MATH 551: APPLIED PARTIAL DIFFERENTIAL EQUATIONS AND COMPLEX VARIABLES
FALL 2019 SYLLABUS

Instructor/Office: Jeffrey Wong (Physics 029B)

Office Hours: See course website for updated office hours

Class times/location: T/Th 3:05-4:20, Physics 259. Dates: **Aug. 27** to **Dec. 6**.

Course Website: Math 551-01 Sakai Site; Piazza site

Textbook: Haberman, *Applied Partial Differential Equations with Fourier Series and Boundary Value Problems*, 5th edition.

Course objectives: We will cover the essential analytical methods for solving linear partial differential equations and boundary value problems, with a focus on the types of problems that arise in the context of physical modeling and engineering. By the end of the course, you should be equipped with the knowledge and intuition required to solve and (more importantly) understand solutions to problems you may encounter in practice or in numerical simulation.

Prerequisites: The basics of Fourier series and ordinary differential equations (at the level of the typical undergraduate course). We will briefly review Fourier series at the start of the course. Comfort with the fundamental concepts of linear algebra (eigenvalues/vectors, linear operators and so on) is essential.

Exams and Grading: Your grade will be based on the following components:

- Weekly homework (see below)
- Midterm: Two in-class midterm exams (dates TBA).
- Final exam: The final exam will be held on **Dec. 13** from 7-10 PM.
- Exams are closed book and closed notes; a 'cheat sheet' will be allowed

Homework:

- Homework will be assigned weekly, except before midterms and the final exam. Due dates will be listed on the assignment; typically one week after assigned.
- Homework must be turned in by the deadline to receive full credit (barring exceptional circumstances for extensions as per Duke policy). If you miss a deadline, you should still complete the homework and turn it in for feedback (this, more than the numerical score, is the point of the assignments!).
- Working and studying in groups is strongly encouraged. However, you should write your own solutions to each problem in your own words.

- Solutions should be complete arguments. For long solutions with many calculations, keep your work organized and make sure there is a clear logic to the steps. Be thorough, but strive for clarity without extraneous work.
- Typing solutions (in LaTeX) is suggested; if handwritten, make sure solutions are readable. Keep problems in the same order as the assignment, if possible.

Ethics: Students are expected to follow the Duke Community Standard. If a student is found responsible for academic dishonesty through the Office of Student Conduct, the student will receive a score of zero for that assignment. If a student's admitted academic dishonesty is resolved directly through a faculty-student resolution agreement approved by the Office of Student Conduct, the terms of that agreement will dictate the grading response to the assignment at issue.

Schedule

The goal is to cover (at least) all the topics listed. A schedule will be posted to the course website. Chapter numbers refer to the textbook (Haberman), but may not correspond exactly to the material we actually cover.

- **Review:** Linear algebra (for vectors and functions) and Fourier series, leading into Section II (Ch. 3).
- **Part I (eigenfunctions, BVPs and PDEs):** Boundary value problems: Sturm-Liouville operators, eigenvalue problems, and solving BVPs using eigenfunction expansions (Ch. 5). Using this framework to solve boundary value problems and three important PDEs - the heat equation and Laplace's equation (Ch. 2), and the wave equation (Ch. 4). Separation of variables and its limitations; inhomogeneous problems (Ch. 8).
- **Part II (integral equations and Green's functions):** Solving integral equations. Green's functions for boundary value problems, distributions and delta functions (Ch. 9).
- **Part III (multi-dimensional PDEs):** PDEs in more than one dimension, e.g. cylindrical and spherical geometries using the techniques of Section II; common eigenvalue problems - spherical harmonics, Bessel functions (Chapter 7). Time permitting: Structure of the Laplacian and non-separable problems (Ch. 7, parts of Ch. 9).
- **Part IV (Complex variables)**: complex functions, evaluating contour integrals and important results (residue theorem, dealing with singularities).
- **Part V(transform methods)**: Fourier and Laplace transforms and their applications to solving PDEs (and ODEs). Problems on infinite domains using transforms. (Chapters 11 and 13)