Mech/Math 358
Engineering Analysis
2012-13 Term 2

Course Organization

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Office Hours: Tuesday - Thursday 12:30-1:00 and by appointment

Website: to be announced

Course Description, Prerequisites and Topics

The study of analytical and numerical solutions of ordinary and partial differential equations, with emphasis on those arising in Mechanical Engineering applications.
Prerequisites are multivariable calculus including partial differentiation and integration; linear algebra and matrix theory; a first course in ordinary differential equations; and elementary numerical analysis. A list of topics and a schedule are appended to this document.

Text

There is no required textbook for the course, but the following are recommended.

1. *Elementary Differential Equations and Boundary Value Problems* (10th ed.) W.E. Boyce & R. C. DiPrima.
2. *Applied Partial Differential Equations (with Fourier Series and Boundary Value Problems)* (4th ed.) Richard Haberman
3. Any of the zillion books with titles like "Differential Equations with Matlab". One such book is *Applied Numerical Methods with Matlab* (2nd ed.) Steven Chapra

Class Meetings, Course Assignments and Computer Labs

Two lectures/week, one computer lab every two weeks, and TA office hours. Assignments will be handed out approximately every two weeks. These will contain problems that you should work and understand before completing the computer labs. Collaboration is allowed on assignments, with the usual warning that you should be sure you understand the material even if you collaborate. *The computer labs should be done independently.* Computer labs are due at 5pm one week from the day of your section. **Note:** You will have difficulty passing the exams and the course if you don't understand the labs.

Tests

There will two midterms and a final. The midterms are scheduled for Thursday, Feb. 14th (Valentine's Day!) and Thursday, March 14th.

Grading

Assignments	10%
Computer labs	21%
Midterms (2)	23% each
Final	23%

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Syllabus

Topics Covered

1. Review of ODEs: classification; initial value, boundary value and eigenvalue problems; analytical theory

2. Review of basic concepts of numerical analysis: numerical solution of initial value problems

3. Shooting methods for boundary value problems: root finding techniques

4. Finite differences; solution of ODEs by finite differences

5. Balance Laws; derivation of the heat equation; scaling and dimensionless variables

6. Solution of heat equation by separation of variables; general considerations

7. Fourier series; formal development, orthogonality, Convergence Theorem

8. Periodic extensions of functions; Fourier sine and Fourier cosine series

9. Solving boundary value problems using Fourier series

10. Classification of partial differential equations; parabolic, elliptic and hyperbolic equations; the heat equation, Laplace and Poisson equations, the wave equation

11. Numerical solution of heat equation by finite differences; explicit methods – stability; implicit methods – Crank-Nicholson

12. Elliptic equations; derivation of Laplace's equation and Poisson equation

13. Analytical solution of Laplace's equation by separation of variables

14. Finite differences for Laplace's equation; Relaxation methods; finite difference methods for elliptic equations

15. Derivation of the wave equation; analytical solution of the wave equation; D'Alembert's solution; right and left-running waves; separation of variables

16. Numerical solution of the wave equation; finite differences, stability, the CFL condition

17. PDEs in other coordinate systems; cylindrical coordinates; spherical coordinates;

18. Bessel's equation; Bessel functions; Fourier-Bessel series

19. Eigenfunction expansions (if time allows)

20. Sturm-Liouville theory (if time allows)

MECH/MATH 358 Schedule
2012-13, Term 2

Monday	Tuesday	Wednesday	Thursday	Friday
	JAN 1	2	3 – **Lecture 1** Review of ODEs	4
7	8 – **Lecture 2** Review of Numerical analysis, numerical IVPs	9	10- **Lecture 3** Solving IVPs in Matlab. BVPs by Shooting methods	11
14 - **Matlab tutorials** **Matlab Basics** **9-11 & 11-1 (repeat)**	15- **Lecture 4** Root Finding Methods: Finite differences	16 - **Matlab tutorial** **Advanced concepts** **11-1**	17 – **Lecture 5** Finite Differences	18 - **Matlab tutorial** **Advanced concepts** **11-1**
21- **Computer Lab #1 Sections 2A & 2B** **Boundary Value Problems**	22 – **Lecture 6** Balance laws Heat equation	23- **Computer Lab #1 Section 2C** **Boundary Value Problems**	24 – **Lecture 7** Separation of variables Fourier series	25- **Computer Lab #1 Section 2D** **Boundary Value Problems**
28	29 – **Lecture 8** Fourier series	30	31 – **Lecture 9** Fourier series	FEB 1
4 - **Computer Lab #2 Sections 2A & 2B** **BVPs & Fourier Series**	5 – **Lecture 10** Intro to PDEs - classification	6 - **Computer Lab #2 Section 2C** **BVPs & Fourier Series**	7 – **Lecture 11** Finite differences for parabolic equations.	8 - **Computer Lab #2 Section 2D** **BVPs & Fourier Series**
11 – UBC Family Day	12 – **Lecture 12** Elliptic pdes – derivation of Laplace's equation	13	14 – **Lecture 13** **First Midterm**	15
18 - **Break Week**	**XXXX**	**XXXX**	**XXXX**	**XXXX**
25 **Computer Lab #3 Sections 2A & 2B** **Fourier Series and Parabolic Eqs.**	26 – **Lecture 14** Laplace's equation – solution by Fourier series	27 - **Computer Lab #3 Section 2C** **Fourier Series and Parabolic Eqs.**	28 - **Lecture 15** Finite differences for elliptic equations	MARCH 1 - **Computer Lab #3 Section 2D** **Fourier Series and Parabolic Eqs.**
4	5 – **Lecture 16** Relaxation methods	6	7 – **Lecture 17** Hyperbolic pdes – derivation of the Wave equation	8
11 **Computer Lab #4 Sections 2A & 2B** **Parabolic and Elliptic Eqs.**	12 – **Lecture 18** Wave Equation – Analytical solutions	13 **Computer Lab #4 Section 2C** **Parabolic and Elliptic Eqs.**	14 – **Lecture 19** **Second Midterm**	15 **Computer Lab #4 Section 2D** **Parabolic and Elliptic Eqs.**
18	19 – **Lecture 20** Finite differences for hyperbolic equations	20	21 – **Lecture 21** Other coordinate systems	22
25 **Computer Lab #5 Sections 2A & 2B** **Elliptic and Hyperbolic Eqs.**	26- **Lecture 22** Bessel's equation, Bessel functions	27- **Computer Lab #5 Section 2C** **Elliptic and Hyperbolic Eqs.**	28 – **Lecture 23** Fourier – Bessel series	29 **Computer Lab #5 Section 2D** **Elliptic and Hyperbolic Eqs.**
APRIL 1 – **Easter Monday**	2 – **Lecture 24** Eigenfunction expansions Sturm-Liouville theory	3	4 – **Lecture 25** Last class – Q&A	6