Three Body System: Apollo Spacecraft Project

In this project, we were required to model a 3-body system to simulate the Apollo Spacecraft, an object with negligible mass, orbiting a system of two much larger objects, the earth and the moon. In order to solve this problem, we first assumed that the center of mass of the earth and the moon lies on the origin. Next, we had to use a combination of differential equations to solve the spacecraft’s motion. In order to solve these differential equations, we use the command ode45. In order to use ode45, we had to convert our second order differential equations into first order differential equations. Next, we plotted a normalized x and y position of the spacecraft versus time. Finally, we plotted the normalized x and y coordinates of the spacecraft to show the path the spacecraft travels with respect to the earth and the moon.

Overall, this project took about three hours to complete. This time included creating the code, making comments, and reviewing our project. Through this project, we were able to take a fairly complex problem and simplify it using ode45. This project has taught me that Matlab can be an invaluable source, and it can make any difficult problem solvable.

Questions:

1. What is the period of the orbit given the initial conditions above? Tolerance ±0.2 seconds
   Answer: ~6.2 s

2. What is the maximum y distance from the Earth given the initial conditions and rotating coordinate system above?
   Answer: \( Y = 2.64 \times 10^8 \) m. I estimated based on the graph that the maximum y value is about 0.6875 units and then multiplied by D.

3. Where is the center of mass of the three body system? Choose one: A. Inside the earth, B. Closer to the earth, C. Closer to the moon.
   Answer: A. Inside the earth. Since the satellite is of negligible mass, the center of mass of the Earth and the Moon is 4.67*10^6 m away from the Earth’s center. Since the radius of the Earth is greater than the distance to the center of mass of the three body system, the center of mass is inside the earth.

4. Experiment with other initial conditions and describe what happens. The spacecraft may go careening off into oblivion.
   Answer: Any change in the initial conditions caused the orbit to go off the graph or take a very round about path. For example, changing the IC for \( y \) to a positive 0.2 causes the spacecraft to fly off the graph to the left. In addition to the last change, if you change the IC for \( x' \) to a positive value of 0.2 and the IC for \( y' \) to a positive value of 1, the spacecraft makes somewhat of a figure eight and then flies off the graph to the right. Overall, making any small changes to the initial conditions creates a large difference in the path of the spacecraft.