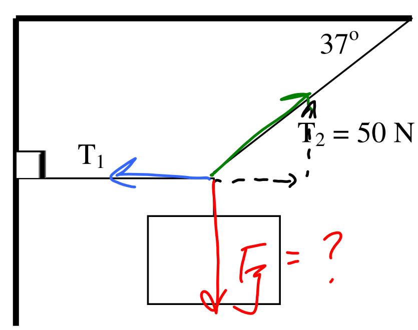
$$\frac{T_1}{\sin 40^\circ} = \frac{F_g}{\sin 85}$$

$$T_1 = F_g \frac{\sin 40}{\sin 85} = 41\,N$$

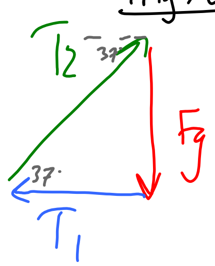
$$\frac{T_2}{\sin 55} = \frac{F_g}{\sin 85}$$

$$T_2 = F_g \frac{\sin 55}{\sin 85} = 53\,N$$

Ex.
An object is suspended as shown. If the tension in one of the ropes is 50 N as shown, what is the weight of the object?

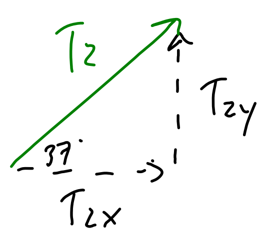


Trig Method



$$F_g = T_2 \sin 37^\circ = 30.1\,N$$

Component Method



$$\sum F_y = T_{2y} - F_g = 0$$

$$\therefore F_g = T_{2y} = T \sin = 30.1\,N$$

You can use **Strategy 1** or **Strategy 2**, just be sure you know both ways. You're bound to hit a brick wall eventually and it's nice to be able to try it from a different angle, no pun intended...