Force and Motion Activity

In this activity you will explore the concepts of velocity and acceleration and force and resulting motion.

Preliminary Questions:

1. A wind-up toy car moves with constant acceleration. Starting from rest, it moves 1 m in the first second. The total distance it moves in 2 s is
   (a) 2 m (b) 3 m (c) 4 m (d) 6 m

2. A wind-up toy car has an acceleration *a*. If you add a mass to the car equal to the car's mass, then its acceleration is
   (a) *a* (b) 2*a* (c) *a*/2

3. A block is pulled along a level surface by a rope at constant speed. The *net* force acting on the block is
   (a) in the direction of the pull (b) opposite to the direction of the pull (c) down (d) zero

Activity 1 – Speed of a battery powered toy car

1. Measure the speed of the battery powered car by using a stop watch to measure the time for it to travel a given distance. Repeat using a couple of different distances.

2. Now measure the speed using the motion sensor. Connect the motion sensor to a laptop computer using the USB interface. The instructors will show you how to use Data Studio to make the measurements. Plot both position and speed as a function of time. Do your curves suggest that the speed is constant? Explain.

   Determine the speed from both curves. How does this value compare with your 'manual' measurements in part 1 above?

Activity 2 – Wind-up toy car

1. Use a stop watch to measure the time for the wind-up toy car to travel 1 m from rest. Repeat for a total distance of 2 m. Calculate the average speed in each case. Are they the same? Why or why not?

2. Now use the motion sensor to measure the position and speed as a function of time. How do these curves compare with those for the battery powered car?

   Does the car accelerate? Explain.

   Is the acceleration constant? Explain.

   What is the initial value of the acceleration?

3. Calculate the acceleration from your ‘manual’ measurements in part 1 above. How do these compare with your measurements using the motion sensor?

4. Effect of mass on acceleration - Now add a mass to the wind-up car and again measure the initial acceleration using the motion sensor. Is the acceleration more than, the same, or less than without the added mass? Explain.

   According to Newton's 2^{nd} law of motion, if the force on the car is the same with and without the added mass, then $F = m_1 a_1 = m_2 a_2$. Is this true for your measurements? If not, then explain why.

Concluding questions and reflections:

1. How can the spring in the wind-up car provide a constant force? Is this what you would expect if the spring obeyed Hooke's law (F = -kx)?

2. Can you think of some other low-cost activities that would help students understand the difference between speed and acceleration?

3. Can you think of other activities that would help students understand Newton's 2^{nd} law of motion?

4. Check out the PhET simulation on "Forces and Motion" at http://phet.colorado.edu. Do you think this would be useful in teaching Newton's 2^{nd} law to a physical science class?