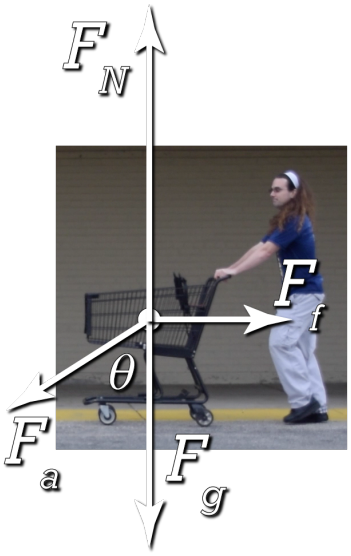
Flipping Physics Lecture Notes:

Introductory Work Problem

A shopper pushes a shopping cart with a force of 6.9 N at an angle of 59° to the left of the negative y-axis. While the cart moves a horizontal distance of 7.0 m, what is the work done by the shopper on the shopping cart?

$$F_a = 6.9N @ 59° \; left\, of - y\; axis; \Delta x = -7.0m; W_{F_a} = ?$$

Draw the Free Body Diagram:



We do not need to break the Force Applied into its components, because the Work equation includes the direction of the force in it.

$$W_{F_a} = F_a d\cos\theta = \left(6.9\right)\left(7\right)\cos\left(90° - 59°\right) = 41.401\, N \cdot m \approx \boxed{41\, J}$$

- The angle in the work equation is the angle between the direction of the force doing the work and the displacement of the object. In this example, the angle is actually 90° minus the angle given in the problem.
- Always use the magnitude of the Force and Displacement in the work equation.

We can also find the work done by the Force Normal and the Force of Gravity:

$$W_{F_g} = F_g d\cos\theta = \left(mg\right)d\cos\theta = \left(mg\right)d\cos\left(90\right) = 0$$

$$W_{F_N} = F_N d\cos\theta = F_N d\cos\left(90\right) = 0$$

Because I felt it would make the video too long, the following was not in the video, however, why not include it here, eh?:

If we assume the cart is moving at a constant velocity, which is a pretty good approximation if you look at the video, we *can* determine the work done by the force of friction. We need the horizontal component of the Force Applied:

$$\sin\theta = \frac{O}{H} = \frac{F_{a_x}}{F_a} \Rightarrow F_{a_x} = F_a \sin\theta = 6.9\sin\left(59°\right) = 5.91445N$$

Redraw the Free Body Diagram with components of the Force Applied.

$$\sum F_x = F_f - F_{ax} = ma_x = m\left(0\right) = 0 \Rightarrow F_f = F_{ax} = 5.91445N$$

$$W_{F_f} = F_f d\cos\theta = \left(5.91445\right)\left(7\right)\cos\left(180°\right) = -41.401 = \boxed{-41\, J}$$

Note: The total work done on the shopping cart while it is moving at a constant velocity is zero. (This is called foreshadowing.)