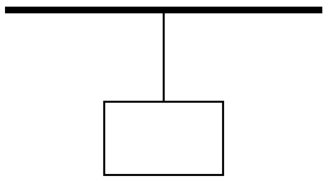
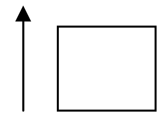
Equilibrium Notes

1 – Translational Equilibrium

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



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?



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

These are both case where the object is in _______________________ ______________________________.

Translational motion refers to motion along a line, therefore:

The condition of equilibrium:

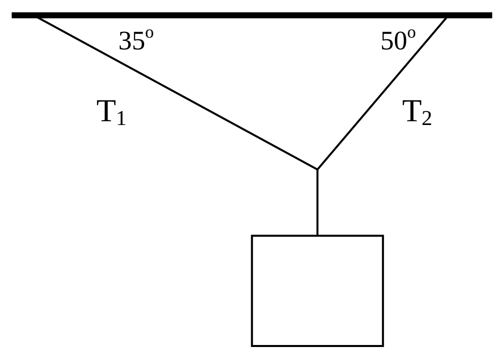
_________________ = ____________________

And so,

_________________ = ____________________

_________________ = ____________________

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



Strategy 1: Components

1. Choose a point in the system that is in equilibrium, with all forces acting on it. In this case use ______________.
2. Draw an _____ _____ _____!
3. Break these forces...
4. Use…

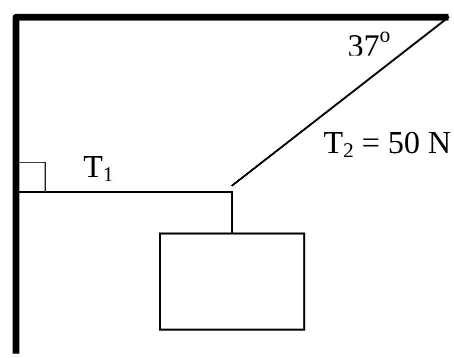
Strategy 2: Create a **closed vector diagram**

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?

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

<u>Ex.</u>

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?



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...

Equilibrium Notes

2 – Torque at 90^o

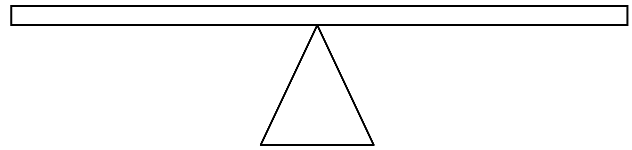
A body in translational equilibrium will have no acceleration in the x or y directions. However it still could be ______________________.

Consider a teeter-totter, with a 100 kg student on one end and a 50 kg student on the other.

What are the net translational forces in:

The x-direction? ________________

The y-direction? ________________



Although the net translational forces are zero, the system has a __________________ _____________________ - so it is not in equilibrium.

An object in equilibrium must have both translational and _____________________ equilibrium.

The second condition of equilibrium is that in order to have no rotation, there must be no net torque.

Torque is defined as: **force x distance to pivot**

Unit of torque: ______________

Imagine trying to loosen the lug nuts to remove a tire from your car. The longer the wrench you use, the easier it will be.

Ex:

A torque of 24.0 Nm is needed to tighten a nut. If a person can apply a force of 100 N, what is the minimum length of wrench that is required?

Torque is a __________________ quantity, which must work in either the clockwise (c) or counterclockwise (cc) directions.

If an object is in rotational equilibrium then:

A few more terms we need to learn before we go on…

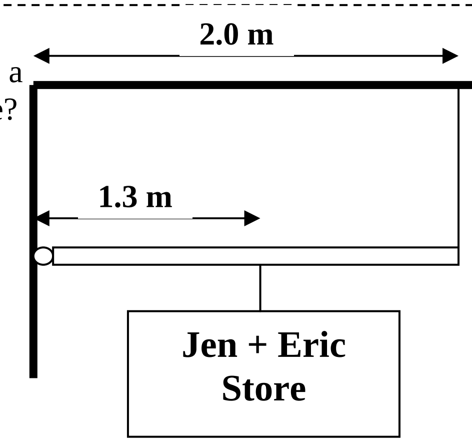
Centre of Gravity:

Uniform Beam:

Arbitrary Position of Rotation:

Ex:

A 350 N store sign hangs from a pole of negligible mass. The pole is attached to a wall by a hinge and supported by a vertical rope. What is the tension in the rope?

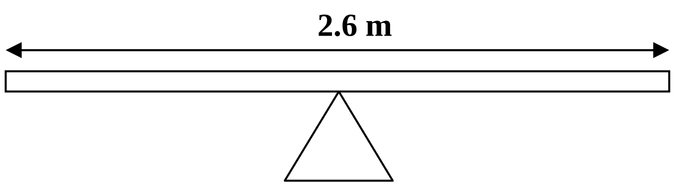


Extension:

What are the vertical and horizontal components of the supporting force provided by the hinge in the last question?

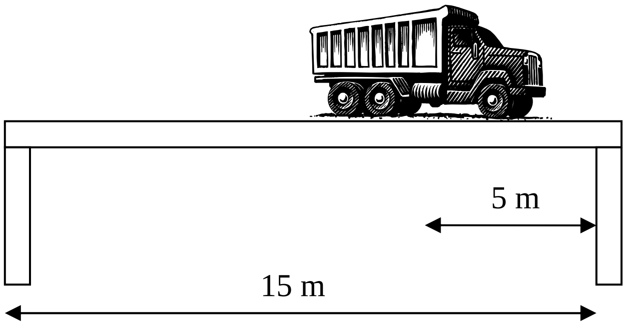
Ex:

Two students sit on opposite sides of an 800 N teeter-totter. Student 1 has a mass of 65 kg and sits at the very end of the teeter-totter. Student 2 has a mass of 90 kg. How far from the pivot should he sit in order to achieve equilibrium?



Ex:

A 3500 kg truck is parked on a bridge as shown. If the bridge deck itself has a mass of 6500 kg find the supporting force provided by each of the two support posts.



Equilibrium Notes

3 – Torque Not at 90^o

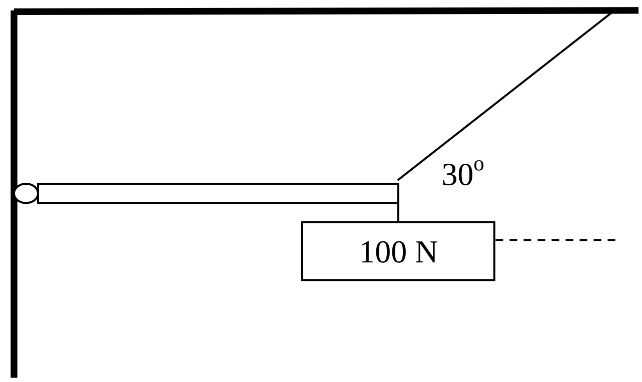
Although we've already learned about torque, we don't quite have the whole story. So far we have only seen torque provided by forces acting perpendicular to the body in equilibrium. **What happens if a force acts in a direction other than perpendicular to the body?**

Ex

A 2.2 m long 50.0 N uniform beam is attached to a wall by means of a hinge. Attached to the other end of the beam is a 100 N weight. A rope also helps support the beam as shown.

a) What is the tension in the rope?

b) What are the vertical and horizontal components of the supporting force provided by the hinge?



First we draw the beam with the forces acting on it and their distances from the pivot:

Notice that if we break the tension in the rope into component forces, the _______________ component does not contribute to the torque in either the clockwise or counterclockwise direction

So, whenever we are calculating the torque on a body we must ALWAYS use the ___________________________ _________________________ of the force.

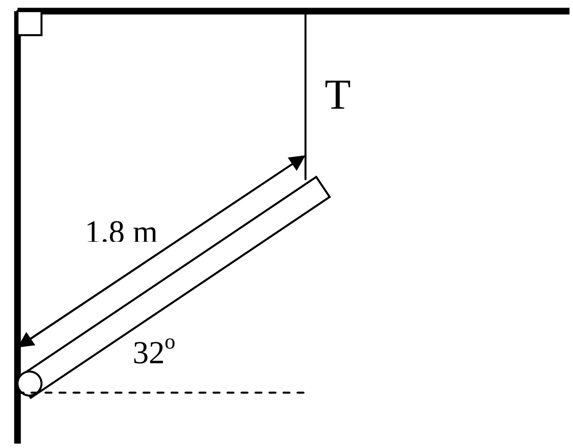
Ok now go solving!

a)

b)

RULE NOT TO BREAK LEST YE BE BROKEN:
When we find the torque acting on a body we MUST ALWAYS use the component of the force that is ____________________ to ______ _____________!!!

Ex
A 1.8 m long 12.0 kg bar is attached to a wall by a hinge and supported by a rope as shown. Find the tension in the rope.



Ex
Find the mass of the object given the information in the diagram and that the weight of the uniform beam is 115 N.