## Reading

**Textbook**: *Numerical Methods for Engineers*, 7th Ed.
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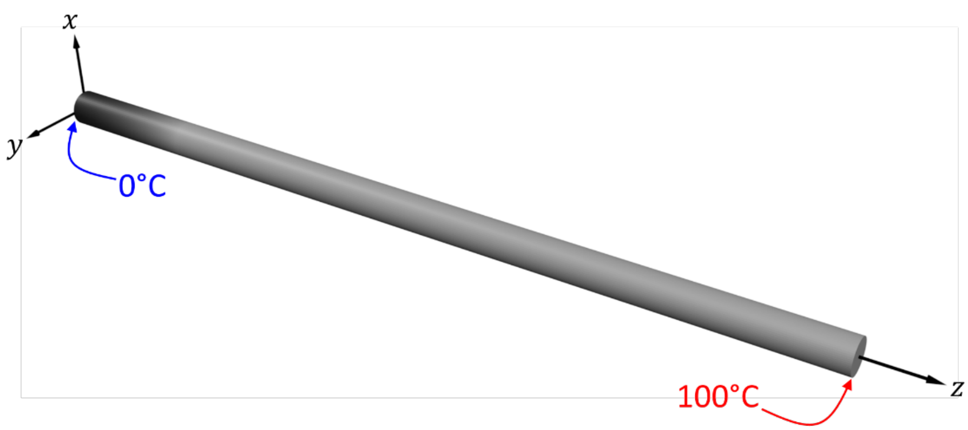
McGraw Hill

**Assignment**: Read Chapters 5 – 8
EMPossible Website, Topic 4.

## `T = simbartemp(z)`

A cylindrical bar is made from a functionally-graded ceramic, where the composition of the ceramic changes over the length of the bar. The bar is 60 cm long so it extends from $z = 0$ m to $z = 0.6$ m. The end at $z = 0$ m is held at a constant 0°C while the other end at $z = 0.6$ m is held at a constant 100°C. Due to the functionally-graded ceramic, the temperature takes on a nonlinear profile along the bar.




To help reconcile the physics of this problem, a function `simbartemp()` was written in MATLAB to simulate the thermal behavior of the bar and calculate the temperature $T$ at any position $z$ in the range $0 \text{ m} \leq z \leq 0.6 \text{ m}$. Calculation time is roughly 30 seconds for every value of $z$ that must be calculated.

## Problem #1: False-Position Method

Write a MATLAB program that implements the false-position method to find the position $z_{\mathrm{RT}}$ along the ceramic bar that is at room temperature (i.e. $T = 22°\mathrm{C}$).

First, visualize the first six iterations of the method where the lower and upper bounds should be initialized to 0 m and 0.6 m, respectively. Each iteration should be displayed in a different plot, not superimposed with data from other iterations. At a minimum, visualize the function, the lower and upper bounds, and the current trial solution. The plots should show the iteration number in the title of each plot. Use clear and professional graphics that are "publication ready" as described in the course syllabus. Try to beat the level of quality of the graphics in the notes. Review the graphics checklist and include it at the end of this assignment.

Second, find and report the root accurate down to a micrometer. Report your answer in units of micrometers.

Hint: Consider using anonymous functions to make it easier to change the function for which you are finding roots. Think of how to solve this problem with a single simple code.

## Problem #2: Secant Method

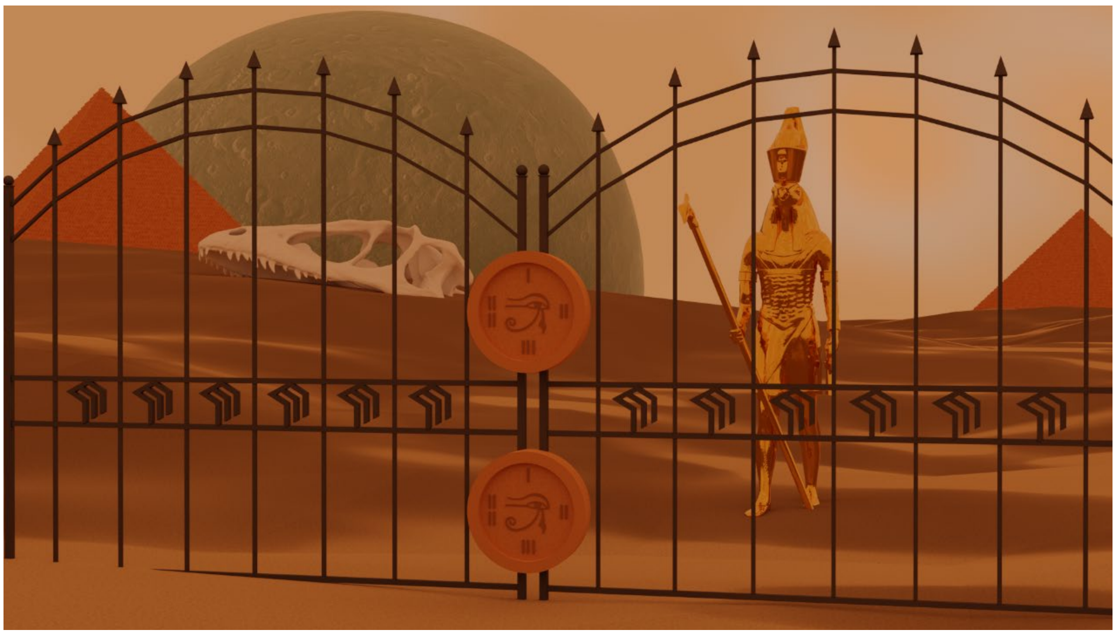
Write a MATLAB program that implements the secant method to find the position $z_0$ along the ceramic bar that is at $T = 50°\mathrm{C}$.

First, visualize the first six iterations of the method over the range $0\ \mathrm{m} \leq z \leq 0.6\ \mathrm{m}$. Each iteration should be displayed in a different plot, not superimposed with data from other iterations. At a minimum, visualize the function, the trial points, the slope projection, and the new trial point. The plots should show the iteration number in the title of each plot. Use clear and professional graphics that are "publication ready" as described in the course syllabus. Try to beat the level of quality of the graphics in the notes. Review the graphics checklist and include it at the end of this assignment.

Second, find and report the root accurate down to a nanometer. Report your answer in units of centimeters.

## Problem #3: Prevent the Apocalypse!

A long time ago, Seth, the Egyptian God of disorder and violence, murdered Osiris to become King of Egypt. Seven years later, Horus, son of Osiris, claimed the throne and defeated Seth in a vicious battle. Today, Seth has returned to earth for revenge and plans to destroy the world in an apocalyptic nightmare. He is hiding somewhere in Egypt. British intelligence intercepted an electromagnetic signal emanating from an ancient Egyptian shabti stored in the British Museum in London. The shabti was made in the image of the Egyptian God Ash, a known ally and supporter of Seth. From this signal, intelligence officers deciphered a MATLAB function `y=ash(x)`. It is believed that the roots of this function encode the GPS coordinates of the pyramid in Egypt where Seth is hiding. To stop Seth and prevent this disaster, help from Horus is needed, but Horus is currently trapped in Duat, frozen in a golden statue. The area where Horus is kept is sealed by two magic locks on an iron gate. Setting the two dials to the correct two numbers will open the lock and release Horus from his statue. The wrong numbers will destroy the statue and Horus inside forever. It is believed that the correct digits for the locks are the orders of the roots: single (1), double (2), triple (3) or quadruple (4).



For this homework, download the mysterious `y=ash(x)` function from the course website. You must download the latest version because the God's are evil. Determine all roots to at least eight digits of precision in order to retrieve GPS coordinates (units of degrees, i.e. *DD.DDDDDD*°) accurate enough to identify the correct pyramid. The first root is degrees north and the second root is degrees east. Enter these coordinates into Google Maps to locate and identify the specific pyramid containing Seth. Further, determine whether the roots are single, double, triple or quadruple to come up with the two-digit code that will release Horus, allowing him to seal Seth inside of the pyramid for the rest of time.

Beware of the `ash()` function! It is cursed and is known to produce strange and erratic behavior on modern computers, including erasure of data within MATLAB! Even worse, calculation time depends on the mood of the Gods, so each value of $y$ evaluated by `ash(x)` can be quick or take a long time. The fate of the world is in your hands!

In this problem, you must provide:

1. A table listing all of the roots, the method you used to find the root, the initial conditions for the method, the root to at least eight digits of precision, and the number of iterations.
2. A professional plot of the `ash()` function that identifies the roots, reports the roots to all digits that were retrieved, and indicates the roots as single, double, triple, or quadruple.
3. A discussion to justify how you identified the roots as single, double, triple, or quadruple.
4. The GPS coordinates and name of the pyramid where Seth is hiding.
5. The two-digit code that will release Horus from his imprisonment.
6. Show all work and steps you used to solve this problem.

Hint: Get started on this problem early! Use the best algorithm in order to minimize iterations and computation time. Be careful of the `ash()` function!