16.216: ECE Application Programming

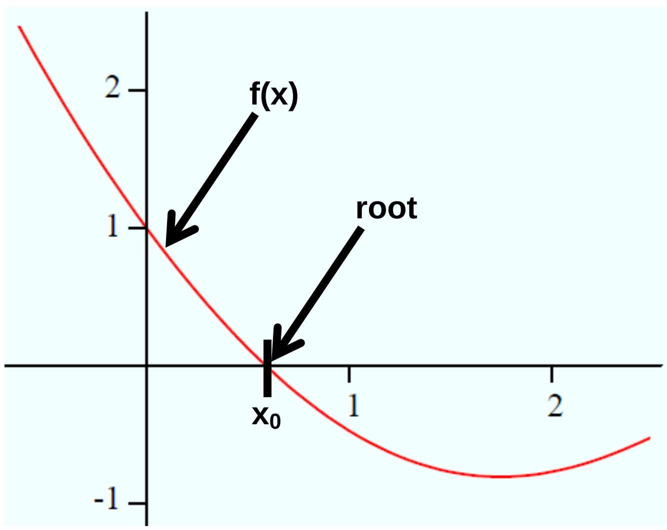
Spring 2012

Programming Assignment #6: Root finding with functions

Due **Wednesday, 4/11/12**, 11:59:59 PM

1. Introduction

This assignment will give you experience writing and using functions. You will find the roots of an equation using a numerical algorithm called the bisection method—given an equation f(x), you will find a value of $x=x_0$ such that $f(x_0) = 0$. You can visualize the solution to this problem as finding the intersection, x_0, of the curve f(x) with the x-axis.



This assignment is adapted from an assignment written by Professor George Cheney for an earlier version of this course.

2. Deliverables

Submit your source file directly to Dr. Geiger (Michael_Geiger@uml.edu) as an e-mail attachment. Ensure your source file name is ***prog6_roots.c***. <u>You should submit only the .c file.</u> Failure to meet this specification will reduce your grade, as described in the program grading guidelines.

At present, this assignment contains no extra credit sections—as you'll see, flowcharts are largely given to you, and I have not yet determined if there's an appropriate programming problem that can be added.

I'll consider our options and potentially add an additional programming section to this assignment for extra credit. If I do so, I will notify you later this week.

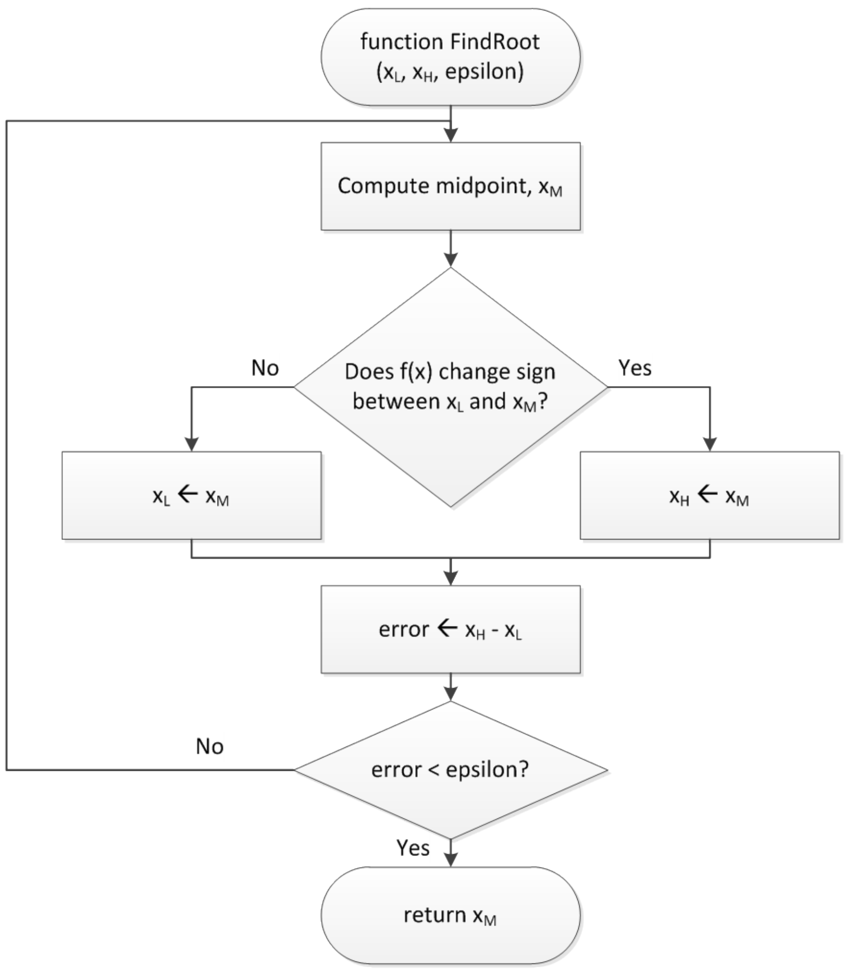
3. Specifications

Bisection method: This method requires a known interval of uncertainty, $x_L \le x \le x_H$ within which a root exists; given this interval, follow these steps:

- Bisect the interval $x_L \le x \le x_H$—in other words, find the midpoint, x_M.
- Determine whether the root lies to the right or left of the midpoint.
- Redefine the interval to be the half interval that encloses the root.
- If the interval of uncertainty is still too large for the specified error, repeat the process, starting again with the bisection step.
- Otherwise, use the midpoint, x_M, as the approximate location of the root.

This method can be described using the following flowchart, which gives the details of a function FindRoot(x_L, x_H, epsilon), where x_L and x_H are the endpoints of the interval of uncertainty, and epsilon is the maximum allowed error.

<u>**You must write and use FindRoot() in your own program.**</u>



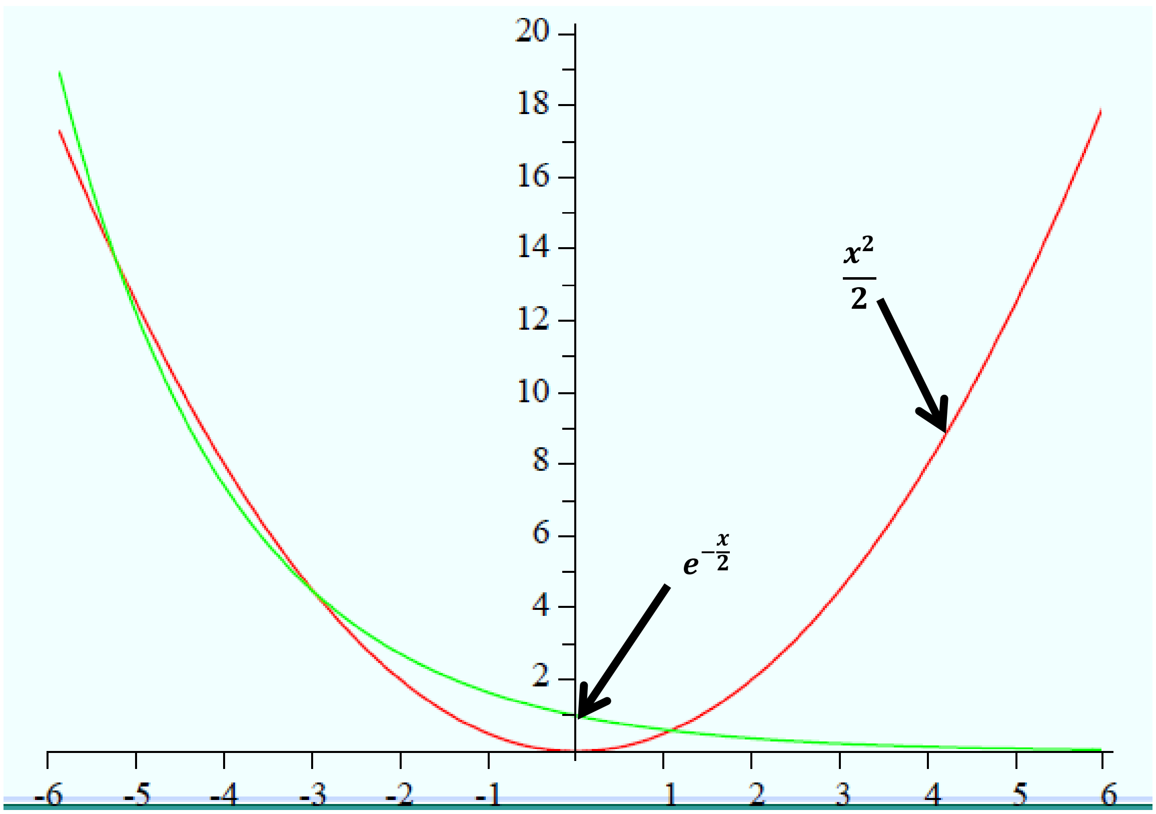
General program structure: Your program should repeatedly use the bisection method to find all of the intersection point of the curves:

$$f_1(x) = \frac{x^2}{2} \text{ and } f_2(x) = e^{-\frac{x}{2}}$$

You can find these points by using the bisection method to find the roots of the following function:

$$f(x) = f_1(x) – f_2(x)$$

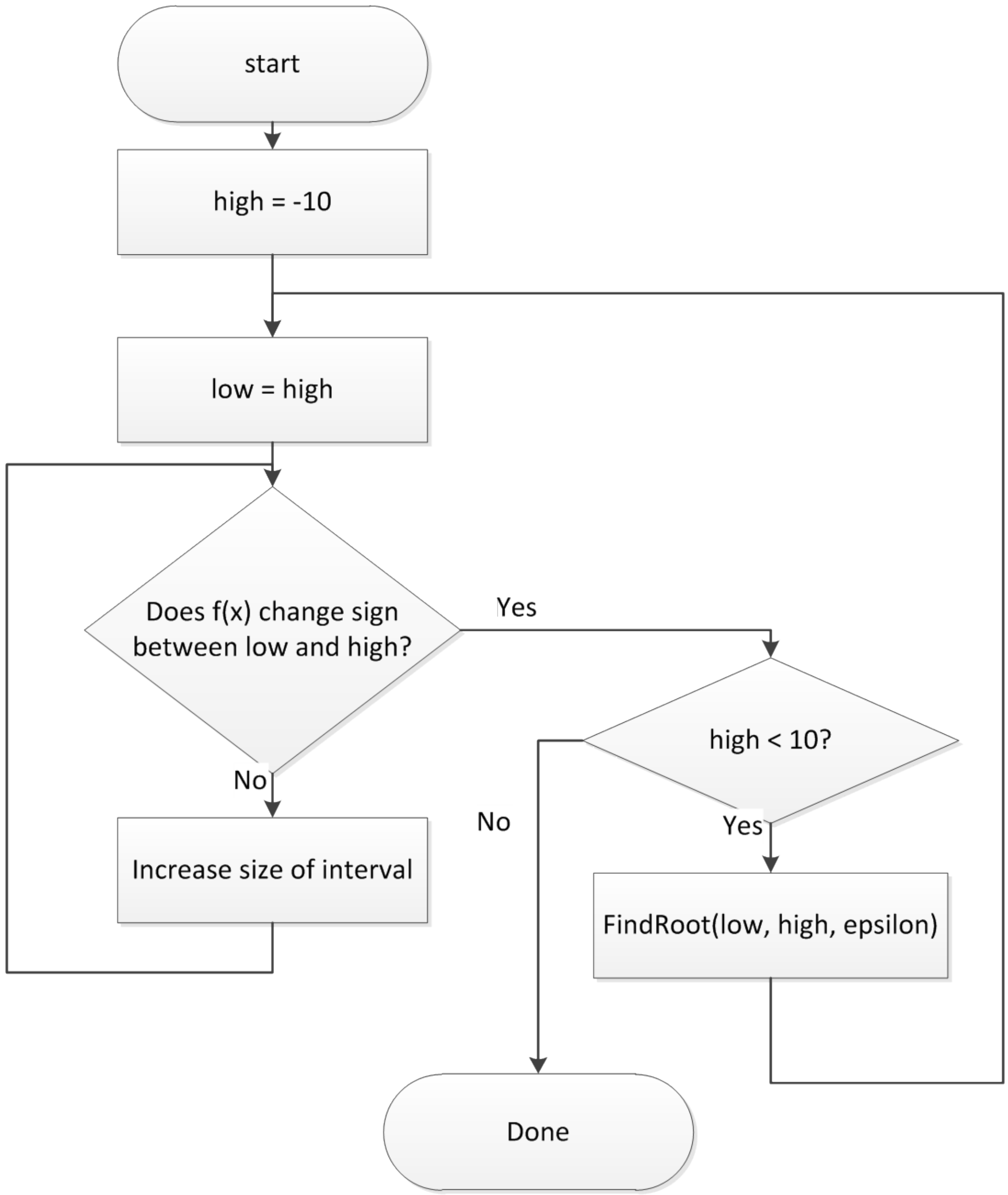
<u>**You must write f(x) for use in your program.**</u>



As you can see above, the two functions intersect a total of three times. To find all three roots, I would like you to scan the range -10 ≤ x ≤ 10, looking for intervals that contain a root; once you find such an interval, use the FindRoot() function described above to find the actual root.

The flowchart on the next page describes the overall program flow.

General program structure (cont.)



Input: Your program does not need to accept any input.

Output: Each time a root is found, your program should print "`Root found at x.xxx`", where `x.xxx` represents the x value at which a root is found, using a precision of three.

Note that there are **<u>no test cases</u>** for this assignment, because the program takes no input, and correct solutions should output the exact same output … which, for obvious reasons, I'm not going to show in the assignment!