PHYS 171: Planetary & Stellar Astronomy
Due: Friday, September 20, 2019

Problem Set #3

1. Orbital capture

a) According to Kepler and Newton, two bodies interacting gravitationally can only have one of four orbit types. Draw or plot representative diagrams for these four orbit types (neatness of diagram will be graded).
Note: two of these orbit types look qualitatively similar to the untrained eye. Make sure that your diagrams indicate the difference(s) between these two types.

b) Suppose that you want to orbit a distant object around a lone star. Initially, the object is very far from the star (and not in orbit, i.e. it does not feel the star's gravity in any significant way). You launch the object towards the star, and somehow are successfully able to put the object in a near circular (or moderately elliptical) orbit around the star. This process is called orbital capture.
Draw a 2D diagram (in the object-star ecliptic plane) that shows the trajectory of the object from far away to in-orbit around the star. The diagram does not have to be "mathematically correct", just a reasonable qualitatively correct diagram for the orbital capture sequence. Explain your diagram in 1-2 sentences.

c) Is your diagram in b) consistent with any of the diagrams in a)? Use your diagrams in a) and b) to determine if 2-body physics is sufficient to generate an orbital capture and determine the necessary ingredient for orbital capture?

2. Pluto and Charon: Pluto and Charon orbit each other with a period of 6.4 days with a semimajor axis of 19.7×10^3 km. Calculate the combined mass of Pluto and Charon (ignore the other moon's of Pluto).

3. Mars's gravity: Mars has a diameter of 6780 km. It has two very small moons: 1) Phobos with an orbital period of 7.65 hrs and a semimajor axis of 9.38×10^3 km and 2) Deimos with an orbital period of 30.3 hrs and a semimajor axis of 23.5×10^3 km.
Calculate the acceleration due to gravity g_{Mars} at its surface and compare it to Earth's (9.8 m/s^2).

4. Momentum and Energy: An object of mass m_1 and velocity v_1 is directed at a stationary object of mass m_2. After "colliding" with each other the objects "stick to each other" and travel as one with velocity v_{final}.
Note: Here "stick to each other" can mean "attached/glued to each other" or "orbit each other".

a) Use conservation of momentum to calculate the v_{final}.

b) Calculate the total kinetic energy of the system before and after the collision (treat as one unit). Is energy conserved? Explain a process or possible processes for this result.