Computational Techniques
Module-1: Introduction

Dr. Niket Kaisare
Department of Chemical Engineering
Indian Institute of Technology - Madras

About the Instructor

- Dr. Niket Kaisare
  - Assistant Professor
    Department of Chemical Engineering
    Indian Institute of Technology – Madras
    Chennai 600036, India

- Research Interests
  - Catalytic micro-reactors
  - Fuel processing / Fuel Cells
  - Multi-scale modeling
  - Optimization and Control

About the Course

This course is designed to give an overview of

Computational Techniques

of interest to engineers

- Focus will be on numerical methods, their properties and analysis
- Approximately 40 one-hour modules

What You Need

For the lectures to be most effective, you need to work with me during each lecture

Keep near you:

- A pen and notebook
- A calculator
- An Excel* spreadsheet (or Google Docs* App.)

"Peer interaction" is highly recommended

*This is not an official endorsement of any product.
I personally find these Apps most suitable to this course.

Computational Techniques

An Overview of the Course

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"*Computational techniques*" or "*Numerical Methods*"
use computers to solve problems by
step-wise, *repeated* and *iterative* solution methods,
which would otherwise be
tedious or *unsolvable* by hand-calculations.

Popularity

- Popularity due to availability of computers
- To solve problems for which algebraic solution cannot be obtained

Advantages

- Extremely powerful problem-solving tools
- Commercial softwares and packages available
- Can provide additional insights into various engineering problems

Historical Perspective

- Babylonian method for $\sqrt{2}$
  (also called Heron's algorithm)

Iteratively calculate using the expression:

$$x^{(\text{new})} = \frac{1}{2}\left(x + \frac{2}{x} \right)$$

Layout of the Course

- Split into various modules (chapters)

- Each module → 4 to 6 one-hour lectures
  - Motivation / Overview of the topic
  - Examples
  - Graphical insight
  - Derivation and analysis
  - Summary

1. Motivation

- Why learn about Heron algorithm for $\sqrt{2}$?

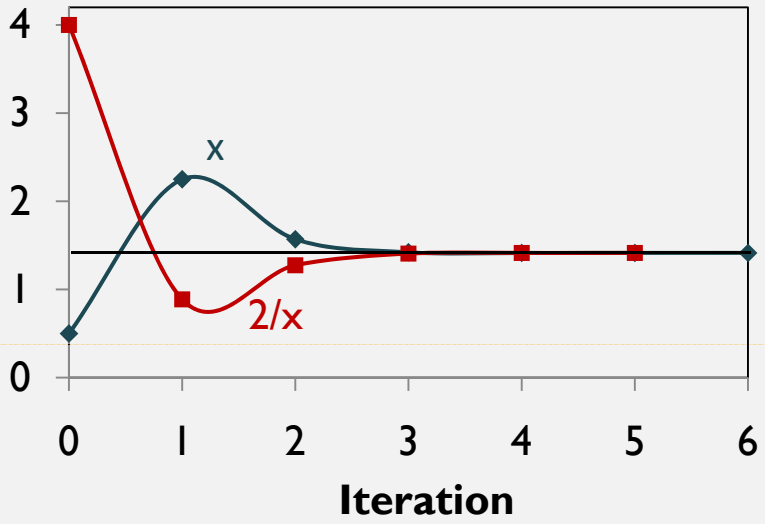
2. Example

- Start with initial guess x = 0.5
- Next value is x = (0.5 + 2/0.5) x ½

iteration	x	2/x	Average
0	**0.5**	4	2.25
1	2.25	0.888889	1.569444
2	1.569444	1.274336	1.42189
3	1.42189	1.406578	1.414234
4	1.414234	1.414193	1.414214
5	1.414214	1.414214	1.414214
6	**1.414214**		

3. Graphical Insight

- For positive values, x and $2/x$ lie on either side of the true solution



4. Analysis

- Taylor's series expansion of $f(x) = (2 - x^2)$ gives us the properties of Henon algorithm (covered in Module 4)

Topics Covered in the Course

- Module 1: Introduction
- Module 2: Computation and Error Analysis
- Module 3: Linear Systems and Equations
- Module 4: Algebraic Equations
- Module 5: Regression and Curve Fitting
- Module 6: Differentiation and Integration
- Module 7: Ordinary Differential Equations (1)
- Module 8: Ordinary Differential Equations (2)
- Module 9: Partial Differential Equations