

## **An Uphill Climb [Experiment]**

Students often think that using a ramp will result in doing less work to lift a heavy object. They are surprised to find that this is not the case. A common procedural pitfall is that students lose sight of the task: to raise an object 20 cm *above the tabletop*. They errantly think the task is to raise an object 20 cm *along the incline*. The procedure was written to keep students aligned to the task, but you'll want to reinforce this during the experiment.

Since dynamics cart masses varies widely, force values measured during the procedure and consequent work values will vary as well. Distance values (along the incline) should range from 59 cm for a 20° incline through 28 cm at 45° to 20 cm at 90° (straight up).

To determine whether or not the difference between two values is significant, have students use this formula: Percent Difference =  $|a - b| / (a + b) \times 200$ . Notice that this is not a percent error calculation – neither value is more reliable than the other. Rather, this formula compares the difference between the two values to the average of the two values.

### ***Answers to Summing Up Questions***

1. The force increases significantly.
2. The distance decreases significantly.
3. The work remains about the same.
4. The force required to lift an object is reduced.
5. The distance required to lift the object is increased.
6. There is no significant difference between taking the shallow path and taking the steep path in terms of fuel consumption. The work along the shallow path was about the same as the work done along the straight-up path.