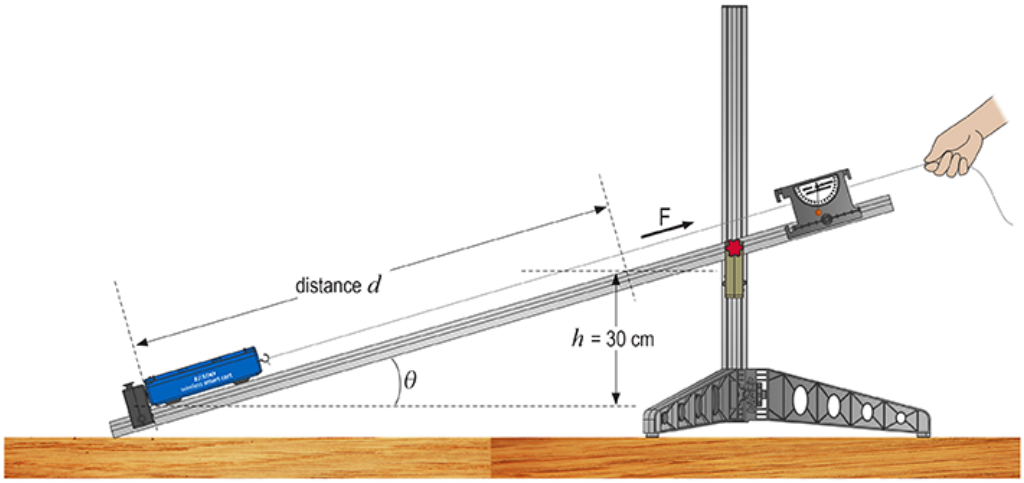
Investigation 12C: Ramps and inclined planes

Essential question: How does a ramp change the force required to move an object uphill?

When the Egyptians built their massive pyramids, they faced the engineering challenge of how to lift the heavy stone blocks vertically into position. The Egyptians may have moved the blocks up ramps (or inclined planes) constructed along the side of the pyramid. How would using a ramp make their job easier? In this investigation you will measure the force required to move the cart up a ramp to a height of 30 cm. How does the force vary? How about the work done?

Force and work required to move the cart up a ramp

1. Open the **12C_InclinedPlanes** experiment file in your software, and then connect your Smart Cart using Bluetooth. Zero the cart's force sensor while nothing is touching the hook.
2. Set up your equipment as in the picture. The plunger on the cart should be facing the end stop, with the hook facing up the ramp. Start with an incline of at least 20°.



3. Attach the cart to the end of a string.
4. Use tape to mark a location on the ramp 30 cm vertically higher than the starting position of the cart.
5. Measure the average force *F* required to move the cart at a slow constant speed to the final position. Measure the distance the cart traveled along the ramp.
6. Repeat for at least two other inclinations of the ramp. Tabulate your results.

Table: Force and distance data for a cart pulled up a ramp

Inclination angle (degrees)	Force (N) (from Smart Cart)	Distance (m)	Work done (J)	Mechanical advantage

Questions

a. Is more force needed to move an object up a steep ramp or a shallow ramp?

b. Using the force applied and the distance moved, calculate the work done on the cart to move it in each case. Explain your results.

c. How can you calculate the mechanical advantage of the ramp using the values in your investigation?

d. Calculate the mechanical advantage for each inclination of the ramp and include the results in your table.

e. Measure the mass of the Smart Cart, and then calculate a theoretical value for the amount of work W_{cart} needed to lift the cart 30 cm. How does this calculated value compare to the work values in your table? Explain why they are different and/or similar.

$$W_{cart} = \Delta E_p = m_{cart}gh = m_{cart}(9.8 \text{ m/s}^2)(0.30 \text{ m}) = \_\_\_\_\_ \text{ (J)}$$

Applying new knowledge

1. Darrius is building a pyramid in his backyard. The final 500 kg block will have to be moved into a position 5.0 meters above the ground. Darrius can push the block on rollers up a ramp with a force of 1000 N. How long does he need to make the ramp?

   asked:

   given:

   relationship:

   solution:

2. Francine is using a screwdriver with a handle that has a diameter of 1.5 inches to drive in a 1/4-20 screw (20 threads per inch). What is the mechanical advantage of her screw and screwdriver combination?

   asked:

   given:

   relationship:

   solution: