

EML3041 Computational Methods Nonlinear Equations

Q1..Write a program in MATLAB that solves a nonlinear equation $f(x)=0$ by using the bisection method. The inputs would be the function, $f(x)$, the initial bracket and the number of iterations. The output would be the estimate of the root of the equation. Make sure that you put validation of the initial bracket as part of the program. Test the program.

Q2..Use programming in MATLAB to solve the following.

How tall can a vertical mast be before it buckles it under own weight – a nonlinear equation model?

In his classic book, *Theory of Elastic Stability*, Timoshenko showed that one needs to solve the following nonlinear equation to find the longest length of a vertical mast (such as a flag pole) before it starts to buckle under its own weight.

$$1 + \sum_{n=1}^{\infty} c_n \beta^n = 0 \quad (1)$$

where

$$c_1 = -\frac{3}{8} \quad (2a)$$

$$c_n = -\frac{3c_{n-1}}{4n(3n-1)}, n = 2, 3, \dots \quad (2b)$$

Once the smallest positive root, β of equation (1) is found, then the longest length of mast before which buckling would start is given by

$$L = \left(\frac{9\beta EI}{4w} \right)^{\frac{1}{3}} \quad (3)$$

where

E = Young's modulus of elasticity,

I = second moment of area,

w = weight per unit length

Go to the internet resources to choose reasonable values for inputs in SI system of units for an aluminum flag mast to find the longest mast one can have before it buckles? Choose a reasonable value of $n \geq 2$ to get started. *Hint:* Use solve, or vpasolve or roots (which one would be most suitable) commands to solve a nonlinear polynomial equation.



Q3..“Deflategate was a National Football League (NFL)

controversy involving the allegation that New England Patriots quarterback Tom Brady ordered the deliberate deflation of footballs used in the Patriots' victory against the Indianapolis

Colts in the 2014 American Football Conference (AFC) Championship Game. The controversy



resulted in Brady being suspended for four games; the team was fined \$1 million and forfeited two draft selections in 2016” [1].

Deflate Gate is a greater lesson for all of us on not jumping to quick conclusions and making hasty calculations. Physicist Neil deGrasse Tyson did not change gauge pressure to absolute pressure; Bill Nye, a mechanical engineer, who calls himself the science guy, did not give convincing arguments; others did not change temperature to absolute temperature; other variables were not accounted for: water vapor pressure, temperature of compressed air (compressed air is hot) to inflate balls, and the time interval between when balls were inflated to when balls were taken to the field,.

Questions

(A)..Do the following problem by hand using TI30Xa calculator. Do the problem on a fresh sheet of paper. Find the decrease in pressure expected in an NFL football if it was inflated in a room at 80°F, left in the room for a while, and brought to field at 40°F, and left there for a while. Use the ideal gas law to find the decrease in pressure as a number in psi. The ideal gas law is given by

$$pv = RT$$

where p is the pressure, v is the specific volume, R is the universal gas constant, and T is the absolute temperature. If any numbers for variables are needed, go to your favorite internet source or book. You should seek the least numbers needed.

(B)..Do the following problems by hand using MATLAB Use the equation given by Johannes Diderik van der Waals to do the same problem as given in part (A). The ideal gas law equation is only accurate for a limited range of pressure and temperature. Johannes Diderik van der Waals came up with an empirical equation that was accurate for larger ranges of pressure and temperature given by

$$\left(p + \frac{a}{v^2}\right)(v - b) = RT$$

where a and b are empirical constants dependent on a particular gas. If any numbers for variables are needed, go to your favorite internet source. You should seek the least numbers needed.

References

[1] Hirschhorn, Jason (May 11, 2015). "Patriots lose 2016 1st-round pick, fined \$1 million for DeflateGate role". SBNation.com. Retrieved February 14, 2017.

Q4..Repeat Q#1 with last absolute relative approximate error as an output

Q5..Repeat Q#1 with prespecified tolerance as an additional input.