MATH529
Mathematical methods for the physical sciences II

Course syllabus

Times	MWF 11:15AM-12:05PM, Phillips 367
Office hours	MWF 12:30-1:15PM CP451
Instructor	Sorin Mitran
Assistant	Nerion Zakaj

This course introduces mathematical methods useful for quantitative modeling. 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 course concentrates on:

- Formulating corect mathematical models
- Analysis of mathematical models
- Solving mathematical models

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, theory 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 5 = 50 points

- Midterm examination = 10 points
- Final examination = 40 points
- Absence accomodation and/or extra credit - additional two homework assignments, 2 x 5 = 10 points

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

Examinations

- A midterm examination during normal class meeting time on We., March 6 and will consist of 5 questions, 10 points total.
- The final examination, Th., May 2, 4:00PM, will consist of 10 questions, 4 points each.

Course policies

- Class attendance is expected and highly beneficial to understanding of course topics. There is no need to inform instructor of planned absences.
- Course grade is based upon accumulation of credit points (0-100). There is no "grading on a curve". Extra credit opportunities are offered for an additional 10 grade points, to allow for missed homework or tests.
- Homework is to be submitted electronically through Canvas as Mathematica or TeXmacs documents. E-mailed homework is not accepted. Late homework is accepted only in the case of University approved class absences. Two supplementary homework assignments should provide sufficient flexibility for individual circumstances. E-mail messages requesting acceptance of late homework due to any other circumstance are deleted without review or response. Students are advised to prepare and submit homework well in advance of the Canvas deadline to allow for unforseen difficulties. Suspension of classes due to campus-wide events (weather, pandemic, etc.) will lead to modification of due dates or elimination of specific assignments for the entire class.

Accessibility resources and services. The University of North Carolina at Chapel Hill facilitates the implementation of reasonable accommodations, including resources and services, for students with disabilities, chronic medical conditions, a temporary disability or pregnancy complications resulting in barriers to fully accessing University courses, programs and activities.

Accommodations are determined through the Office of Accessibility Resources and Service (ARS) for individuals with documented qualifying disabilities in accordance with applicable state and federal laws. See the ARS Website for contact information: https://ars.unc.edu or email ars@unc.edu.

Counseling and psychological services (CAPS). CAPS is strongly committed to addressing the mental health needs of a diverse student body through timely access to consultation and connection to clinically appropriate services, whether for short or long-term needs. Go to their website: https://caps.unc.edu/ or visit their facilities on the third floor of the Campus Health Services building for a walk-in evaluation to learn more.

Title IX resources. Any student who is impacted by discrimination, harassment, interpersonal (relationship) violence, sexual violence, sexual exploitation, or stalking is encouraged to seek resources on campus or in the community. Reports can be made online to the EOC at https://eoc.unc.edu/report-an-incident/. Please contact the University's Title IX Coordinator (Elizabeth Hall, interim – titleixcoordinator@unc.edu), Report and Response Coordinators in the Equal Opportunity and Compliance Office (reportandresponse@unc.edu), Counseling and Psychological Services (confidential), or the Gender Violence Services Coordinators (gvsc@unc.edu; confidential) to discuss your specific needs. Additional resources are available at safe.unc.edu.

Course materials

Course topics

- Review of ordinary differential equations (ODE): first-order, classification, theory, second-order, initial and boundary value problems
- Orthogonal functions and Fourier series (FOU)
- Boundary value problems (BVP)
- 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, Seventh edition recommended, 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 for the Zill textbook in the table below, analogous material available in Kreyzig textbook is denoted as ♯11.1 – 3) 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		
01	01/10	ODE	Lesson01 (.nb) §1.1-4	Lesson02 (.nb) §2.1-2
02	01/17	FOU	Lesson03 (.nb) §12.1-3, ♯11.1 – 4	Lesson04 (.nb) §12.4-6, ♯11.5 – 7
03	01/24	BVP	Lesson05 (.nb) §13.1-2	Lesson06 (.nb) §13.3
04	01/31	BVP	Lesson07 (.nb) §13.4	Lesson08 (.nb) §13.5
05	02/07	BVP	Lesson09 (.nb) §13.6	Lesson10 (.nb) §13.7-8
06	02/14	BVP	Lesson11 (.nb) §14.1-2	Lesson12 (.nb) §14.3
07	02/21	SPH	Lesson13 (.nb) §15.1-3	Lesson14 (.nb) §15.4
08	02/28	TRS	Lesson15 (.nb) §15.5	Lesson16 (.nb) §15.6
09	03/06		Midterm review Practice mid-term solution	Midterm examination
10	03/20	CPX	Lesson17 §17.1-3	Lesson18 (.nb) §17.3-4
11	03/27	CPX	Lesson19 (.nb) §17.5-8	Lesson20 (.nb) §18.1
12	04/03	CPX	Lesson21 §18.2-3	Lesson22 §19.1-2
13	04/10	CPX	Lesson23 §19.3-5	Lesson24 §19.5-6
14	04/17	CPX	Lesson25 (.nb) §20.1-3	Lesson26 (.nb) §20.4-6
15	04/24	CPX	SCtoolbox.zip	Practice final examination

Homework

Homework assignments are posted through Canvas. Homework questions are classified as:

- Exercises, 0.25 points, 5 minutes
- Problems, 0.50 points, 10 minutes
- Projects, 1 point, 20 minutes

The above list shows the grade points awarded for correct solution of each question type and the time needed to draft a solution, assuming theoretical course concepts are well understood. Note that true understanding of course topics requires solution of additional questions, typically 2 to 4 times the number of those drafted as formally submitted homework. It is assumed students will do so in preparation for each homework.

Students may freely choose what questions to solve according to the rules:

- If Project questions are specified, at least one must be solved
- If Problem questions are specifiedunweighted scalar, at least two must be solved
- If Exercise questions are specified, at least four must be solved
- Solution to questions totaling 5 grade points must be presented for full credit
- Questions solved in class may not be included in submitted homework.

Questions are taken from the Zill textbook, with §12.1(p685):1-5 indicating questions 1 to 5 from exercise for section 12.1 on page 685. Questions shall also be posted to the website for users of other textbooks. Section §1.R indicates the review section for Chapter 1.

Submit homework as a Mathematica notebook HWXX.nb or TeXmacs document HWXX.tm containing computer calculations and graphics, with answers labeled as above. Modify XX to indicate homework being submitted.

Homework Template: HWXX.nb.

Nr.	Issue Date	Due Date	Topic	Exercises	Problems	Projects	Template	Solutions
01	01/17	01/24	ODE	p11:1-10	pp11-12:13-20,23-26	-	HW01.nb	
02	01/24	01/31	ODE	p725:2-6	pp727-8:2-8	p728:12-13	HW02.nb	
03	01/31	02/07	BVP					
04	02/07	02/14	BVP					
05	02/14	02/21	BVP					
06	02/21	02/28	TRF					
07	03/20	03/27	CPX					
08	03/27	04/03	CPX					
09	04/03	04/10	CPX					
10	04/10	04/17	CPX					
11	04/17	04/24	CPX					
12	04/24	04/29	CPX					

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.

- Install Mathematica (most recent version, currently 14.0) for which UNC has a site license. Go to Undergraduate Library Help center if you encounter problems.
- Download the course stylesheet file UNC.nb, and set it as the default.

- Install TeXmacs.

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/MATH529