Follette   AST101IN   Fall, 2011   Name: ____________________

Homework #8 - Orbital Motion and Gravity

(Kepler and Newton's Laws)
Due Thursday, October 20, 2011

Follow the instructions below and answer all of the questions

1. Go to: http://astro.unl.edu/naap/pos/animations/kepler.html
2. Familiarize yourself with the tabs, sliders and animation controls until you feel like you have a pretty good idea of what each of them do.
3. Under "Visualization Options" click on "show solar system orbits", "show solar system planets" and "label the solar system orbits"
4. Now under "Orbit Settings" set parameters for Mercury and hit "OK" . This gives your test planet the exact same orbital parameters as Mercury, so their orbits should lie on top of one another.
5. Change Mercury's eccentricity to both higher and lower values. What happens to the orbit as you do each? Describe the trend.

6. What does an eccentricity of 0.0 appear to correspond to (what shape is it)?

7. What shape are all of the orbits with an eccentricity greater than 0?

8. Drag the semi-major axis outward until you can see all of the planets in the solar system (and Pluto). Which one appears to have the greatest eccentricity? Note: You can verify your conclusion by choosing that planet under "set parameters for" and clicking OK again. What is the exact value of the eccentricity for this planet?

9. What might life be like on Earth if its orbit was similarly eccentric? Can you think of any problems it might cause? You can investigate by setting parameters for Earth and clicking "OK" then dragging the eccentricity to match the value you recorded in the last question.

10. Now under the "Kepler's 1st Law" tab, click on "show empty focus". Where does it put the empty focus for an orbit with an eccentricity of zero? Does this make sense based on its shape? Why or why not?

11. (a) You can deselect “show empty focus” or leave it selected while you click on “show radial lines” then click “start animation”. What do you notice about how the lines change over the course of the orbit? (hint: look at the summation at the bottom of the Kepler’s 1st Law box).

(b) What does this relationship have to do with Kepler’s 1st Law?

12. Deselect everything in the Kepler’s 1st Law box and pause the animation. Click on the Kepler’s 2nd Law tab. Click on “sweep continuously” then click “start sweeping”. What is this showing? How many segments are there?

13. Click on “erase sweeps” and pause the animation. Click on the Kepler’s 3rd Law tab. Look back at your notes or look up what kind of units p and a must be in in order for that equals sign to appear between them instead of a proportionality symbol. Record what you find below.

14. If you are not still looking at a planet at the orbit of Earth (semimajor axis = 1AU), but with a higher eccentricity, reset the Orbit Settings to how you had them at the end of your Kepler’s 1st Law investigation. Sketch the Sun and the orbits of the Earth and your Planet X below.

15. Now slide the eccentricity to the right and to the left of this point. Look at the graph of period versus semi-major axis. Is the white dot representing planet X changing location? Where is it compared to the point for Earth? Is this surprising to you? If so, why?

16. How would you explain what you just observed in terms of Kepler's 2nd Law?

17. Can you make the Planet X point move away from the point for Earth? If so, what do you have to change?

18. Use what you discovered above to find the orbital periods (you can estimate them from the graph – no rulers required!) of Uranus, Neptune and Pluto and record them below.

    Uranus:

    Neptune:

    Pluto:

19. Now click on the "Newtonian Features" tab. Click the "vector" box next to v. This will show you the direction that the planet is moving (the direction of its velocity) at any given **instant**. Run the animation. Does it ever point right along the circle?

    If your answer doesn't make sense to you, there is a very simple experiment that you can do at home to shed some light on it. Tie something fairly light and non-dangerous (like perhaps a ping pong ball) to the end of a string and go outside (far away from people – you'll be throwing things!). Hold tightly at one place and swing the string so that it traces out a circle over your head. Once you have a nice orbit going, let go. Make sure to take note of where the object was in the circle when you let go. When you let go of the string, how does it travel relative to the circle that you were tracing before (its orbit)?

20. Now select the "vector" box next to the acceleration a. and run the animation. What direction does it point in?

21. Complete the following statement "The direction of the acceleration for an orbiting object always points ______"