School of Mathematics and Statistics
MAST90026 Computational Differential Equations
2024

Course Outline

In Computational Differential Equations you will learn how to write and implement numerical solutions to a variety of problems commonly encountered in science and engineering. Understanding the behaviour of the mathematical problem gives insight into the pitfalls for the unwary in using canned packages inappropriately or uncritically.

The subject will cover different material to MAST30028. However, students with previous experience in MATLAB and numerical techniques will be better prepared than those without.

This year the course will cover numerical methods for two-point boundary value problems and for common partial differential equations in 1 and 2 spacial dimensions.

Topics will include: boundary value problems for ordinary differential equations; the solution of parabolic, hyperbolic and elliptic partial differential equations. I will introduce finite difference, finite element and spectral methods.

Prerequisites

Ability to program in something, e.g. C, MATLAB, Mathematica, Perl, Fortran, Python etc. Students should ideally have taken a subject in partial differential equations.

Classes

Monday 11AM – 1PM and Wednesday 11:00AM – 12:00PM Wilson Lab (Room G70), Peter Hall building.

Consultation hours

My consultation hours are Monday 1:15 – 2:15 PM and Wednesday 12:00 – 1:00 PM in Room 206 in Peter Hall.

Assessment

- Weekly homework problems, worth 20% in total (released on Wednesday 12:00PM in Weeks 1–4 and due on Wednesday 11:00AM in Weeks 2–5).
- Three (3) assignments, worth 20% each (released on Wednesday 12:00PM in Weeks 5, 7, 9) due on Wednesday 11:00AM in Weeks 7, 9, 11.
- One 15 minute group talk including a copy of slides provided to me, worth 20%. Held in week 12 (possibly also week 11 depending on size of class).

Lecture schedule

Starting	Content	Software	Refs.
26 Feb	BVPs I: Finite Differences (FD)		L, I
4 Mar	BVPs II: Collocation methods		S
11 Mar	BVPs III: Finite elements (FEM)		I
18 Mar	Handling nonlinearity		
25 Mar	Elliptic eq. I: FD		I
	Mid semester break (1 week)		
8 Apr	Elliptic eq. II: FEM		G
15 Apr	Iterative methods for linear systems		G, L
22 Apr	Parabolic equations I: Method of Lines (MOL)		L
29 Apr	Parabolic equations II: FD		L
6 May	Hyperbolic equations: FD		L
13 May	Evolution equations : operator splitting		L
20 May	Student talks		

References

These books go beyond the subject in coverage, and somewhat in depth however they offer a good background.

G Gockenbach, *Understanding and implementing the finite element method*, SIAM, 2006.

I Iserles, *A first course in the numerical analysis of differential equations*, 2nd ed., CUP, 2008.

L Leveque, *Finite Difference Methods for Ordinary and Partial Differential Equations: Steady-State and Time-dependent problems*, SIAM, 2007. Note: Availiable online through University Libraries.

S Jie Shen, Tao Tang, and Li-lian Wang, *Spectral methods. Algorithms, analysis and applications*, Springer Series in Computational Mathematics, 41. Springer, Heidelberg, 2011. Note: Availiable online through University Libraries.

Jesse Collis

February 2024.