

### 3.3 Free Fall

In this laboratory you will investigate the kinematics of objects moving under the influence of gravity alone, as well as a few interesting features of motion when other influences are present.

#### Ball Drop

##### Predict:

If you dropped a basketball from a height of about two meters, what would the motion be like? Sketch plots of position, velocity, and acceleration vs. time for the ball's motion. Include a bounce or two, and predict scales for the axes as well. Sketch all on the same large graph using different color pencils. What are the essential features of your graphs?

##### Experiment:

Position the motion sensor so that it can track the basketball's motion all the way to the floor. Place the basketball about 20 cm below the motion sensor and release. Do some trial runs and set the axes' scales. Repeat the experiment until you get a good run.

- Copy your experimental position, velocity, and acceleration graphs. Make sure that they are stacked vertically with matching time scales. Note that the motion sensor measures position as distance from the sensor. So when the ball is at position 30 cm, it is at 30 cm from the motion sensor but maybe 1.7 m from the ground. Compare your predictions and experimental results. How do they agree and/or disagree?
- From the experimental acceleration vs. time graph determine the average acceleration and uncertainty in that average (the standard deviation) for a relatively smooth region of data. Record the percent difference between this value and the accepted value and determine whether the values are consistent with each other to within the uncertainty.
- From the experimental velocity vs. time graph determine the acceleration and its uncertainty during free fall. (Remember that velocity is the derivative —slope— of position.) Record the percent difference

between this value and the accepted value and determine whether the values are consistent with each other to within the uncertainty.

- From the experimental position vs. time graph determine the acceleration and its uncertainty during free fall. Use the kinematic equations and an appropriate curve fit. Be sure to describe how you determined the acceleration. State the percent difference between your experimental value for  $g$  and the accepted value.

### Filter Drop

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**Predict:** If you drop a coffee filter instead of a basketball, how would the graphs be different? Yes, the coffee filter will not bounce; but there's something more interesting going on than that! Sketch your predictions for position, velocity, and acceleration vs. time, and point out any important differences you would expect to see compared to the basketball graphs.

**Experiment:** Drop a coffee filter, or a stack of up to a half-dozen filters, and compare your results with your predictions. How do they differ? Is the acceleration constant in this case? Explain.