Free Fall

Physical Concepts

1. An object’s displacement is
   (a) always a vector
   (b) a vector only if the object is at rest
   (c) a vector only if the object is in motion
   (d) always a scalar
   (e) a scalar only if the object is at rest
   (f) a scalar only if the object is in motion.

2. The velocity of an object is proportional to elapsed time
   (a) always
   (b) only for positive acceleration
   (c) only for negative acceleration
   (d) only for constant acceleration
   (e) never.

3. (This is not a multiple choice question; provide a short answer for all four situations given.) Describe the motion of an object:
   (a) accelerating in the same direction as its motion.
   (b) accelerating in the direction opposite to its motion.
   (c) whose velocity doesn’t change during a certain time interval.
   (d) whose initial velocity is zero but whose acceleration is not zero.

4. A student on the planet Arret in another solar system drops an object to determine the acceleration due to gravity ($g$) and records the following data (in local units):

<table>
<thead>
<tr>
<th>TIME</th>
<th>DISTANCE</th>
</tr>
</thead>
<tbody>
<tr>
<td>(in surgs)</td>
<td>(in welfs)</td>
</tr>
<tr>
<td>0.0</td>
<td>0.00</td>
</tr>
<tr>
<td>0.5</td>
<td>0.54</td>
</tr>
<tr>
<td>1.0</td>
<td>2.15</td>
</tr>
<tr>
<td>1.5</td>
<td>4.84</td>
</tr>
<tr>
<td>2.0</td>
<td>8.60</td>
</tr>
</tbody>
</table>

   (a) What is the acceleration due to gravity ($g$) on Arret, expressed in welfs · surg$^{-2}$?
   (b) A visitor from Earth finds that one welf is about 6.33 cm and one surg is about 0.167 s. What can we say about Arret?
Laboratory Results

[Include supporting graphs and tables, as necessary.]

1. What is your average value for $g$? What is the standard deviation of your data? What is your result for the acceleration due to gravity from the averaging method (average ± standard deviation of the mean)?

2. What are the slope and intercept of your regression line? What are the uncertainties of these quantities?

3. With Excel Tools, find the correlation coefficient associated with your linear regression. Using a table of correlation coefficients, state the significance of the fit, i.e., what is the probability that this level of correlation is accidental?

4. Is the uncertainty in position measurement consistent with the uncertainties in your two different results?

5. Compare your results for the gravitational acceleration. Do they agree? Which is more “accurate?” Which is more “precise?”

6. Discuss the nature of the uncertainties in your results. Are they random? Is there evidence of systematic error? If so, can you attribute the source (without making up a story—that is, the source(s) you identify must be consistent with the magnitude and direction of the error)?