Physics 1090 Homework #7

Due Thursday, October 29, 2:00 pm

Reading assignment: Chapters 15, 16 of the notes.

1. **Measure your reaction time using Galileo's concept of acceleration**

If you hold a ruler against a wall, and let it fall, assuming it's not in contact with the wall, it will **pick up speed at a rate of 10 meters per second per second.**

(a) Use this fact to write down how fast it's going after: 0.1 sec., 0.12 sec., 0.15 sec., 0.18 sec., 0.2 sec.

(b) Now figure out its **average** speed during the first 0.1 sec., the first 0.12 sec., …, 0.2 sec.

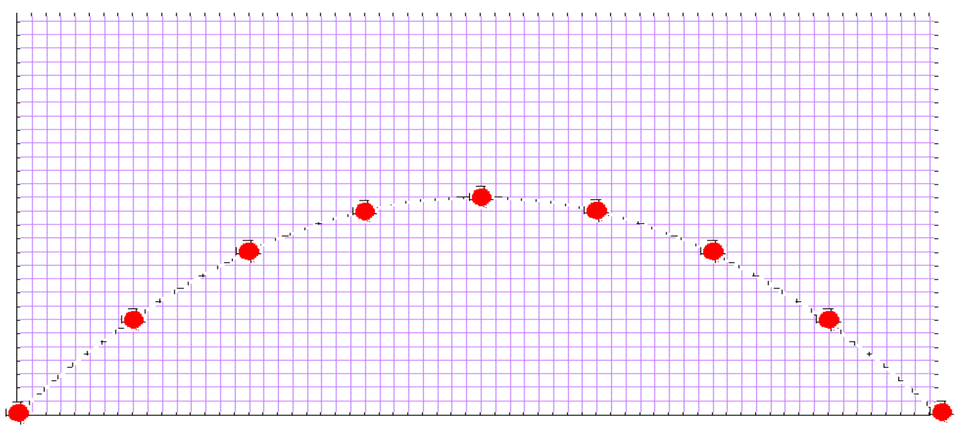
(c) Use the only formula I said you should know to find **how far it falls** in the first 0.1 sec., then in 0.12 sec., 0.15 sec., 0.18 sec., 0.2 sec.

(d) Use these results to **plot a graph of distance as a function of time** from time 0 to time 0.2 sec.

(Guess the first 0.1 sec.—remembering it always falls *four* times as far in twice the time!)

(e) Use your graph and a friend to find your reaction time, and state what it is. Have several tries and take the average. (Have your friend hold the ruler against the wall with a finger at the top of the hanging ruler. You have a finger pointing close to the bottom of the ruler, ready to pounce when your friend lets go of the ruler at some random time. Measure how far it fell before you stopped it, and deduce your reaction time.)

2. **Galileo's Analysis of Projectile Motion**



The above picture represents the flight of a ball thrown into the air (although air resistance effects have been neglected). The background grid is in 20 cm. squares. The blobs represent the position of the ball *at successive 0.2-second intervals.*

(a) By counting lines, find the average *horizontal* velocity of the ball, in meters per second, during the first fifth of a second. (Remember, each square is 20 cm. across (from side to side or top to bottom), and average speed = distance/time.)

(b) By reviewing the whole picture, find how the horizontal velocity (in meters per second) varies throughout the flight.

(c) By counting squares, find the average *vertical* velocity of the ball during the first fifth of a second.

(d) Make a table of the ball's average vertical velocity *for all eight 0.2-second periods in the flight*. Count velocity upwards as positive, downwards as negative.

(e) Use your results from part (d) to plot a graph of the ball's vertical velocity (on the *y*-axis) as a function of time (on the *x*-axis) for the whole flight.

(f) Acceleration is *rate of change of velocity*. It is measured here in meters per second per second. Use your graph from (e) to plot a graph of the vertical acceleration as a function of time for the whole flight.

(g)What can you conclude about the acceleration of the ball at the topmost point of the path?

(h)Suppose now instead that the ball had been thrown directly upwards. Would it be accelerating at the topmost point of its flight?

(i) Galileo states in *Two New Sciences* (page 153): *"..so far as I know, no one has yet pointed out that the distances traversed, during equal intervals of time, by a body falling from rest, stand to one another in the same ratio as the odd numbers beginning with unity*". (The odd numbers beginning with unity just means 1, 3, 5, 7, ...). Show how you can verify this assertion using the picture above. What are the *total* distances fallen at the end of each fifth of a second starting from rest (at the top)?

3. **Using Vectors**

Look at the flashlet of a ball rolling off a table. Redraw the figure as well as you can. **Assume the successive lines (both horizontal and vertical) correspond to one-second intervals** (this is a big table—perhaps off the edge of a cliff would be more appropriate!)

(a) Draw a vector representing the displacement of the ball (how far it's moved) from time t = 0 to time t = 1 second. Draw three more displacement vectors corresponding to displacement from t = 1 to t = 2, 2 to 3, and 3 to 4.
(b) Since each time interval equals one second, how do these displacement vectors relate to the average velocity during successive seconds?
(c) Draw two vectors (not on your figure, in a new place) representing the average velocity in the first second and the second second. Put their tails together, so a vector from the head of one to the head of the other represents the velocity change in that second. What is the value of this change?
(d) From the figure, and what you know about falling, what is the initial horizontal speed (approx)?