TEST 1

Web Physics

9-28-06

Sign your name below to indicate that you will neither give nor receive information about this test until the instructor has announced that all students have taken it.

1. All work to be checked must be entered in the spaces provided.

2. There are 4 numbered problems. Some sheets have problems on both sides. Scan through all the problems before you begin writing your solutions.

3. You may use a calculator and the list of approved equations.

4. The time limit is 90 minutes. You must put down your writing instrument when time is called.

<table>
<thead>
<tr>
<th>Problem</th>
<th>Recommended Max. Time</th>
<th>Possible Points</th>
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<tbody>
<tr>
<td>1</td>
<td>15</td>
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<td>4</td>
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<td>Total</td>
<td>80</td>
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</table>
1. A rocket sled on a straight, horizontal track accelerates uniformly from rest, achieving a velocity of 300 m/s in a time of 4.0 s. The velocity then remains constant for 2.0 s. Finally, the sled decelerates uniformly for 4.0 s at a rate of 50 m/s².

a. Draw a velocity vs. time graph of the motion of the rocket sled. (5 pts)

```
V (m/s)
300
200
100

0  2  4  6  8  10
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b. Calculate the displacement of the sled in the following time intervals. You may simply write down your answer. (5 pts)

\[ t = 0 \text{ to } 4.0 \text{ s:} \]

\[ t = 4.0 \text{ to } 6.0 \text{ s:} \]

\[ t = 6.0 \text{ to } 10.0 \text{ s:} \]

c. Draw a position vs. time graph of the sled's motion. Scale the position axis. (5 pts)

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x (m)

0  2  4  6  8  10
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t (s)
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2. A projectile is launched from point A with velocity, \( V_0 \). Draw each of the following vectors with a length proportional to the magnitude of the velocity. This means you need to accurately determine the horizontal and vertical velocity components in order to draw the velocity vector with the correct direction and magnitude.

a. the velocity vector at point B in the path (5 pts)
b. the velocity vector at point C in the path (10 pts)

Below the graph, describe in words how you determined each of the above velocities. While you may write dvats, your description must be primarily in sentence form. Four sentences should be sufficient.
3. A cannonball is fired from ground level toward a hill. The cannon is aimed at angle of 37° above the horizontal, and the ball leaves the barrel at a speed of 50 m/s. The top of the hill is 40 m higher than the top of the cannon.

   a. Draw your diagram and make your lists of givens. These will apply to all parts of this problem. Therefore, you only have to give this information once. (4 pts)

   b. Determine the two possible values of the vertical component of the cannonball’s velocity as it strikes the top of the hill. (6 pts)

   c. Determine the two possible values of the time interval between when the cannonball leaves the barrel and it strikes the top of the hill. (6 pts)

Continue this problem on the next page.
d. Using your two values of the vertical component of velocity and the time interval between when they occur, show by direct calculation of \( a = \frac{\Delta v}{\Delta t} \) that the vertical component of acceleration has the expected value. (4 pts)

4. The photograph (provided on the back of the cover page) is a multiple-image photograph of a plastic ball bouncing from left to right on a level table. The photograph is superimposed on a grid with x- and y-axes for ease in taking position measurements. The images of the ball were taken with a light that produced flashes at a rate of 20.0 flashes/second. The images are numbered for convenience in referring to them. The x-axis coincides with the table’s surface. Note that the ball was not in contact with the table for images 7 and 16.

We will call the major divisions of the grid, gu (for grid units). With this unit, the entire grid is 22 gu long and 15 gu high. In taking position measurements, read the grid scales to within 0.1 gu. That’s half of the smallest division.

Use significant figures correctly in writing the results of calculations and measurements.

Use \( g = 9.80 \, \text{m/s}^2 \).

a. Suppose that measurements were taken of the horizontal position of the ball as a function of time from images 8 through 16. If a quadratic fit were performed on the horizontal positions as a function of time, tell how you would use the results of the fit to show whether the horizontal velocity of the ball was constant. Explain your answer with reference to the appropriate dvat formula. (4 pts)

b. With your pencil, place a dot at the bottom of each of the images 8 through 16 of the ball. Draw a smooth curve through these points and extrapolate the curve down to intersect the table’s surface at \( y = 0 \). DO NOT include image 7, as this was recorded before the ball bounced. (2 pts)

c. Assume now that the horizontal velocity of the ball is uniform. Determine the horizontal velocity of the ball after the first bounce. Take measurements to determine the magnitude of that velocity in gu/s to the greatest accuracy you can. Specify clearly what measurements you take, and show your calculation of the horizontal velocity below. (4 pts)
d. Take measurements from the photograph to determine the maximum height reached by the ball after the first bounce. Remember, the table surface is at y = 0. Read positions from the bottom of the ball, and give your result in gu. (2 pts)

e. The photograph is smaller than real life. The actual diameter of the ball is 0.0254 m. Use this in order to determine a scale factor to convert distances measured on the photograph to actual distances. Briefly describe how you find the scale factor (1 sentence), and show your calculation. Give the scale factor in units of meter/gu. (4 pts)

f. Use your scale factor to convert your result from part c to units of m/s and your result from part d to units of m. Give the converted values below. You need not show your work. (2 pts)

Magnitude of horizontal velocity (m/s):

Maximum height (m):

Show your work for part g on the back of this page.

g. Use the measurements that you’ve made up to this point to determine both the magnitude and direction of the initial velocity of the ball, that is, the velocity as the ball rebounded from the table between images 7 and 8. Carry out the problem in an orderly manner. If you need to do scratch work, do it on separate paper. It’s important that the instructor be able to follow your work. To that end, do the following:

i. List the given information, identifying quantities with the usual symbols, including distinguishing subscripts for horizontal and vertical quantities. A diagram isn’t needed, since the photo on the x-y grid serves that purpose. (3 pts)

ii. State the goal. Make sure you know what you’re solving for. (1 pt)

iii. Select appropriate dvats. Solve for the unknowns symbolically. Substitute values and units at the last step. (8 pts)

iv. Do your checks mentally rather than writing them.