Physics 141 Due: September 16, 2016
Homework Set # 2 12 pm

1. (**75%**) WeBWorK set # 2.

2. (**12.5%**) Suppose you are navigating a spacecraft far from other objects. The mass of the spacecraft is 1.5×10^5 kg (about 150 tons). The rocket engines are shut off, and you are coasting along with a constant velocity of <0, 20, 0> km/s. As you pass the location <12, 15, 0> km you briefly fire side thruster rockets, so that your spacecraft experiences a net force of $<6 \times 10^4, 0, 0>$ N for 3.4 s. The ejected gases have a mass that is small compared to the mass of the spacecraft. You then continue coasting with the rocket engines turned off.
    a. Where are you an hour later?
    b. What approximations and/or simplifying assumptions did you make in your analysis?

3. (**12.5%**) In the software download area of the Physics 141 web site (located at http://teacher.pas.rochester.edu/phy141/Software/SoftwareIndex.htm) you will find a movie that shows the launch of the space shuttle (NASAHW02.mov). Use Logger Pro to analyze this movie and answer the following questions:

    a. What is the vertical acceleration of the space shuttle?
    b. What is the force generated by the engines?

    Use the following steps in this analysis:

    a. Download the movie clip from the Physics 141 web site.
    b. Start Logger Pro.
    c. From the "Insert" menu, select "Movie" to open the movie you want to analyze.
    d. At the bottom right-hand side of the video window you see a button with red dots with allows you to "Enable/Disable Video Analysis". Enable video analysis a set of tools will appear on the right-hand side of the video window.
    e. Select the ruler button to set the scale. Use the "ruler" on the right of the space shuttle to calibrate your screen. After selecting the ruler button you move your mouse to one end of the "ruler" in the video, click-and-hold your mouse button, move your mouse to the other end of the "ruler," and release the mouse button. A window will emerge, asking you for the length the "green line" you just drew on the screen.
    f. Use the "red dot button" to add a "point" and use the mouse to determine the position of one particular point on the space shuttle. Each time you select a position in a frame, the video will advance to the next frame.
    g. After completing your data entry you will see that the *x* and *y* positions and velocities for all frames are listed in the data table. These data can be exported by selecting "Export as …. Text" from the file menu. The file created can be opened with programs such as Excel or Igor and use these tools to plot for example the vertical velocity as function of time and determine the acceleration. You can also use Logger Pro to do the fit and determine the

acceleration. Using "Graph Options" under the "Options" menus you can remove the horizontal position from the graph, add the vertical velocity, etc.

Hand in a graph showing the velocity of the shuttle as function of time and describe how you obtained the acceleration of the shuttle and the force generated by its engines.

4. (**Optional; 25% extra credit**) Write a program in VPython to display the motion os a cart traversing on a track at constant velocity
   a. Create a box to represent a track 2 meters long, 10 cm wide, and 5 cm high. Orient the long axis of the track along the *x* axis.
   b. Create a second box to represent a low-friction cart that is 10 cm long, 4 cm high, and 6 cm wide. Give this box a symbolic name so that you refer to it later in the program.
   c. Position the cart so that it is 1 cm above the track, and its left edge lines up with the left end of the track.
   d. Create a vector variable to represent the velocity of the cart. Give the cart an initial velocity of (0.2, 0, 0) m/s.
   e. Using a time step of 0.01 seconds, write a loop to use the position update formula to animate the motion of the cart as it travels at constant velocity from one end of the track to the other.
   f. Change the program to start the cart at the right end of the track and move to the left.
   g. What would happen if the cart had a nonzero *y* velocity component? Try it!

   Submit the actual programs via email to Professor Wolfs (wolfs@pas.rochester.edu). The name of the file should be hw02p04XXYYYYYYYY.py where XX are your initials and YYYYYYYY is your student id number and the subject of your email should start with hw02p04XXYYYYYYYY.