ME 2016 Computing Techniques

Section C - Spring 2017

Computing Project One

Due Thursday, February 16th at 3:00pm

Numerical Errors and Root-Finding Algorithms

Please read all instructions (on 2 pages) before starting to write any code.

Submission of your answers

- At the end of the class on 02/07, upload any Matlab code that you have written on T-Square
- By 3:00 pm on Thursday 02/16, upload your final Matlab codes on T-Square.
- At the start of the class on 02/16, turn in the print-out of the codes, the print-out of the outputs of your code and the graph.

Problem statement

A shock wave, which is an extremely thin non-equilibrium region, is caused by the collision of fast moving gas with slower moving gas (e.g., the leading edge of a supersonic wing). The following equation relates the dimensionless velocity inside the shock wave ϕ to the various parameters of the system:

$$\frac{1-\phi}{(\phi-\alpha)^{\alpha}} = exp[\beta(1-\alpha)M_1(\xi-\xi_0)]$$

where ξ is the dimensionless position inside the shock wave, M_1 is the Mach number for the high velocity gas and α and β are constants. For $\alpha = 0.32$ and $M_1 = 2$, determine ϕ at the leading edge of the shock wave (i.e. $\xi = \xi_0$).

Tasks

1. Write the equation to be solved in the form $f(\phi) = 0$ (for the case $\xi = \xi_0$). Plot the function $f(\phi)$ as a function of ϕ to get an idea of the value of the root (you can only plot f for $\phi > 0.32$).
2. Write a function for the *secant* algorithm. The inputs should be the function f (as an anonymous function handle), the 1st initial guess x_0, the 2nd initial guess $x1$, and the maximum allowable approximate percent relative error, ε_a^{max}. The outputs of the functions should be the value of the root, x_r, the value of the approximate percent relative error, ε_α, and the number of iterations, N_{iter}. Name your function *secant*. Verify that you code works by solving Example 6.6 from the textbook.
3. Based on your figure in Question 1, and appropriate values for the initial guesses so that the secant algorithm converges to the true root

4. Using $\varepsilon_a^{max} = 1 \times 10^{-8}\%$ find the value of ϕ using your secant algorithm
5. Verify your answer using the MATLAB f_{zero} function (use the MATLAB help to figure out the options and syntax for f_{zero})
6. Report the value of x_r, N_{iter} and ε_α.

Submit your codes using a single *m* _le called *LastnameFirstnameCP*1.*m* where *Lastname* is your last name and *Firstname* is your first name. This _le should include two functions: *LastnameFirstnameCP*1 and *secant*. The function *LastnameFirstnameCP*1 should have no input variables and no output variables. Running the function *LastnameFirstnameCP*1 should:

- solve Example 6.6 using the secant algorithm
- print out x_r, and ε_α after 3 iterations for example 6.6
- plot the function *f*
- *S*olve the equation using $\varepsilon_a^{max} = 1 \times 10^{-8}\%$
- print out x_r, N_{iter} and ε_α.
- print out x_r obtained with the f_{zero} function

Make sure to include comments in your codes as described in class.