Homework 7

Due Wednesday, 4 March

Note that this is not due before your exam, as we had originally planned. We strongly suggest that you do Problem 2, Problem 3, and Problem 5 before the exam, as they may be quite helpful to your studying.

1. Astrologers claim that the positions of the planets can influence events on Earth. In this problem, you'll calculate whether this is plausible or not.

   (a) Which planet's gravity do you think would have the greatest effect on Earth? Venus' orbit is closest, but Jupiter is largest.

   (b) Look up astronomical parameters for Earth and your chosen planet. What is the closest they ever are to each other? You may approximate their orbits as circles, and can find all the information you need on Wikipedia. Show how you estimate their distance of closest approach.

   (c) What acceleration does your chosen planet impart to objects on Earth? Is this acceleration relevant to anything?

2. A ball is attached to the end of a string hanging from the roof of a subway car. The train goes around a curve, turning to the left. You know that the car is traveling at 60 km/hr.

   - Which way will the ball appear to swing? Why?
   - If the ball swings at an angle of 15°, what is the radius of curvature of the curve in the tracks?

3. A Renaissance astronomer, Johannes Kepler, observed that the amount of time that a planet takes to travel around the Sun T is proportional to the 3/2 power of the long axis of its orbit.

   We are not equipped to analyze this for general orbits. However, we can calculate this for a circular orbit.

   Consider a planet of mass m orbiting a star of mass M in a circular orbit of radius r. Find the relationship between the time T it takes to travel around the Sun and the radius r of its orbit. (Your answer will also involve the gravitational constant and the mass of the star.) Show that your value for the time it takes to go around the Sun is proportional to the 3/2 power of the radius.

   Hint: Think about the relationship between T and ω.

4. In the last problem, you found a relationship between the time it takes a planet to travel around the Sun, its distance from the Sun, the mass of the Sun, and G. Given that $G = 6.67 \times 10^{-11} \frac{\text{m}^3}{\text{kg s}^2}$ and the radius of the Earth's orbit is $r = 1.5 \times 10^{11}$ m, find the mass of the Sun.

5. The film *Apollo 13* tells the story of three astronauts trying to survive aboard a crippled spacecraft in space between the Earth and the Moon. It involves scenes where the actors appear to be "weightless", mimicking the experience of the astronauts. Since going to space was prohibitively expensive, the producers shot those scenes in a set inside an aircraft. The aircraft flew in parabolas with an acceleration of precisely g downward; during this time, the astronauts appeared to float inside the set, as the aircraft climbed and then dove toward the ground.

   (a) The astronauts were able to experience "weightlessness" for about 25 seconds at a time. How far did the aircraft have to climb and then dive in order to do this?

   (b) Consider three forms of "weightlessness":

   - The experience of the actors and crew of the film *Apollo 13* in this aircraft
   - The experience of astronauts in the Space Station, in orbit around Earth at a low altitude
   - The experience of the astronauts in a real deep space mission like *Apollo 13*, in which the astronauts flew 400,000 km from Earth (which has a radius of around 6000 km).

   What are the similarities between the dynamics of "weightlessness" in these situations? What are the differences?