Assignment 4

CAAM 519 Fall 2021

due Monday November 8 (11:59 pm)

In this assignment, you will gain some experience with pointers and functions. You will also implement Newton's method for root finding. Recall that Newton's method for a function $f : \mathbb{R} \to \mathbb{R}$ is the following iteration:

$$x_{k+1} = x_k - f'(x_k)^{-1} f(x_k),$$

given some initial guess x_0 for the root.

- (5pts) Create a header file called newton_functions.h. In this header file, put in guard rails and define prototypes for seven functions:
 - function1, function2, and function3, which should each take in a double and return a double.
 - derivative_of_function1, derivative_of_function2, and derivative_of_function3, which should each take in a double and return a double.
 - update_iterate, which does not return anything but should take in a double pointer called xiter and also two function pointers that themselves take in a double and return a double. Please name these two function pointers function and derivative_of_function in your prototype.
- (10pts) Create a source file called newton.c which includes the header file given above. You will also need to include other standard header files as we have done in previous assignments. At the beginning of this source file, #define two macros, one called TOLERANCE with a value of 1e-9 and one called MAX_ITERATIONS with a value of 10. Within this source file, implement functions 2x, $5x^2$, and sin(x) in function1, function2, and function3 respectively. Implement their derivatives in the corresponding functions you defined in the header file. For sin(x), note that you will need to include math.h and also compile the code by linking the standard math library with "-1m" as follows:

gcc -o main newton.c -lm

- (10pts) Implement Newton's method in the source file newton.c. This can be done by first implementing the function update_iterate, which should take in a pointer to the value of the kth iterate x_k in xiter and the function and its derivative as function pointers. Upon calling update_iterate, the pointer xiter should contain the value of the (k + 1)th iterate x_{k+1} . Next, implement the Newton iteration within the main function by calling update_iterate until either $|f(x_k)| < \text{TOLERANCE}$ or the number of iterations exceeds MAX_ITERATIONS. For the absolute value function, call fabs.
- (5pts) Run the Newton iteration on the three functions you have implemented, with initial guesses 50, 13.5, and 3.0 for 2x, $5x^2$, and $\sin(x)$ respectively. Print out x_k and $f(x_k)$ for each iteration. To do this in your main function, you can just include three while loops that implement the Newton iteration, i.e. one for each function.

Please put your code and output into a LAT_EX document and upload your pdf generated from LAT_EX and source and header files to Canvas.