Math 365 **Homework 7** **Due November 30, 2016**
Grady Wright

1. (15 points) NCM 7.16

2. (15 points) NCM 7.18

3. (20 points) The initial value problem (IVP) below simulates the trajectory of a small satellite in the Earth-moon system, where all orbits lie in a plane:

$$x_1''(t) = x_1(t) + 2x_2'(t) - \mu^* \frac{x_1+\mu}{D_1} - \mu\frac{x_1-\mu^*}{D_2}, \quad x_1(0) = 0.994,\ x_1'(0) = 0,$$
$$x_2''(t) = x_2(t) - 2x_1'(t) - \mu^* \frac{x_2}{D_1} - \mu\frac{x_2}{D_2}, \quad x_2(0) = 0,\ x_2'(0) = -2.0015851063790825,$$

where,

$$0 \le t \le b = 17.06521656015796,$$
$$\mu = 0.012277471, \quad \mu^* = 1-\mu,$$
$$D_1 = ((x_1+\mu)^2 + x_2^2)^{3/2}, \quad D_2 = ((x_1-\mu^*)^2 + x_2^2)^{3/2},$$

The mass of the satellite is neglected. The coordinate system moves so that the origin is the center of mass of the Earth and moon, and it rotates so that the Earth and moon lie on the x_1 axis a distance 1 apart (the Earth is just left of the origin, and the moon is just left of (1,0)). The constants are chosen so that $\mathbf{x}(b) = \mathbf{x}(0)$.

(a) Use the `ode45` function to calculate one period of the orbit for each of the relative error tolerances of 10^{-2}, 10^{-4}, 10^{-6}. Create a phase portrait of x_2 vs. x_1 for each case. Try setting the `OutputFcn` of the `options` structure to `odephas2` (i.e. `options = odeset('OutputFcn',@odephas2)`) and then passing this into the `ode45` function to "animate" the orbit.

(b) Use `ode45` with 10^{-6} relative error to compute the orbit for *three* periods, and make a phase portrait. Explain what is wrong with the results. Try decreasing the relative error tolerances to see if the problem can be fixed. Describe what happends.

(c) Repeat part (b) with the `ode113` function. How do the results from this function compare to those of the `ode45` function? Explain in words.