Nonlinear Dynamics and Chaos - Group Work

Professor:
Dr. Joanna Bieri
joanna_bieri@redlands.edu

Test the numerical methods for the initial value problem

$$\dot{x} = -x$$
$$x(0) = 1$$

NUMERICAL METHODS

1. (SLOPE FIELD) Using the program dfield.jar, plot the Phase Portrait for your system. Dfield.jar is a free program that you can download to your own computer or it is also available on the computers in the classroom.

2. (EULER) Open the program euler.m. Go through the code line by line and comment the code saying at each line what the program is doing. Run the program for dt=1, 0.5, 0.1, 0.01. What happens as you decrease your time step?

3. (IMPROVED EULER) Repeat problem 2 for the Improved Euler Method.

4. (RUNGE-KUTTA) Repeat problem 2 for the Runge-Kutta Method.

5. (COMPARE THE METHODS) Run each of the methods for a time step dt=0.1. What are some differences? Which gives the best solution? Which gives the worst? NOTE: You can solve the ODE exactly so you can calculate the error $E = |x_{real} - x_{numerical}|$.

EXTRA: Try using the numerical methods for the problem

$$\dot{x} = \frac{1}{x}$$

with initial condition $x(-1) = 10$. Use step sizes $dt = .6, .4, .3, .2$ to estimate the solution at $t = 2$. Explain what is happening here.