Chapter 6 Applications of Newton's Laws

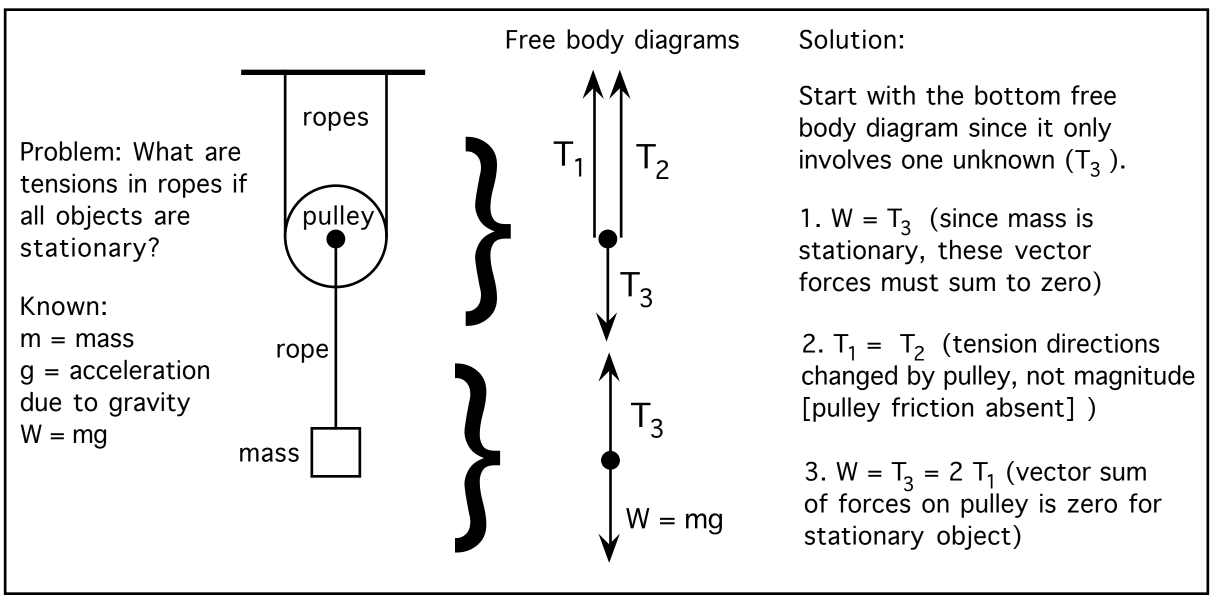
Section 6.1

Friction Remember that there are two kinds of *coefficients* of friction: static [stationary] and kinetic [linear motion]), but that neither of the coefficients have units. The maximum static frictional force is given by $f_S(\text{max}) = \mu_S N$ and the kinetic frictional force is given by $f_k = \mu_k N$. In all these cases, frictional force is proportional to the normal force exerted by the object's support.

Determine where on the object and in what direction the frictional force acts. The direction of a frictional force is always opposite to the direction of an object's motion (or potential motion). If frictional force is present, remember to include the frictional force(s) when writing Newton's second law for the object.

Section 6.2

Tension Ropes and cables carry (that is, transmit) forces in the form of tension. A rope under tension means: a force applied at one end of a rope is transmitted by the material of the rope through to the opposite end where the rope is attached. Pulleys (of small mass and without friction) do not change the magnitude of the tension– just the direction of the tension. Solving problems involving tension requires drawing free body diagrams. Following is an example which is equivalent to the well example:



Springs Pulling on a spring stretches it and pushing on a spring compresses it. In either case the displacement $\vec{\mathbf{x}}$ (the amount of stretch or compression) of the spring is proportional to the applied force required to displace the spring. The reaction to this applied force is the force exerted back by the spring $(\vec{\mathbf{F}}_S)$. The force exerted by the spring is then given by: $\vec{\mathbf{F}}_S = -k\,\vec{\mathbf{x}}$. This equation is called Hooke's Law (which holds for a wide variety of materials– even ones which do not look like springs). Note that the force exerted by the spring is always in a direction opposite to the displacement.

Section 6.4 (example)

Problem: What are tensions in ropes if all objects are accelerating as one?

Known:

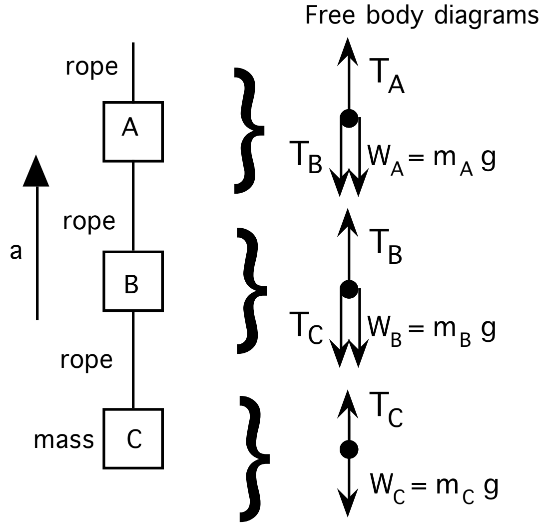
$m_A = 5$ kg

$m_B = 3$ kg

$m_C = 2$ kg

$a = 3\ m/s^2$

$g = 9.8\ m/s^2$



Solution:

Start with the bottom free body diagram since it involves fewest unknowns (T_C).

1. $T_C - W_C = m_C a$ (Newton's second law) Solving: $T_C = W_C + m_C a = 25.6$ N

2. $T_B - T_C - W_B = m_B a$ (Again Newton's second law) Solving: $T_B = T_C + W_B + m_B a = 64$ N

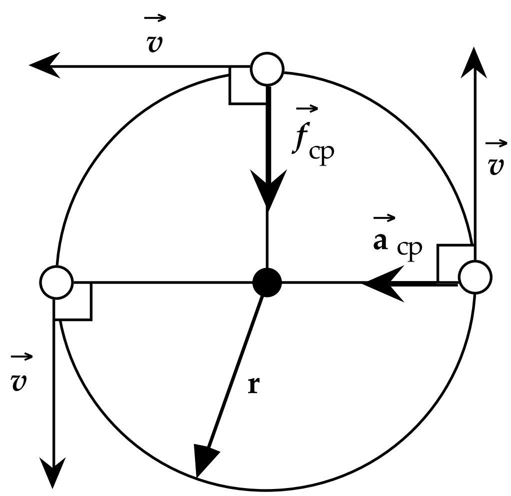
3. $T_A - T_B - W_A = m_A a$ (Again Newton's second law) Solving: $T_A = T_B + W_A + m_A a = 128$ N

Section 6.5

Circular motion

You should understand that centripetal force is ***not*** a new type of force, but is just what we call any external force that causes an object to go in a circle.

The essential difficulty in circular motion problems is identifying which force (or sum of forces) is actually providing the centripetal force. This means you must practice identifying the force components that point toward the center of the circular motion.



- The equation for centripetal force $\left(f_{cp} = m\, a_{cp} = \frac{mv^2}{r}\right)$ is a descriptive equation. That is, once you know what real force component is pointing towards the center of the circular motion, you can set that force component equal to $\frac{mv^2}{r}$. You can then solve for v (the tangential speed) or r as required.

- Uniform circular motion describes constant speed motion in a circle of radius r. The amount of time required to go around the circle once is called the period (T) and the distance traveled in that single revolution is given by the circumference ($2\pi r$). The speed can be found from: $v = \frac{\text{distance}}{\text{time}} = \frac{2\pi r}{T}$.

- As shown in the figure above, there is always a 90° angle: between v and a_{cp}, between v and f_{cp}, and between v and r.