Flipping Physics Lecture Notes:
Introductory Newton's 2nd Law Example Problem and Demonstration
(or Finding the Force of Friction between a Dynamics Cart and Track)

Newton's Second Law of Motion: $\sum \vec{F} = m\vec{a}$

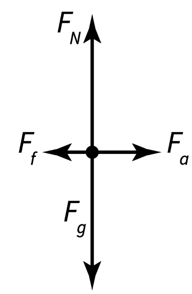
Example Problem: A 613 g cart is released from rest on a horizontal track and travels 52.0 cm in 1.15 seconds while experiencing an average, horizontal applied force of 0.490 N. What is the magnitude of the force of friction between the cart and the track?

Known Values: $m = 613g;\ v_i = 0;\ \Delta x = 52.0cm;\ \Delta t = 1.15s;\ F_a = 0.490N;\ F_f = ?$

Convert mass to kg: $m = 613g \times \frac{1kg}{1000g} = 0.613kg$

Convert displacement to meters: $\Delta x = 52.0cm \times \frac{1m}{100cm} = 0.52m$

Draw the Free Body Diagram of the forces acting on the cart:



Use Newton's Second Law:

$$\sum F_x = F_a - F_f = ma_x \Rightarrow F_a = ma_x + F_f \Rightarrow F_f = F_a - ma_x$$

The only variable we don't know is the acceleration in the x-direction. We can consider the acceleration to be constant because the forces are constant (or at least very close to constant). Therefore we can use the uniformly accelerated motion equations:

$$\Delta x = v_{ix}\Delta t + \frac{1}{2}a_x\Delta t^2 = (0)\Delta t + \frac{1}{2}a_x\Delta t^2 = \frac{1}{2}a_x\Delta t^2 \Rightarrow a_x\Delta t^2 = 2\Delta x \Rightarrow a_x = \frac{2\Delta x}{\Delta t^2}$$

$$\Rightarrow a_x = \frac{(2)(0.52)}{1.15^2} = 0.786389\frac{m}{s^2}$$

And now we can go back to the equation for friction and substitute in numbers:

$$F_f = F_a - ma_x = (0.49) - (0.613)(0.786389) = 0.00794329 \approx \boxed{0.00794N}$$

Is the force of friction negligible?

$$\frac{F_f}{F_a} = \frac{0.00794329}{0.490} = 0.0162108 \approx 0.016 \Rightarrow 0.016 \times 100 = 1.6\%$$