MATH529L
Laboratory: Mathematical methods for the physical sciences II

Course syllabus

Times	Th 3:30-5:30PM, Phillips 367
Instructor	Sorin Mitran

This course introduces computational approaches to the methods of mathematical physics. The series of laboratories is closely linked to the MATH529 course, and extends the implementations initially sketched out in the course. Historically, such methods have been developed within research in the physical sciences, but now find applicability across many fields including medical, biological and social sciences. The laboratory concentrates on:

- Introducing symbolic and numerical computation methods
- Verifying analysis of mathematical models
- Extending solution of the mathematical models by considering effect of parameter variation upon solution

Within the vast range of mathematical models, this course discusses models in which the current state of a system is known and a hypothesis is made on the way the system may change. The mathematical transcription of such a model is one or more differential equations (DEs). Assuming that students have had a first exposure to ODEs through the MATH383 prerequisite, more advanced analysis and solution methods will be discussed.

The instructor reserves the right to make changes to the syllabus. Any changes will be announced as early as possible.

Course goals

Students will acquire proficiency in the formulation and solution of physical models expressed as ODEs, systems of ODEs, and PDEs, in both real and complex numbers.

Honor Code

Unless explicitly stated otherwise, all work is individual. You may discuss various approaches to homework problems with students, instructors, but must draft your answers by yourself. In joint projects, each student will clearly identify which portions of the work they contributed.

Grading

Required work

- Homework - Best 10 assignments x 10 = 100 points. Assignments are continuation of each laboratory notebook to investigate additional questions.

Mapping of point scores to letter grades

Grade	Points	Grade	Points	Grade	Points	Grade	Points
H+,A *cum laude*	101-110	H-,B+	86-90	P-,C+	71-75	L-,D+	56-60
H+,A	96-100	P+,B	81-85	L+,C	66-70	L--,D-	50-55
H,A-	91-95	P,B-	76-80	L,C-	61-65	F	0-49

Course policies

- Students are free to establish their own schedule; there is no need to inform instructor of absences. Course attendance is highly recommended to gain insight into course topics. Repeated absences will probably lead to inability of timely homework submission.

- Late homework is not accepted.

- Homework is to be submitted electronically through Canvas

Course materials

Course topics

- Review of ordinary differential equations (ODE): first-order, classification, theory, second-order, initial and boundary value problems

- Fourier methods (FOU)

- Boundary value problems (BVP)

- Graph Laplacian (GRF)

- Polar coordinate formulations (POL)

- Spherical coordinate formulations (SPH)

- Integral transforms (TRS)

- Fast Fourier transform (FFT)

- Partial differential equations (PDE)

- Complex analysis (CPX)

Textbook

Advanced Engineering Mathematics, D. Zill, 7th edition, or *Advanced Engineering Mathematics* E. Kreyzig, Tenth edition recommended.

Class slides

Slides summarizing the main topics of each lecture or mini-lab are generally posted 48 hours prior to class time. Work through the slides while reading the associated textbook material (indicated by section numbers, e.g., §1.1-3 in the table below) before class to gain a first exposure to lecture material. Lessons contain theoretical concepts and present instructor-solved examples. In-class lab sessions are focused on active student learning of course material through problem formulation and solution. Homework extends lab topics. MATH529L further explores computational applications.

Week	Date	Topic	Thursday
01	01/11	ODE	Lab00 (.nb, .tm) §1-3
02	01/18	FOU	Lab01 (.nb, .tm) §12
03	01/25	BVP	Lab02 (.nb, .tm) §12
04	02/01	BVP	Lab03 (.nb, .tm) §13
05	02/08	BVP	Lab04 (.nb, .tm) §13
06	02/15	POL	Lab05 (.nb, .tm) §14
07	02/22	SPH	Lab06 (.nb, .tm) §14
08	02/29	TRS	Lab07 (.nb, .tm) §15
09	03/07	TRS	Lab08 (.nb, .tm) §15
10	03/21	FFT	Lab09 (.nb, .tm)
11	03/28	PDE	Lab10 (.nb, .tm) §16
12	04/04	PDE	Lab11 (.nb, .tm) §16
13	04/11	CPX	Lab12 (.nb, .tm) §17
14	04/18	CPX	Lab13 (.nb, .tm) §18
15	04/25	CPX	Lab14 (.nb, .tm) §19

Software

Modern software systems allow efficient, productive formulation and solution of mathematical models. A key goal of the course is to familiarize students with these capabilities, using the Mathematica computational package and the TeXmacs scientific editor.

- Install Mathematica for which UNC has a site license. Go to Undergraduate Library Help center if you encounter problems
- Install TeXmacs which is public domain software
- The mma Mathematica plugin for TeXmacs will be installed in class.

Tutorials

Software usage is introduced gradually in each class and miniLab session, so the first resource students should use is careful, active reading of the material posted in class. In particular, carry out small tasks until it becomes clear what the software commands accomplish. Some additional resources:

- Mathematica
  - http://www.wolfram.com/language/fast-introduction-for-math-students/en/
  - http://www.wolfram.com/wolfram-u/catalog/gen005/
  - http://www.wolfram.com/language/fast-introduction-for-programmers/en/
- TeXmacs:
  - http://www.texmacs.org/tmweb/help/tutorial.en.html
  - https://www.youtube.com/watch?v=mlcqGRv7xhc

Course material repository

Course materials (lecture notes, workbooks, homework, examination examples) are stored in a repository that is accessed through the subversion utility, available on all major operating systems. The URL of the material is http://mitran-lab.amath.unc.edu/courses/MATH529L