3.3 Free Fall

What kind of motion is falling?

What kind of motion is falling? We know falling objects accelerate, and that is a good place to start when examining their motion.

In this investigation, you will

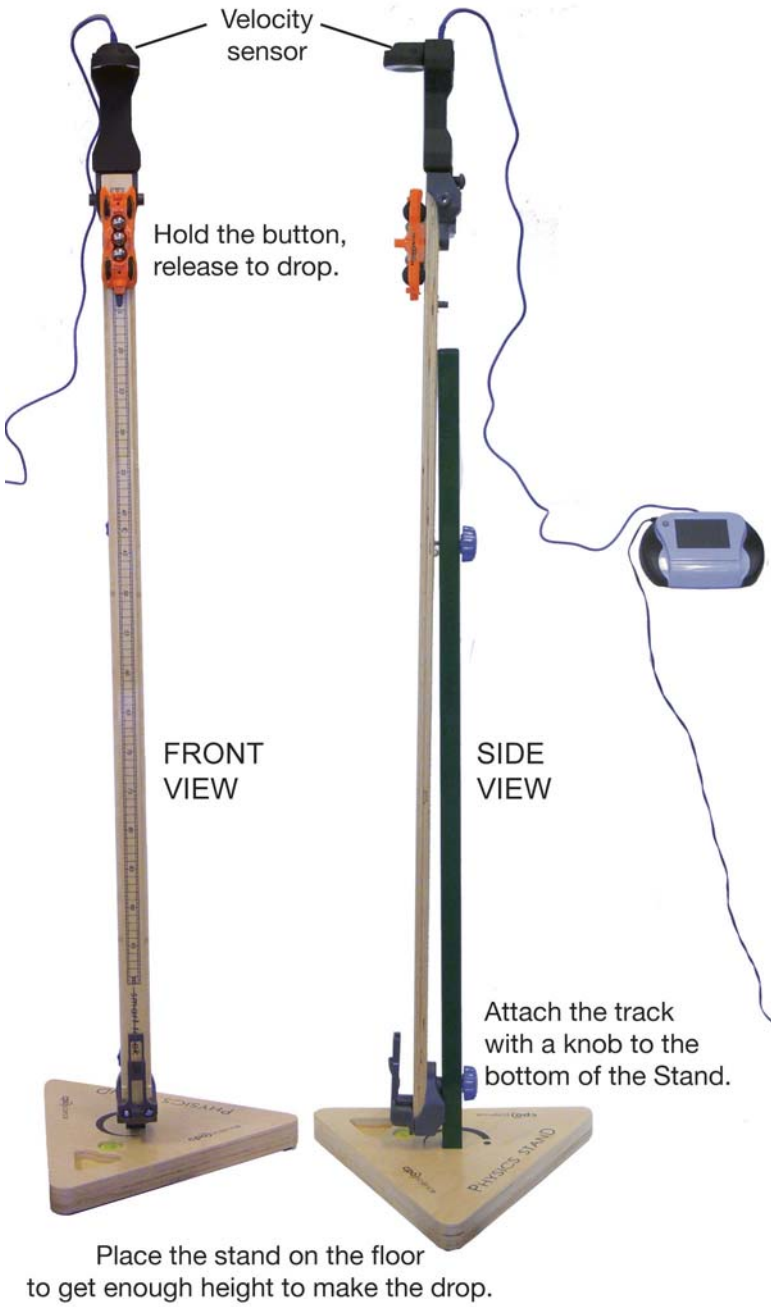
- determine an equation for the velocity in free fall.
- use the equation to make predictions.

Materials List

- DataCollector
- Physics stand
- SmartTrack
- Steel marble
- Distance-Velocity sensor
- Plastic marble

1 Free fall

1. Set up the physics stand and the velocity sensor from the SmartTrack as shown in the diagram, putting the stand on the floor. Putting a rag in the catcher helps to eliminate noise in the data.
2. With the DataCollector on a table, select data collection mode from the home screen and use the setup tab to set the samples to 20 and the rate to 20 Hz.
3. Attach the target to the EnergyCar and press the hold button and use the target to hang the car from the pin that comes through the track. Make sure the wheels are properly set on the track.
4. Press the go button and release the hold button after the countdown. The DataCollector will measure the time, position and velocity of the car as it falls.
5. The fall takes less than one second. Be careful not to push or shake the track overly. To get the technique right, you should perform several trials.



2 Analyzing the data

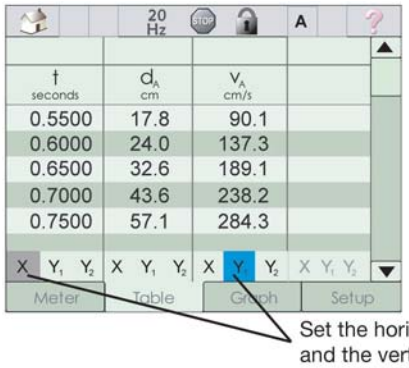
a. Once the DataCollector takes the samples, switch to table view. You should be able to scroll through the position and velocity data.

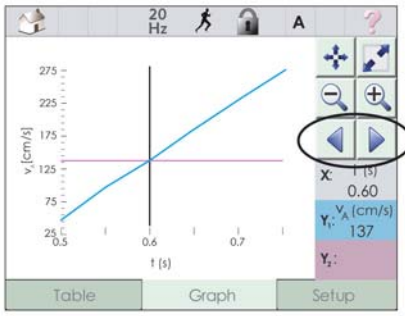
b. Set the time (t) column to be X and set the velocity (v) column to be Y1. Switch to graph view.

c. Describe the graph you see. Is it a straight line or a curve?

d. What will quantity of this experiment is represented in the slope of your graph? Calculate the slope from the velocity and time at two separate points on the graph. (*Note*: The positive direction is defined as the direction moving away from the sensor, so positive motion indicates the marble's direction of movement is *down* in this experiment.)

e. The equation for a straight line is $y = mx + b$. Determine the slope, m, and the y-intercept, b, from the graph using the cursor. Rewrite the equation for a straight line using the following variables: velocity, v; initial velocity, v_0; acceleration due to gravity, g; and time, t.





AVERAGE ACCELERATION

$$g_{avg} = \frac{v_2 - v_1}{t_2 - t_1}$$

f. Calculate the acceleration (slope) from two points in the 30 to 60 cm range of the track. Compare this acceleration with the acceleration you derive from the slope of the line in part d. Are the two values similar? By what percentage are they different? Give a possible explanation for any differences.

3 Different masses

1. Repeat the experiment with the car and one or two steel marbles. You need the magnet plate to hold the marbles in during the fall. Careful, the marbles can fall out on impact. The car and target are about 58 grams and the steel marbles are 28 grams. You can also try other objects. Not all objects will work. Some objects might not be reflective enough to work with the sensor

4 Modeling what you observe

a. How do your values of acceleration compare with the accepted value of g, which is 9.82 m/s^2? Your answer should be in terms of a percent difference between your result and the accepted value.

b. Suppose friction from the air was substantial enough to observe. What would the effect be? Would air friction tend to increase or decrease the acceleration you measured?

c. From your multiple trials you should be able to estimate an error for your measurement. How big is this error relative to the difference you calculated in part a above?

d. Based on part b, do you find that your experiment is in agreement with the accepted value of g?

e. Discuss any possible sources of error in the experiment. Make sure you assess whether each potential source of error could be large enough to explain any differences you observed.