Physics 141   Due: September 23, 2016
Homework Set # 3   12 pm

1. **(50%)** WeBWorK set # 3.

2. **(15%)** There is no general analytical solution for the
   motion of a 3-body gravitational system. However, there
   exists an analytical solution for the very special case
   shown in the Figure on the right. In this Figure, three
   stars are shown, each of mass *m*, which move with the
   same speed in the plane of the page along a circle of
   radius *r*. The three stars move in a clock-wise direction.
   Calculate how long it will take for this system to make
   one complete revolution.
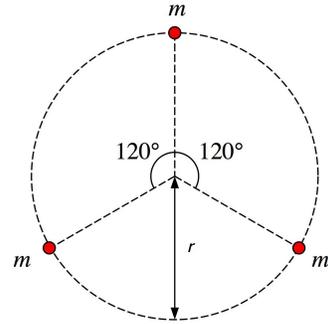
3. **(15%)** A hanging copper wire with a diameter of 2 mm has an initial length of 3 m
   and hangs vertically from the ceiling of your dorm room. When a 5 kg mass is
   attached to its end, the wire stretches by 0.425 mm; when a 10 kg mass is attached to
   its end, the wire stretches by 0.85 mm. The density of copper is 9 g/cm^3 and one
   mole has a mass of 63 g. Find the approximate value of the effective spring stiffness
   of the inter-atomic force. Explain your analysis and any assumptions you may have
   made.

4. **(20%)** 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
   two movies that shows someone tossing a ball in an elevator that is moving up
   (ElevatorMovie1.mov and ElevatorMovie2.mov). Use Logger Pro to analyze the
   motion of the ball in both movies and answer the following questions:
   a. What is the acceleration of the ball in each toss? In ElevatorMovie1.mov you
      will only be able to examine one toss, while in ElevatorMovie2.mov you will
      be able to examine multiple tosses.
   b. What can you say about the difference in the motion of the elevators in the
      two movies?

5. **(Optional; 25% extra credit)** Place a spacecraft of mass 15000 kg at a location 10
   Earth radii to the left of the center of the Earth and give it an initial velocity as shown
   in the Figure.

   $\vec{v}_i$
   • Earth
   Spacecraft
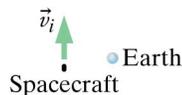
   Let it coast, subject only to the gravitational attraction of the Earth, whose mass is
   6×10^{24} kg. Plot a trail behind the spacecraft so that you can see the shape of the
   trajectory. At each step in the iteration, check for the spacecraft being closer than one
   Earth radius from the center of the Earth, and stop the program if that happens.
   a. Predict what will happen when the initial speed of the spacecraft is zero.
      Then try it.
   b. Try various initial velocities. What is the minimum speed required to go
      around the Earth without colliding? This orbit can be shown to be an ellipse.

c. Cut the time step you used in your program by a factor of two and make sure that you essentially get the same trajectory seen in (b). If there is a significant change in the trajectory, keep cutting the step size until you no longer see a change in the trajectory. Repeat step (b) if your earlier step size was too large (resulting in poor accuracy and a strong dependence of the orbit in the step size). On the other hand, if the orbit plots very slowly, you may have chosen a step size that is much smaller than necessary. Try doubling the step size repeatedly until you start to see significant changes in the trajectory, then reduce the step size somewhat.

d. Using the step size that provides good accuracy, determine the launch speed that leads to a circular orbit.

e. Predict what will happen if the initial speed is somewhat greater than the speed that produces a circular orbit. Now try it.

f. What is the minimum launch speed for which the spacecraft escapes, never coming back?

g. Try launching the spacecraft to the left, straight away from the Earth with the speed that produces a circular orbit in (d).

h. When launching to the left, what is the minimum launch speed for which the spacecraft escapes, never coming back. Compare your answer with the results you obtained in (f)?

Submit the actual programs via email to Professor Wolfs (wolfs@pas.rochester.edu). The name of the file(s) should start with hw03p05XXYYYYYYYY where XX are your initials and YYYYYYYY is your student id number and the subject of your email should start with hw03p05XXYYYYYYYY.