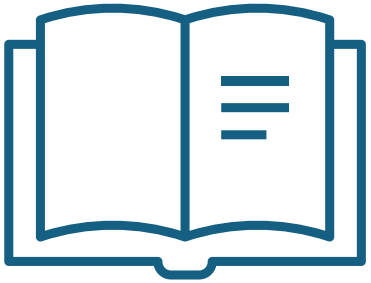
UNIVERSITAS GADJAH MADA
DEPARTMENT OF CIVIL AND ENVIRONMENTAL ENGINEERING
BACHELOR IN CIVIL ENGINEERING

Numerical Methods

Mathematics and Civil Engineering

Mathematics and civil engineering



- Reference
  - Chapra, S.C., Canale, R.P., 2015, *Numerical Methods for Engineers*, 7th Ed., McGraw-Hill Book Co., New York
    - Part One: Chapters 1 to 4 (pp 3 to 114)

Numerical methods

Numerical methods are techniques by which mathematical problems are formulated so that they can be solved with arithmetic operations. Although there are many kinds of numerical methods, they have one common characteristic: they invariably involve large numbers of tedious arithmetic calculations. It is little wonder that with the development of fast, efficient digital computers, the role of numerical methods in engineering problem solving has increased dramatically in recent years.

(Chapra and Canale, 2015)

arithmetic is the part of mathematics that involves the adding and multiplying, etc. of numbers (Cambride Dictionary)

Numerical Methods is a broad area of mathematics and computer science focused on approximating solutions to mathematical problems that are difficult or impossible to solve analytically

Phases of engineering problem solving

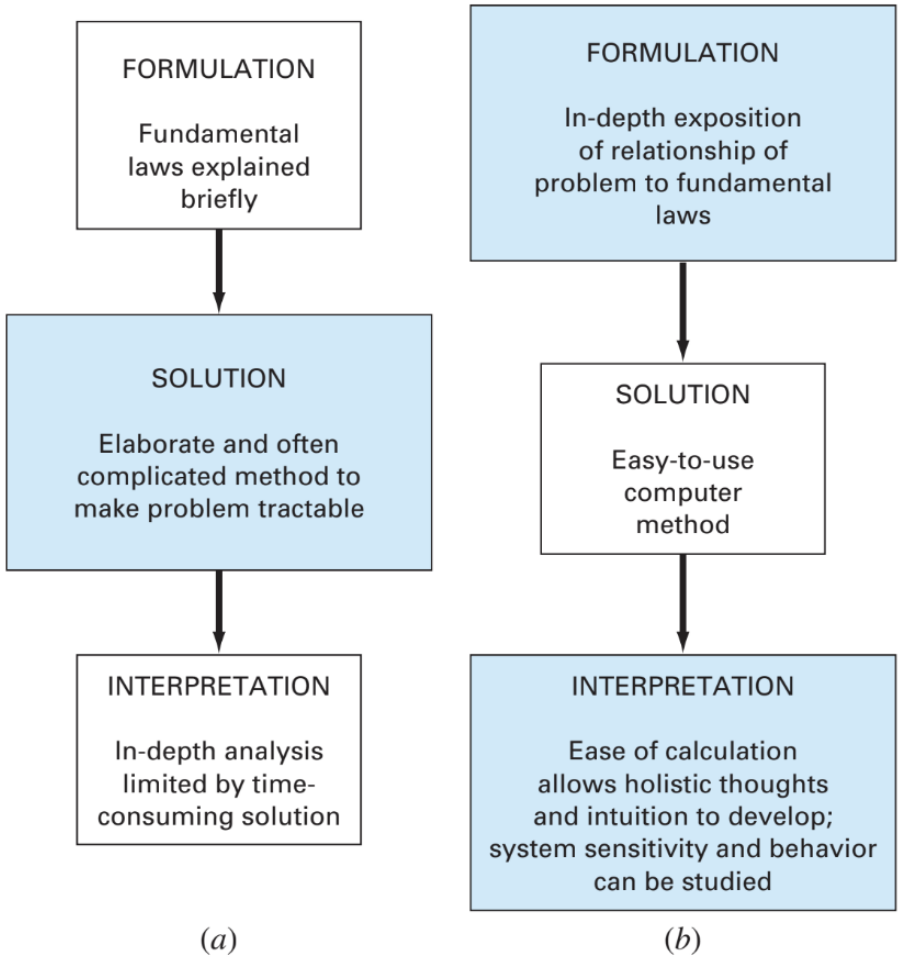
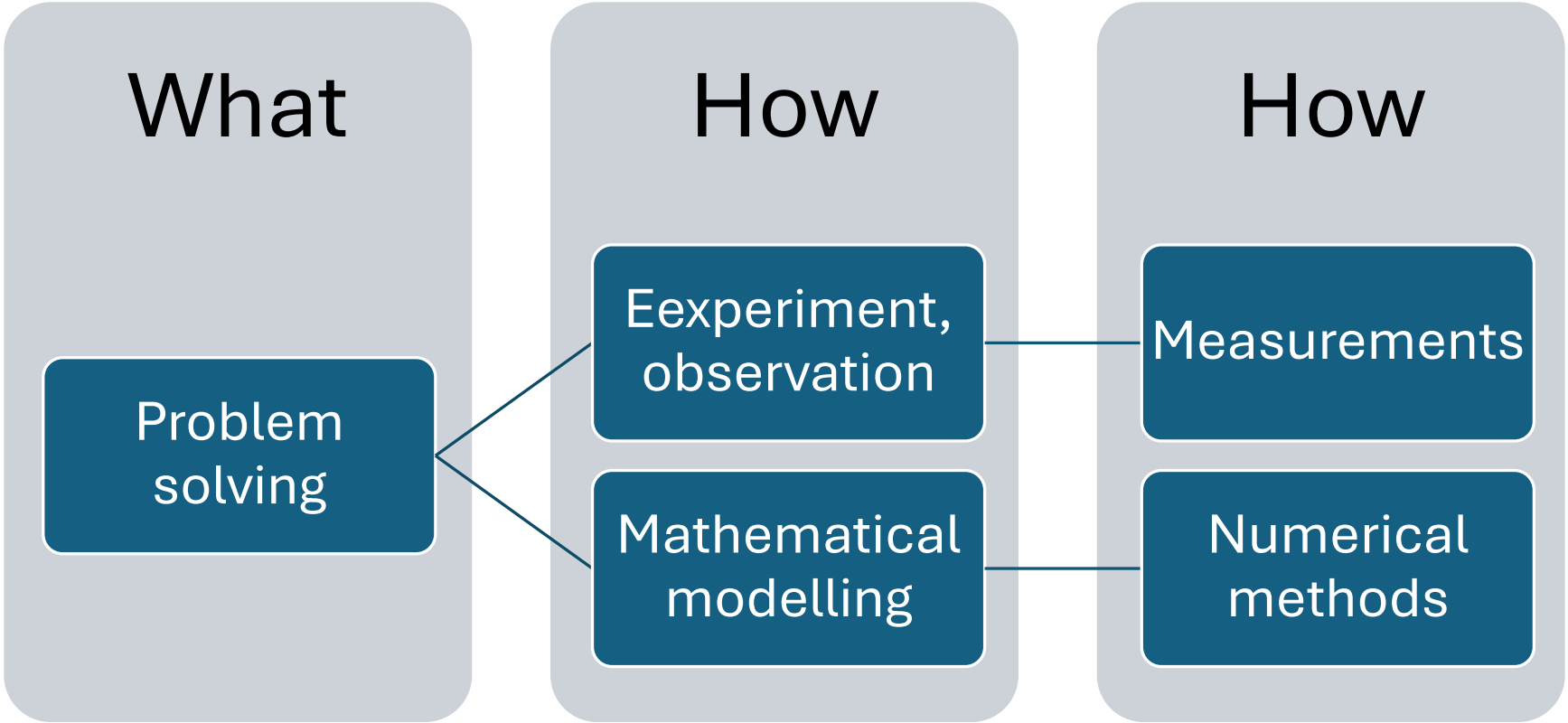


FIGURE PT1.1
The three phases of engineering problem solving in (*a*) the precomputer and (*b*) the computer era. The sizes of the boxes indicate the level of emphasis directed toward each phase. Computers facilitate the implementation of solution techniques and thus allow more emphasis to be placed on the creative aspects of problem formulation and interpretation of results.

Mathematical modelling and engineering problem solving



Mathematical model

A mathematical model can be broadly defined as a formulation or equation that expresses the essential features of a physical system or process in mathematical terms. In a very general sense, it can be represented as a functional relationship of the form

$$\text{Dependent variable} = f\left(\text{independent variables}, \text{parameters}, \text{forcing functions}\right) \tag{1.1}$$

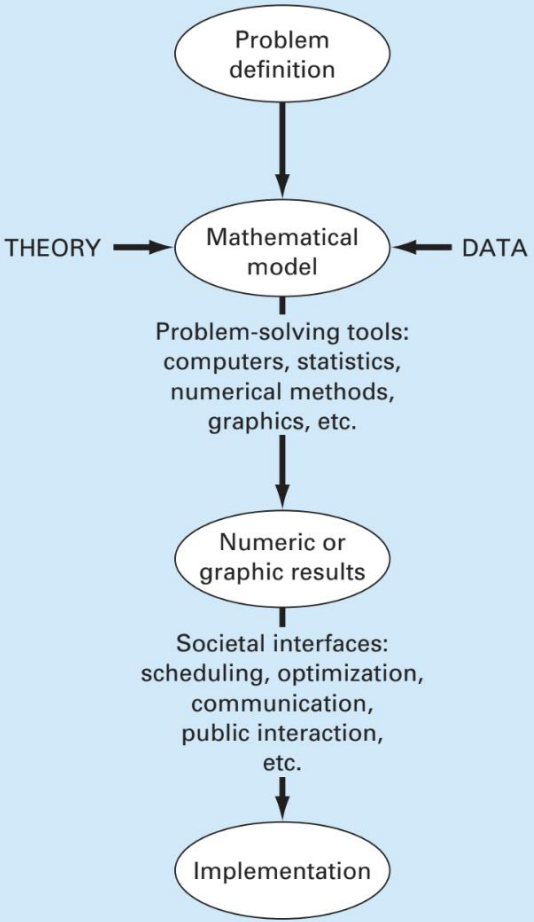


FIGURE 1.1
The engineering problem-solving process.

Computer programming languages

- Spreadsheet
  - Miscrosoft Excel
  - Numbers
- Application/packages
  - MatLab
  - Octave
- Computer programming languages
  - Visual Basic
  - Fortran
  - Python

Approximations and round-off errors

- Numerical method/technique approximates, thus it yields an estimate to, the exact (analytical) solution
- It produces an “error”, that is the discrepency between the estimate and the exact solutions
- Such “error” is the characteristic of numerical solution
- There are two types of numerical error
  - Round-off error
  - Truncation error

Approximations and round-off errors

- Round-off errors
  - originate from the fact that computers (and calculators) retain only a fixed number of significant figures during a calculation
  - computers use a base-2 representation, thus computers cannot precisely represent exact base-10 numbers
  - examples

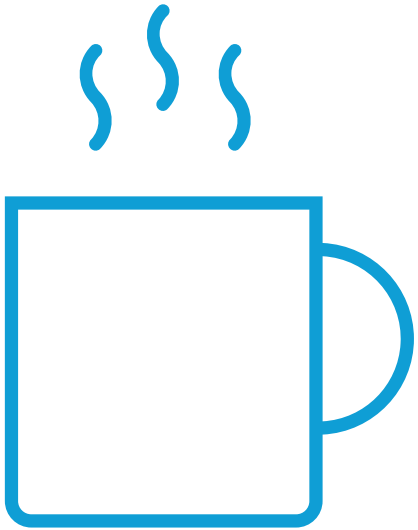
    $\pi = 3.14159265358979 \ldots$

    $e = 2.71828182845905 \ldots$

    $\sqrt{7} = 2.64575131106459 \ldots$

Accuracy and precision

Truncation errors and the Taylor series



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