Recitation Problems for Week 3, Tuesday

2.C16. What is the acceleration of gravity at the surface of the Moon?

2.S51. A object of mass m has its position described by the vector $\vec{r} = r\hat{r}$ and its velocity given by the vector

$$\dot{\vec{r}} = r\dot{\theta}\hat{\theta}\,,$$

both of which are expressed in polar form and the magnitude of the position vector, r is a constant. (a) What is the momentum of the object in polar form? (b) What is the velocity of the object in Cartesian coordinates? (c) In polar form, what is the general form of any external forces acting on the object?

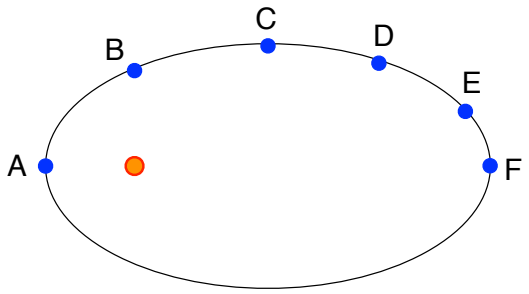

Figure 1: The figure for problem 3.C23.

3.C23. A planet is orbiting a star in an elliptical orbit as shown in Figure 1. (a) For each of the points along the orbit, A,B,C,..., sketch the momentum vector $\vec{p}$ of the planet. At which point is the magnitude of $\vec{p}$ largest and at which point is it smallest? (b) For each of the points along the orbit, A,B,C,..., sketch the force vector $\vec{F}$ showing the force exerted on the planet by the star. At which point is the magnitude of $\vec{F}$ largest and at which point is it smallest? (c) At which points along the orbit are $\vec{p}$ and $\vec{F}$ perpendicular to each other? (d) At which points along the orbit are $\vec{p}$ and $\vec{F}$ parallel to each other?

3.S63. A NASA spacecraft made a flyby of a small asteroid. Visual observations led them to estimate that the asteroid is roughly spherical in shape with a $55\,km$ diameter. Best estimates before the flyby were that the asteroids density is about that of terrestrial rocks, $\rho_a \approx 3000\,kg/m^3$. At its point of closest approach to the asteroid, the spacecraft

is about 1200 km away. We also know that the spacecraft has a mass of 850 kg and is moving at a speed of 10 km/s relative to the asteroid. After the spacecraft passed the asteroid, its trajectory will have been deflected by some amount. (a) Make a rough sketch of the encounter, and indicate approximations that you will make to determine how large the deflection was. (b) Make a very crude estimate for the change in momentum of the spacecraft. (c) How far would the spacecraft move off its original course after one day of travel? (d) Detailed observations of the spacecraft led NASA to conclude that the asteroid was actually a very loose collection of rocks, and not a solid ball. On what basis could they have made this conclusion?

3.C9. A scale for weighing objects is built using a stiff spring supporting a solid plate. Items are weighed by placing them on the plate and then measuring by how much the spring compresses. Assume that the spring has a constant, k and the mass of the plate is m_p. The object being weighed has mass m_o. Show that the compression of the spring is proportional to the mass of the object, *e.g.* show that the mass of the plate does not matter.