B1 Numerical Algorithms

4 lectures, MT 2023

Introduction

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Course Overview

- 4 Lectures and 1 computational class.
- The focus of this course will be on the use of numerical methods in engineering science.
- Supporting material from courses:
  - P101 Calculus 1
  - P102 Calculus 2
  - P104 ODEs
  - A102 PDEs

Acknowledgements

- Special thanks to Prof Ron Daniel who delivered this course up to 2012.

  The lecture slides you have include some material prepared by Prof Daniel.

- Special thanks to Professor Vicente Grau who lectured this course 2013-2017.

  The lecture slides that I will present borrow some content (plots) from Prof Grau.

- Special thanks to Professor Stephen Roberts who lectured “Engineering Computation”.

  The lecture slides that I will present borrow some content from Prof Roberts.

Course Material

PDF copies of:

- These slides.
- Tutorial sheet.
- OLD lecture notes – use as a guide only!

Bonus videos on Panopto – playlist for each lecture on Canvas.

Useful material – weblinks on Canvas.

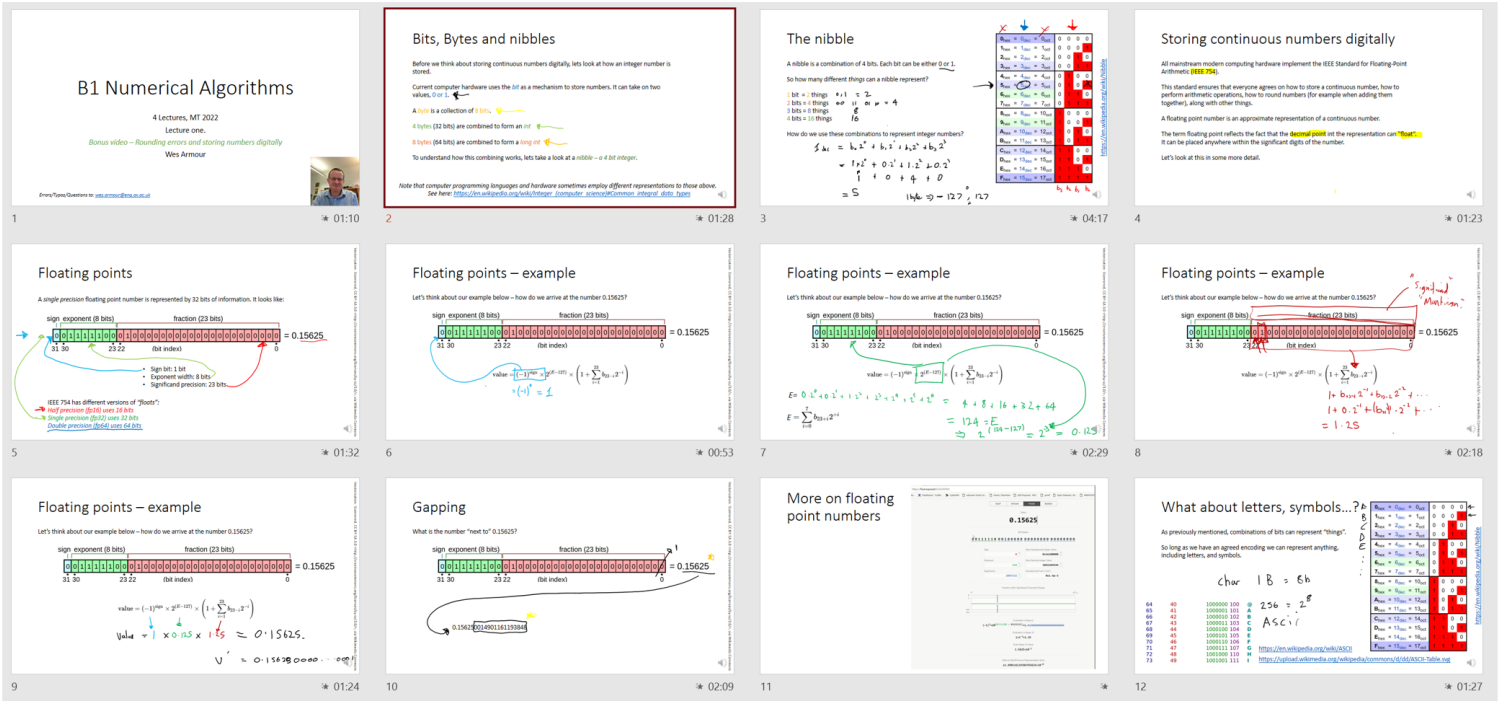
MATLAB codes used are also available on canvas.

If something is *really* not clear, and you are *really* stuck, email wes.armour@eng.ox.ac.uk

Course Material

Numerical representations and details

Panopto bonus video



Reading

- Wikipedia has some excellent material that can be extremely helpful.
- G. Wheatley, “Applied Numerical Analysis – 7th Editions”, Pearson International Edition.
- R.L Burden, J.D. Faires, “Numerical Analysis – 8th Edition”, Thomson International Student Edition.
- F B Hildebrand, “Introduction to Numerical Analysis – 2nd Edition”, Dover reprint.

The Classics…

- ❑ *Press, Teukolsky, et. al., “Numerical Recipes 3rd Edition: The Art of Scientific Computing” (2007).*
- ❑ *Froberg, “Introduction to Numerical Analysis” (2nd edition): Addison Wesley (1973).*

A hands on text…

- ❖ *Kiusalaas, “Numerical Methods in Engineering with Matlab/Python…”, Cambridge (2016).*

Learning Outcomes

- Finite difference approximations (*numerical differentiation…*) (Lecture 1)
  - forward, backward and central difference equations,
  - formulae for more than one variable,
  - formulae for higher order derivatives.

- Numerical quadrature (*also known as integration…*) (Lecture 1)
  - trapezium rule,
  - Simpson's rule,
  - sampling methods.

- Sources of error and convergence (Lecture 1)
  - round-off error,
  - truncation error,
  - order of an algorithm,
  - Taylor series analysis,

Learning Outcomes

- Function fitting and approximation (Lecture 2)
  - Linear regression,
  - polynomial regression,
  - condition number,
  - Richardson's method,
  - differentiation and noise.

- Numerical integration of ODEs (Lecture 3)
  - predictor-corrector methods,
  - modified Euler method,
  - Runge-Kutta methods,
  - adaptive step-size control (*Adams-Bashforth / Adams-Moulton).*

- Linear PDE solution by finite differences (Lecture 4)
  - Elliptic (*Laplace*),
  - Parabolic (*diffusion*),
  - Hyperbolic (*wave*).

Finally…

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I do hope you find the course interesting and enjoyable!