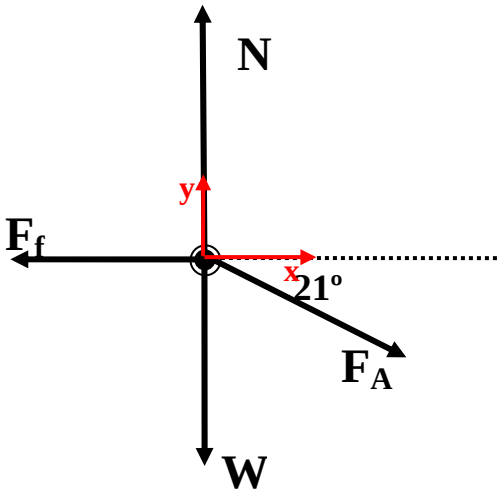
Physics 151 Class Exercise: Vectors

1. To move a large crate across a rough floor, you push down on it an angle of 21º. Find the force necessary to start the crate moving, given that the mass of the crate is 32 kg and the coefficient of static friction between the crate and the floor is 0.57. (Start with a free-body diagram, add a coordinate system, and then write the equations for the summation of forces. Remember that you will need to determine the normal force to include friction.)



Write out the summation of forces in the x direction.

$$\Sigma F_x = F\cos\theta - \mu N = 0$$

Note that we don't know the normal force. We typically will look at the summation of forces in the y direction to determine the normal force and then use this in the x-equation. Write out the summation of forces in the y direction and determine the normal force.

$$\Sigma F_y = N - mg - F\sin\theta = 0$$

$$N = mg + F\sin\theta$$

Substitute the normal force into the x-equation.

$$F\cos\theta - \mu_s(mg + F\sin\theta) = 0$$

$$F\cos\theta - \mu_s F\sin\theta = \mu_s mg$$

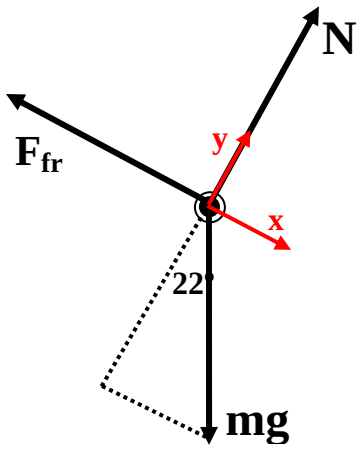
$$F = \frac{\mu_s mg}{\cos\theta - \mu_s \sin\theta}$$

$$= \frac{0.57(32\,\text{kg})\left(9.81\ \frac{\text{m}}{\text{s}^2}\right)}{\cos 21° - 0.57\sin 21°}$$

$$= \boxed{250\ \text{N}}$$

Note that we have two Fs -- so we will need to factor.

2. A skier travels down the trail as shown below. The slope is inclined at an angle of 22º and the coefficient of kinetic friction is 0.2. What is the skier's acceleration down the hill?



Write out the summation of forces in the x direction.

$$\Sigma F_x = mg\sin\theta - \mu N = ma_x$$

Write out the summation of forces in the y direction and determine the normal force.

$$\Sigma F_y = N - mg\cos\theta = 0$$

$$N = mg\cos\theta$$

Substitute the normal force into the x-equation.

$$mg\sin\theta - \mu N = ma_x$$
$$mg\sin\theta - \mu\left(mg\cos\theta\right) = ma_x$$
$$g\sin\theta - \mu g\cos\theta = a_x$$
$$g\left(\sin\theta - \mu\cos\theta\right) = a_x$$
$$\left(9.81\frac{m}{s^2}\right)\left[\sin 22° - (0.2)\cos 22°\right] = a_x$$
$$1.86\frac{m}{s^2} = a_x$$

Note that mass cancels out and is not needed. This would not be apparent if we had substituted values into the equation earlier and is one of many advantages of doing problems algebraically.