Phys 213L: University Physics Laboratory
The Work-Energy Theorem

Pre-lab Exercise

1. An initially stationary 15.0 kg crate is pulled, via a cable, a distance $L = 5.70 \text{ m}$ up a frictionless ramp, to a height of $2.50 \text{ m}$, where it stops.
   (a) How much work is done on the crate by the gravitational force?
   (b) How much work is done on the crate by the tension in the cable?

2. Consider the diagram on the first page of the lab. Both masses are 10 kg and the second mass falls 1.50 m. If the initial velocity of the system is 0.25 m/s, what is final velocity?
Introduction:

The air track can be used to study the Work-Energy Theorem. The tension in the string $T$ is a constant force that does work on the air track slider, changing its Kinetic Energy.

The Work-Energy Theorem is expressed as:

$$W = \Delta KE = KE_f - KE_i,$$

where $W = (F \cos \theta)s$ the applied force in the direction of the displacement multiplied by the displacement over which the force acts, and,

$$KE = \frac{1}{2}mv^2$$ is the Kinetic Energy of the object that the force does work on.

For the air track experiment, the Work-Energy Theorem can be expressed as:

$$Fs = \frac{1}{2}mv_f^2 - \frac{1}{2}mv_i^2$$
**Procedure:**

1. Begin with the Work-Energy Theorem and show that after a displacement $s$, the final velocity of the air track slider is given by:

   $$v_f = \sqrt{2gs \left( \frac{m_2}{m_1 + m_2} \right) + v_i^2}$$

2. Set up a Data Studio experiment to record both position versus time and velocity versus time data. The $v$ vs $t$ data will look fairly messy! Save both data sets.

3. Export the $v$ vs $t$ data to Excel. Choose a range of this data that is decreasing linearly and fit a linear function to it.

4. Follow this procedure for three different falling masses.

**Question:**

How can you use the fitting function for the $v$ vs $t$ data and your original $x$ vs $t$ data to accurately determine the displacement $s$ without taking the displacement directly from your $x$ vs $t$ data?

5. For the three falling masses predict the final velocity using the Work-Energy Theorem.

6. Compare your predictions with the velocity taken from the linear fit to the $v$ vs $t$ data.

**Note:**

You can choose the initial velocity to be zero or some non-zero value after the motion starts. In either case, use the time data to identify the displacement traveled from your $x$ vs $t$ data.