PHYSICS 113 – Recitation Assignment 6

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Name

Recitation Assignment # 6

Oct. 28, 2009

You may complete this in class. However, if you are unable to do so, it is expected that you complete this for recitation next time.

If you have any questions, please ask.

Today we're going to do a problem that we can't really do with pen and paper – the three body problem. Basically, we're going to have 2 "stars" orbiting one another. We're then going to fire a third star into the pair, and see how everything scatters.

In the meanwhile, we're going to look at the momentum and energy of the system.

New Concepts: Physical

- Potential Energy
- Kinetic Energy

Numerical

- Dimensional Analysis

Computational

- Plotting Data

As always, please have Coleman come by to look at your work occasionally, leave a comment in your code, indicating who it was who wrote it, and be sure to send him your code when you're done, with the subject line: "Physics 113 yourname prog6.py".

1. First and foremost, it has been very awkward when we're doing calculations worrying about solar masses, the gravity constant, G, conversions from years to seconds, and so forth. One of the most useful things that we can do is write down dimensionless equations:

$$\vec{F}_{12} = \frac{m_1 m_2}{r_{12}^2}\hat{r}_{12}$$
$$U_{12} = -\frac{m_1 m_2}{r_{12}}$$

   The way this works is as follows: If all of your masses are in solar masses, all of your distances in Astronomical units, all of your velocities in units of units of earth's velocity. The "time" is the only weird unit (it ends up being in units of $yr/2\pi$). Don't worry too much about it, though. Otherwise, everything works perfectly!

So to begin with, I want you to take a look at prog3b.py that you submitted to Coleman. You can use it to remind you of the physics.

Now start your new program. You'll want to have two "stars" orbit one another. They should have:

- A separation of 1
- A radius of 0.2
- A mass of 1 (each)
- Colors: 0 should be red, and 1 should be blue
- Set the initial velocity so that the two are in a circular orbit around one another.

Now, I realize that this is complicated, so I've actually made you a starter program at:

```
http://www.physics.drexel.edu/~goldberg/prog6_starter.py
```

It has a *lot* of the physics already programmed in, but you'll note that one of the stars is very light compared to the other.

Please make the corrections described above.

☐ 2. Now it's time to check for conservation of energy. We know that energy is supposed to be conserved. To do that, we're going to make a plot. Making a plot requires:

```
from visual.graph import *
```

at the top of your code.

It also requires you to set up a "display" before your loop, as well as a "gcurve" to be plotted.

```
g1=gdisplay(xmin=0,xmax=tmax,ymin=-3,ymax=3)
ekin=gcurve(gdisplay=g1,color=color.red)
```

Note that for the moment, I'm only going to compute kinetic energy.

At some point under your loop, you're going to have to *compute* the total kinetic energy for the stars. You may (of course) use the non-relativistic limit. I'm choosing to call mine "K".

To add a point to the plot, you may then add:

```
ekin.plot(pos=(t,K))
```

☐ 3. Now do a similar calculation for the potential and total energy. They should be plotted with the same "gdisplay" but with different "gcurve"s.

Hint: If you add up all of the calculations of:

$$U = \sum_i \sum_{j \neq i} -\frac{m_i m_j}{r_{ij}}$$

each time around, then you are going to be off by a factor of 2. You're going to double count each pair.

4. Now add a third star. Make it:

   - The same size as the other two
   - Yellow
   - Make a yellow trail behind it as well.
   - m=1
   - With $\vec{r}_0 = -10\hat{i}$
   - With $\vec{v}_0 = 0.5\hat{i}$

   Note, you do not need to do anything additional under the "while" loop. Everything should already work perfectly. Seriously, don't mess with it.

   Make the simulation run for 30 units of time.

   Looks pretty weird, no?

   What happens to the energy?

5. Now play around with your code. You should adjust the timesteps to make energy as conserved as possible. How small did your timesteps get.

   Adjust the masses and initial values of the particles, until you get a particularly interesting looking scattering experiment.

   Adjust your initial values very slightly and see if you get a different result.