Notes:
• Submit your homeworks (programs in C, sample output files, and files with explanations) using the turnin program on faraday.physics.arizona.edu
• Homework problems will get full credit only if: (a) the C programs compile successfully, (b) the programs have self-explanatory comments and variable names, and (c) the programs have proper indentation.
• No credit will be give to late homeworks.

The aim of the second homework set is to help you practice your skills in solving simple ordinary differential equations.

1. Radioactive decays of nuclei
   The nucleus $^{56}\text{Ni}$ is radioactive and decays into $^{56}\text{Co}$ with a characteristic time of $\tau = 8.8$ days. The differential equation that describes the rate of change of the number $f_{Ni}$ of $^{56}\text{Ni}$ is
   \[ \frac{df_{Ni}}{dt} = -\frac{f_{ni}}{\tau} \]  
   (1)
   (a) Write a program that solves equation (1) for the initial condition $f_{Ni}(t = 0) = 10^8$, using the 4th order Runge-Kutta method.
   (b) Plot the number of $^{56}\text{Ni}$ nuclei that did not decay as a function of time.
   (c) How long does it take for all the $^{56}\text{Ni}$ nuclei to have decayed?

2. Epidemiology
   Differential equations are very useful in studying the outcome of contagious diseases. Let $f_w$ the fraction of people in a population that are well, $f_i$ the fraction that are ill, and $f_d$ the fraction that have died. If the characteristic timescale for the spreading of a disease is $\tau_s$, the characteristic timescale for the ill to either recover or pass away is $\tau_d$, and the fraction of people that recover is $X$, then the evolution of the population is described by the set of equations
   \[ \frac{df_w}{dt} = -\frac{f_w}{\tau_s} + X \frac{f_i}{\tau_d} \]  
   (2)
   \[ \frac{df_i}{dt} = \frac{f_w}{\tau_s} - \frac{f_i}{\tau_d} \]  
   (3)
   \[ \frac{df_d}{dt} = (1 - X) \frac{f_i}{\tau_d} \]  
   (4)
   (a) Write the program that solves the above system of equations using the 4th order Runge-Kutta method, for $\tau_s = 300$ days, $\tau_d = 10$ days, $X = 0.2$, and an initial population of healthy people, i.e., $f_w = 1$, $f_i = f_d = 0$. Plot the fraction of healthy, ill, and dead people as a function of time. What is the outcome of this outbreak after 20 years?
   (b) Repeat the above exercise for a disease that has a much faster timescale for spreading, i.e., $\tau_s = 5$ days. What is the outcome of this outbreak after 2 years?