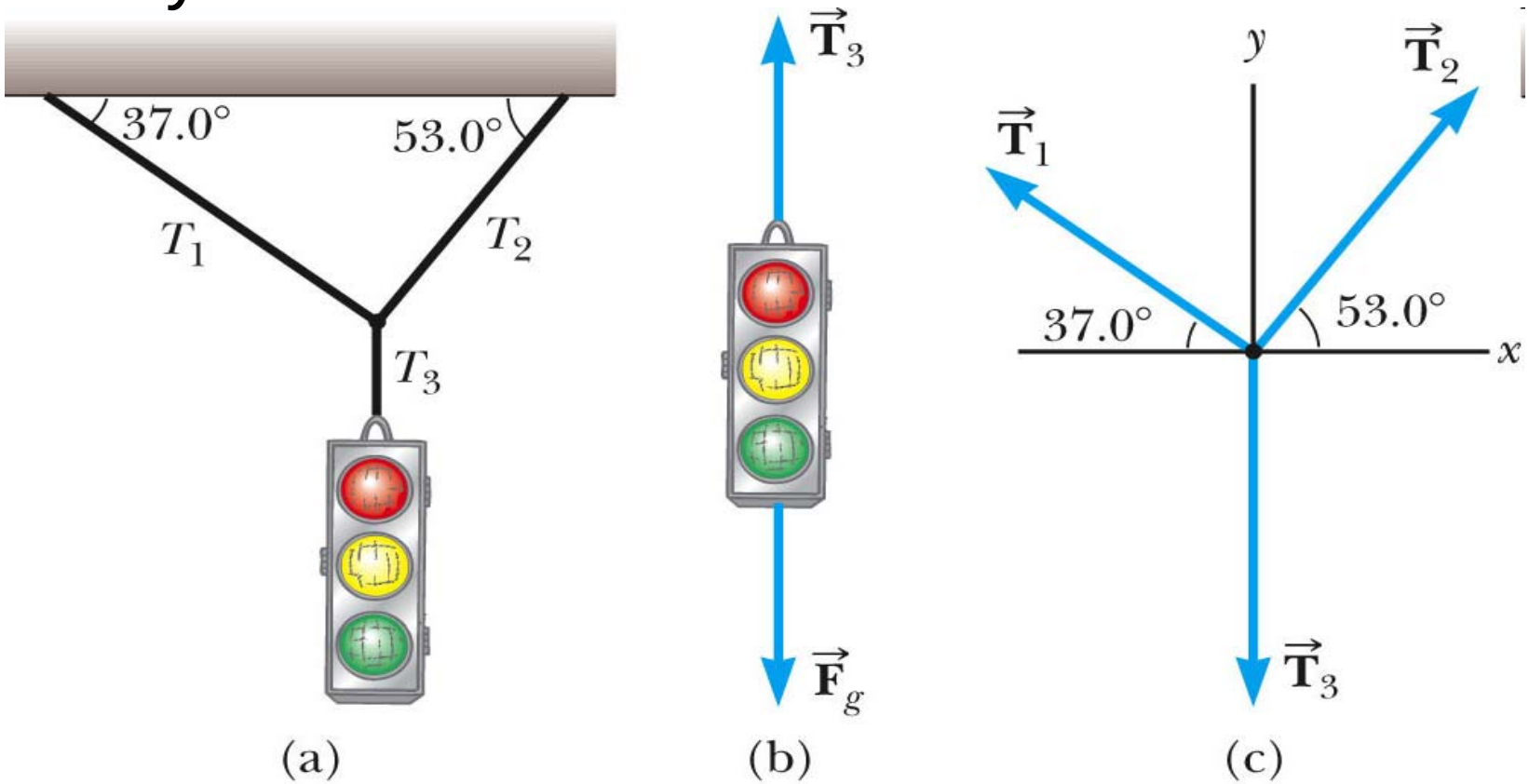
Draw free Body Diagram

- Identify all the forces acting on the object of interest
- Choose an appropriate coordinate system



Apply Newton's 2nd law

sum of *all* the forces acting on the object

$$\sum \vec{F} = m\vec{a}$$

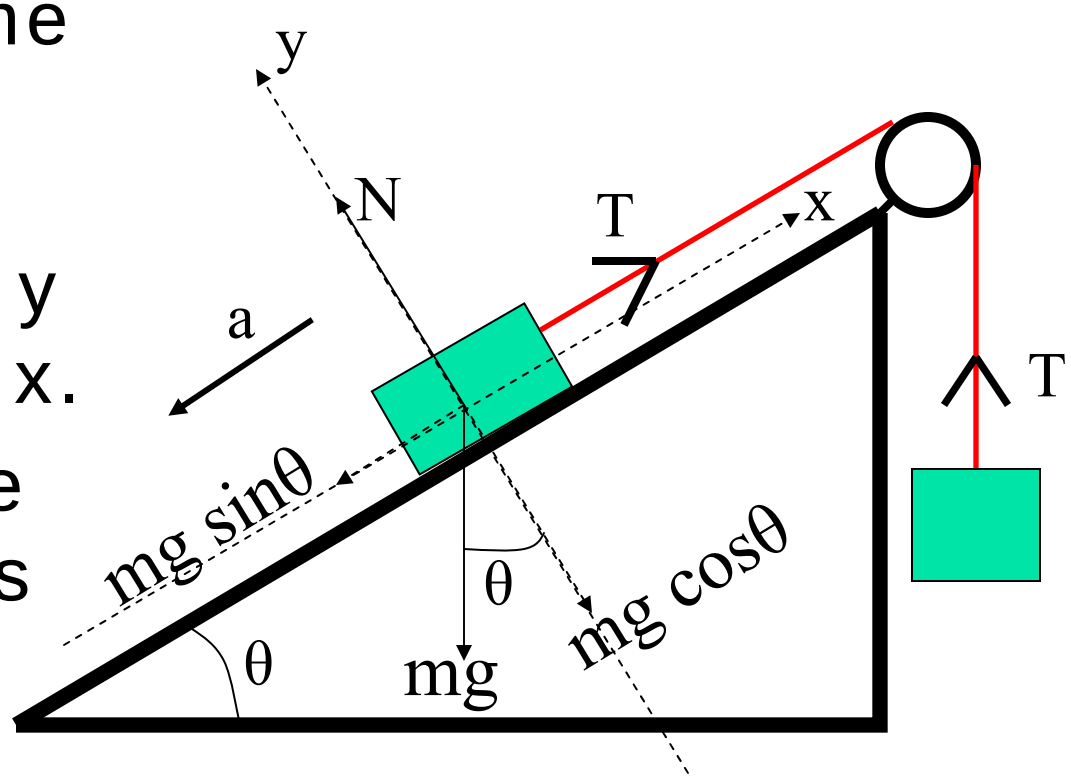
Remember this is a *vector* equation!

$$\sum F_x = ma_x$$

$$\sum F_y = ma_y$$

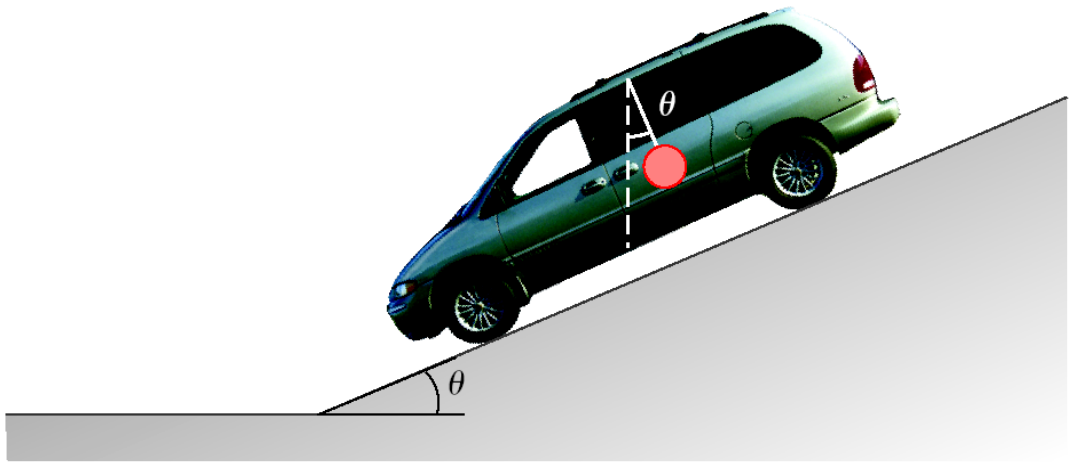
Inclined Planes

- Choose the coordinate system with x in the same or opposite direction of acceleration and y perpendicular to x.
- Replace the force of gravity with its components.



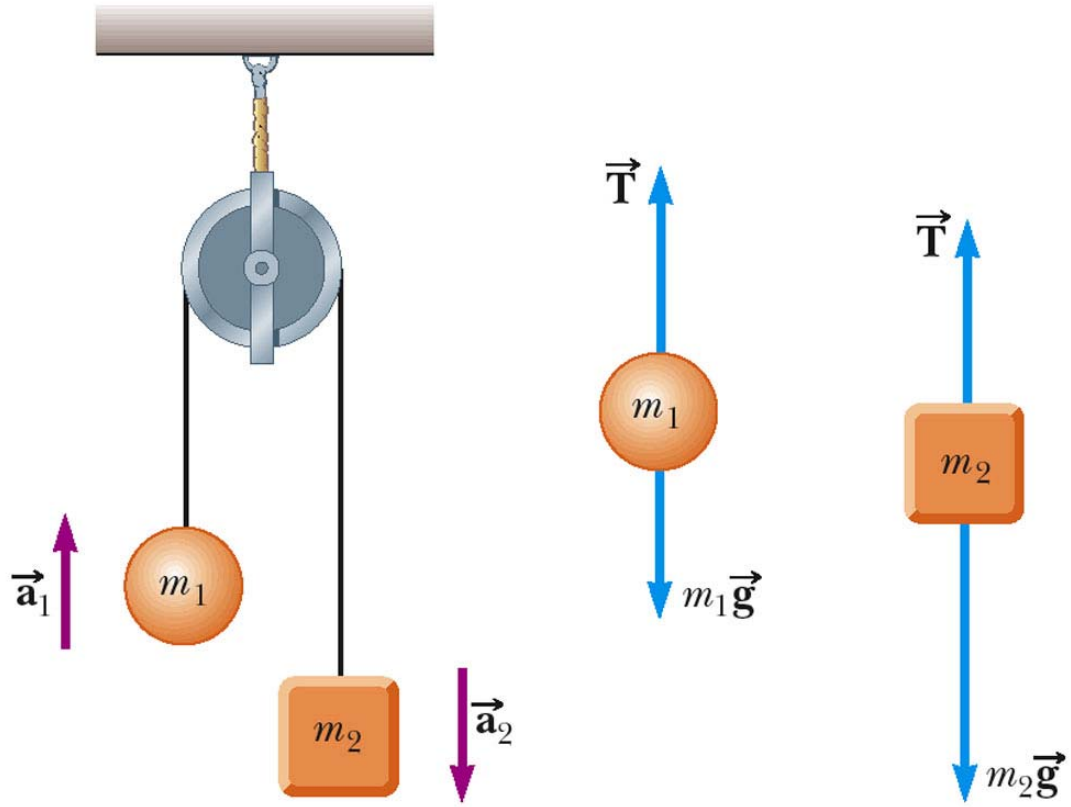
Example #4-73

A van accelerates down a hill (Fig. P4.71), going from rest to 30.0 m/s in 6.00 s. During the acceleration, a toy (m = 0.100 kg) hangs by a string from the van's ceiling. The acceleration is such that the string remains perpendicular to the ceiling. Determine (a) the angle θ and (b) the tension in the string.



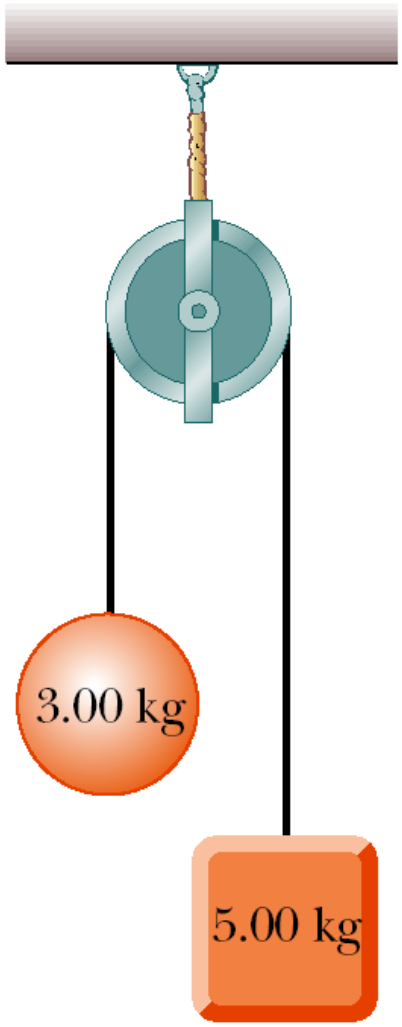
Two objects connected by a massless string

- Draw free body diagrams
- Apply Newton's Laws separately to each object
- The magnitude of the acceleration of both objects will be the same
- The tension is the same in each diagram
- Solve the simultaneous equations



Example #4-38

Two objects with masses of 3.00 kg and 5.00 kg are connected by a light string that passes over a frictionless pulley, as in Figure P4.34. Determine (a) the tension in the string, (b) the acceleration of each object, and (c) the distance each object will move in the first second of motion if both objects start from rest.



Newton's Third Law

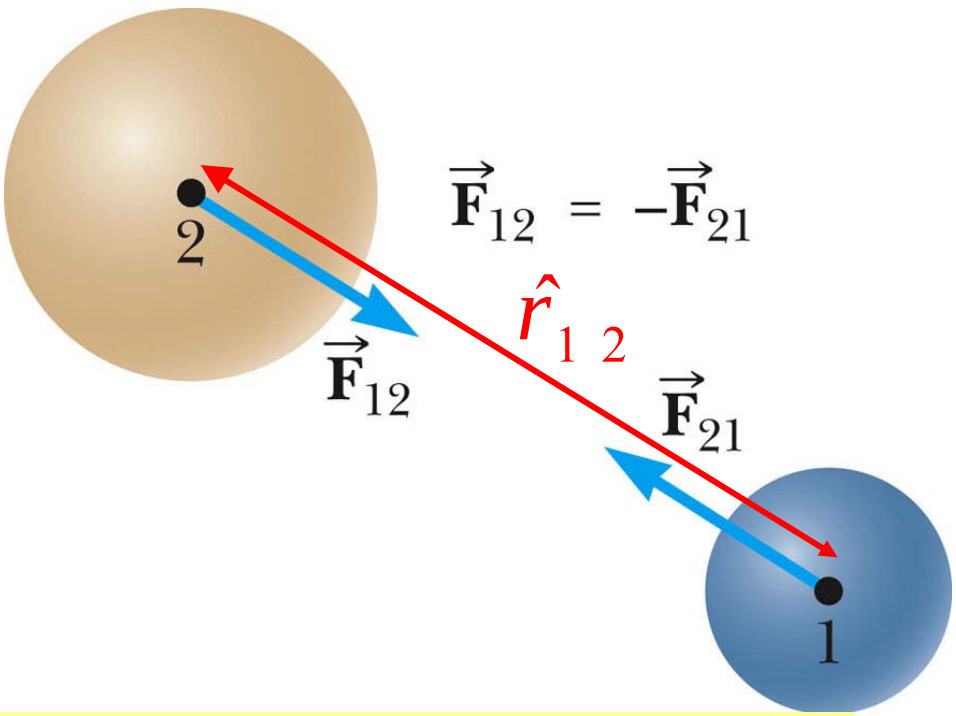
- If object 1 and object 2 interact, the force exerted by object 1 on object 2 is equal in magnitude but opposite in direction to the force exerted by object 2 on object 1.

$$\boxed{\vec{\mathbf{F}}_{12} = -\vec{\mathbf{F}}_{21}}$$

  - Equivalent to saying a single isolated force cannot exist

Newton's Third Law cont'd.

- F_{12} may be called the *action* force and F_{21} the *reaction* force
  - Actually, either force can be the action or the reaction force
- The action and reaction forces act on **different** objects



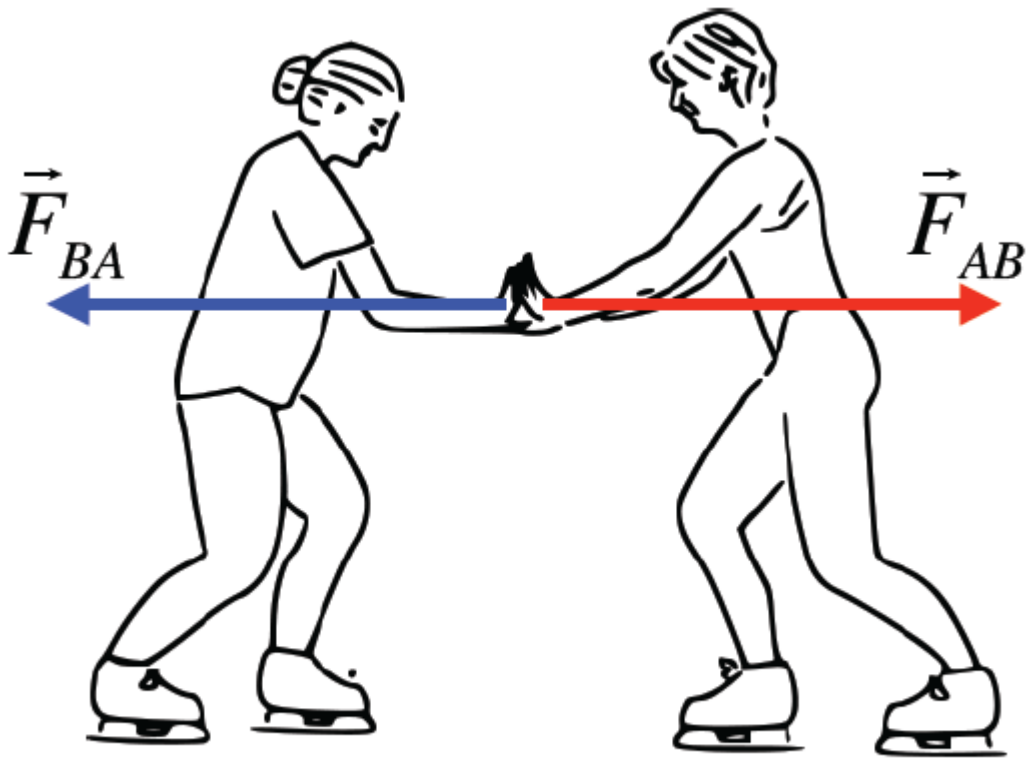
Example: two planets attract each other with gravitational force

$$\vec{F}_{12} = -\frac{Gm_1m_2}{r^2}\hat{r}_{12}$$

Newton's Third Law cont'd.

ice skaters on a frozen pond: contact forces

$$\vec{F}_{AB} = -\vec{F}_{BA}$$



Third-law Force Pair

Equilibrium

- An object either at rest or moving with a constant velocity is said to be in *equilibrium*
- The net force acting on the object is zero (since the acceleration is zero)

$$\sum \vec{\mathbf{F}} = 0$$

Equilibrium cont.

- Easier to work with the equation in terms of its components:

$$\sum F_x = 0 \; and \; \sum F_y = 0$$

- This could be extended to three dimensions

Example #4.19

A 150 N bird feeder is supported by three cables as shown below. Find the tension in each cable