ME 6000

Computational Methods in Engineering

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Introduction

- Instructors
  - Prof. S. P. Venkatesan (Heat Transfer Lab)
  - **Dr. Ratna Kumar Annabattula (Machine Design Section)**
  - Dr. Narasimhan Swaminathan (Machine Design Section)

Course Content

- **Number representation, Errors and Approximations (RK)**
- **Solution of Linear Algebraic Equations (RK)**
- Solution of Non-Linear Equations (SPV)
- Interpolation Methods (SPV)
- Differentiation and Integration (SPV)
- **Transformation Techniques (RK)**
- Differential Equations (NS)
- Regression Methods (SPV)
- **Statistical Methods (RK)**
- **Introduction to Optimization Methods (RK)**

Grading Policy

- Quiz -1 (15%)
- Quiz -2 (15%)
- Assignments (30%)
- End Semester (40%)

Honor Code

- Assignments should be carried out independently
- Late submissions will be penalised
- 85% attendance is a MUST
- Each assignment is a potential grade enhancer. Be aware of it from the beginning and don't ask for grade enhancements at the end!

Class Schedule

- Every Thursday 15:00 hrs - 17:00 hrs

Textbooks

- *Numerical Methods for Engineers*, Steven C Chapra and Raymond P Canale, 5th Edition, Tata McGraw Hill
- *Computational Science and Engineering*, Gilbert Strang
- *Computational Methods in Engineering*, S. P. Venkateshan, Ane Books

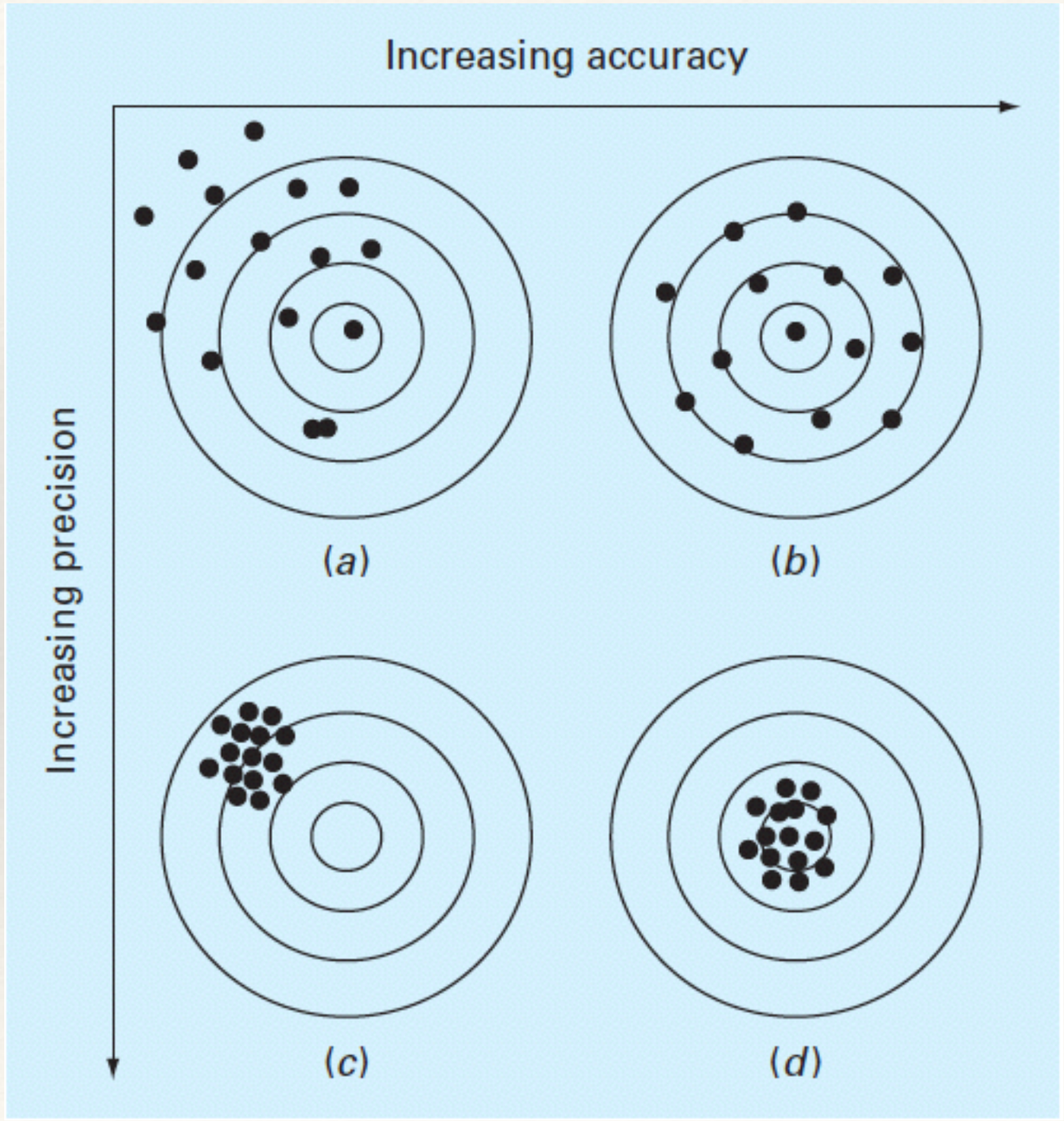
Mathematical Modeling

- Dependent variable $= f$(independent variables, parameters, forcing functions)
- Solving problems numerically involves many approximations and the ensuing errors

Approximations and Errors

- Numerical techniques are prone to give rise to some **errors** due to some **approximations**
- Significant figures / digits (π=3.14159265……..)
- Accuracy
- Precision
- Error Definitions
  - Truncation Errors
  - Round-Off Errors

Accuracy and Precision



Source: Applied Numerical Methods for Engineering, Steven C Chapra

Errors

- E_t = true value - approximation
- True fractional relative error = true error / true value
- Approximate relative error = approximate error / approximation
- Condition for acceptance: $|\varepsilon_a| < \varepsilon_s$
- $\varepsilon_s = (0.5 \times 10^{2-n})\%$ implies that the result is correct to at least n significant digits.
- *Example: Let's say we have measured the lengths of a bridge and a rivet to be 9999 and 9 cm, respectively. If the true values are 10000 and 10 cm respectively, what is the true error and what is the percentage relative error?*

Errors

- *Truncation errors* are due to the approximations used to represent the exact mathematical procedures (e.g. truncating Maclaurin series of e^x)
- *Round-off errors* result when numbers having limited significant figures are used to represent exact numbers

Example

$$e^x = 1 + x + \frac{x^2}{2} + \frac{x^3}{3!} + ...$$

- Calculate truncation error with 1, 2, 3 and 4 terms used for evaluating $e^{0.5}$

Number systems

- Binary
- Octal
- Decimal
- Hexadecimal

Conversion between number systems

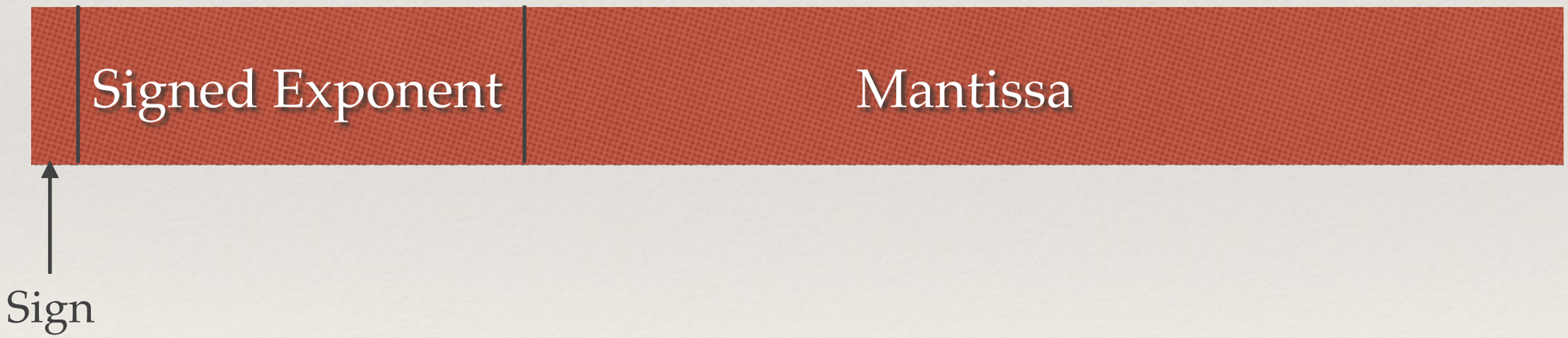
- Work out on how to convert integers

Computer Representation of Numbers (Integers)

- 4-bit computer
- 8-bit computer
- signed and unsigned integers
- Range of integers in base-10 that can be represented on a 16-bit computer

Floating Point Representation

- A floating point may be represented in m . b^e format.



References

- Steven C Chapra, Raymond P Canale, *Numerical Methods for Engineers*, 5th Edition, Mcgraw Hill, 2006