Homework Set 2

ASTR 5900, Computational Physics & Astrophysics

Due 2026 February 20, 11:59pm

Carry out the following work and write up an informal report showing the outputs (e.g., plots/graphs, tables) and answers to questions. Prepare your report in LaTeX (e.g., use Overleaf), generate a pdf file, and ***upload your report as a single pdf file*** on Canvas. Your report should ***include links to your project code*** file(s) in your GitHub repository. Code should have adequate comments, be human-readable, and have at least 3 git-commits (more is better).

1. Consider the following equation:

$$x^3 - 7x^2 + 14x - 5 = 0$$

Showing your work, find a solution to this equation *by hand* (meaning using only a calculator, pen, and paper; no code), to a precision in the value of x (error in x) smaller than 0.01,

(a) [1 point] using the bisection method (with initial guesses of $x_0 = 0$ and $x_1 = 1$) and

(b) [1 pts] using the Newton-Raphson method (with $x_0 = 0$).

(c) [0.5 pts] How many iterations did it take for each method?

2. Write a code that computes roots for each of these methods (bisection and Newton-Raphson). Your code should allow inputs for the initial guess(es) and the maximum error tolerance for the solution (relative error, ϵ). It should return the solution and count the number of steps taken.

(a) [2 pts] Use your code to find a solution to the equation in problem 1, to a precision of $\epsilon < 10^{-8}$, for both methods. Show the outputs of each step. How many iterations did each of the two methods take?

(b) [1.5 pts] How sensitive is the number of iterations to the location of your initial guess? To answer this, simply try 3 or 4 different initial guesses (further or closer to the known answer), and comment on what you find.

(c) [1 pts] Using the Newton-Raphson, experiment with initial guesses and see if you can find any that would lead your code astray. Describe and comment on what you find.

3. [3 pts] Find an equation *that is of interest to you* that does not have an analytical solution but can be solved with one of the above methods. Give and describe the equation and why you find it interesting. Use your own code to find the solution to this equation (perhaps for a few different values of the coefficients/constants in your equation). Show and discuss your findings.

Guidance: It would be ideal if you found an equation that is important in your research or classwork or of more general physics/astrophysics interest. But it's ok for this to be any equation that interests you. You can use any resources at your disposal (e.g., google, discuss with classmates, professors, etc.) to find ideas for something to use here. Just have fun with this and explore whatever you want.