APMA 0360: Partial Differential Equation
Spring Semester 2018

Short course description: This course follows on from APMA0350 - Applied Ordinary Differential Equations, which covers examples of ordinary differential equations, classification of their structure and methods of solution, including solving systems of linear equations. APMA0360 assumes this background and covers examples of where partial differential equations (PDE) arise, their structure and methods for solving them. Examples will come from the physical and biological sciences as well as economics. APMA1330 is available as a follow-up course for those who wish to pursue the topics further.
If you have taken APMA0330, you should continue on with APMA0340.

Instructor and TAs:
Jérôme Darbon
182 George Street (Applied Mathematics), room 221
E-mail: `jerome_darbon@brown.edu`
Office hours: Tuesdays: noon-2:00pm and Thursdays: noon-2:00pm. (provisional for now)

Graduate TA:
Ernesto Caceres-Valenzuela
Email: `ernesto_caceres_valenzuela@brown.edu`
Office hours: TBA

Undergraduate TA:
Ari Goldbloom-Helzner
Email: `ari_goldbloom-helzner@brown.edu`
Office hours: TBA

Scheduled meeting times:
Tuesdays and Thursdays 10:30-11:50am in Foxboro Auditorium, Kassar House, 135 Thayer St.
Recitation: TBA

The lectures are the primary means of instruction. These will be related to sections in the textbook or other references, but will expand on the topics we are covering. You will be expected to follow up on the lectures with reading and examples. You are welcome to ask questions. I am also likely to ask the class questions during a lecture.

At the recitation, Ernesto will present examples, which he may demonstrate himself or ask the participants as a group to work through in discussion. The recitations are intended to be more interactive and flexible than the lectures. The recitations are an opportunity to discuss topics that have been covered in class.

Prerequisites
Calculus, including series, multivariable functions and vector calculus at the level of MATH0180, MATH0200 or MATH0350; linear algebra or matrix methods at the level of MATH0520; ordinary differential equations at the level of APMA0350 or equivalent.

Course website: We will use Canvas for the class. Homework, solutions to homework, announcements, complementary material and additional information can be found there.

Textbook:
J.D. Logan - Applied Partial Differential Equations, 3 rd edition, Springer (2015) This is a required text for the course. It is available to students as an e-book through the Science Library, see `https://search.library.brown.edu/catalog/b7375379`

Course topics (not necessarily in linear order)

- Differentiability of functions of several variables; mathematical terminology of continuous or bounded functions and open, closed or bounded domains. Review of Greens theorem and results from vector calculus.
- Examples of partial differential equations and their formulation; conservation laws, oscillatory waves, heat conduction or chemical diffusion, diffusion and random processes, electrostatics.
- Solution methods and examples for first-order PDEs.
- Classification of second-order PDEs and standard forms; boundary conditions and initial conditions; well-posed problems.
- Solutions of some standard linear second-order PDEs in unbounded domains; transform methods.
- Solutions for some standard linear second-order PDEs on bounded domains; Fourier series, separation of variables, Sturm-Liouville problems and eigenfunctions with specific examples.
- More examples of PDEs drawn from physical sciences, biology and mathematical economics with background explanations.
- Introduction to numerical methods for solving PDEs (using Matlab).

Homework: Weekly problem sets that involve readings, pencil-and-paper math problems, and computer programming. Homework will include both theoretical and computational (i.e. those requiring computer programming) problems. More precisely, HW will generally require to do the mathematical analysis (using methods covered in class) of an optimization problem which gives an numerical algorithm to solve it and to implement this algorithm. Homework will typically be due each Friday before 12:00pm. Late HW will not be accepted or graded, because I plan to hand out HW solutions shortly after HW has been collected.

Learning Goals
By the end of the course, students will be expected to recognize how PDEs arise as quantitative models of physical, biological or other systems, and even develop new models. We use these mathematical models to understand how phenomena are related and to make quantitative predictions of outcomes. We will see that seemingly unrelated systems yield similar PDEs and we can develop a classification scheme for them. These standard features, especially for linear problems, will enable us to come up with solution strategies. Even if a full solution is not possible, we will know if a system is well-posed. For example, are the boundary conditions or initial conditions appropriate for the problem to have a well-defined answer?

The course will prepare students for more advanced courses that may look in more depth at the underlying mathematical theory, or numerical methods for solving PDEs. The theory that we cover will arise naturally in context. The course should provide students with the background to work with partial differential equations as they may arise in other undergraduate courses.

Required course activities and expected times:
Scheduled class meetings (these continue in the Reading Period): 3 hours/week; 39 hours
Reading and reviewing class work: 3 hours/week; 39 hours
Weekly assignments: 5 hours/week for 12 weeks; 60 hours
Recitations: 1.5 hours/week for 12 weeks; 18 hours
Preparation for two mid-term tests: 10 hours
Final exam and preparation: 18 hours
Total expected time: 184 hours

There will be **weekly** assignments based on questions arising out of the course. The assignments will be posted on Canvas and will be due by **noon** on Fridays. They must be submitted in the indicated drop box (box number 11) on the first floor of 182 George Street. Your submission should be a single stapled packet with your legible written answers arranged in order with the questions on the problem sheet. Be sure to give your name and assignment number on the top page.
Show your work for a calculation this means you should display the process used not just state a final result. For a question given as Show that ... you should write a complete argument.
You may discuss assignments with other students, but you must write up your own answer independently. When you have collaborated with other students, please acknowledge this by adding a note such as "I discussed question X with A and B."
The assignments are meant to be part of the learning process and are not tests as such. Allow adequate time and start them well in advance of the due date. Some answers may not come to you immediately but then become clear a day later. If you are stuck though, seek help from office hours, via email or discussing with other students. Finally if you are not able to complete a question write a short note to describe what you tried and what you think may be important. Credit on assignments will come from a serious effort as much as anything else.
No late assignments will be accepted. This is so that we can promptly post solutions for the class to view. Your two lowest homework scores will be dropped. This is intended to address cases of routine illness or other short-term disruption. Students presenting a Deans note related to missing assignments will be required to use these two drops, with further accommodations for longer disruptions.

There will be **two in-class tests**, scheduled for Tuesday February 27, 2018 and Thursday April 8, 2018. No notes, books, or calculators may be used in these tests. The tests will cover topics covered in the period prior to the test.

There will be a scheduled final exam on Monday, May 14, 2018 at 2.00 p.m (Exam Group 09). This will cover the full scope of the course. The aim is to assess the skills and knowledge developed over the course of the semester.

Evaluation:
Grades will be based on the assignments (20%), the two in-class tests (40%) and final exam (40%). Attendance and participation will be considered as an additional factor which may be used to resolve borderline grades.

Further notes
It is requested of all students that they review the Brown Academic Code, available here: `https://www.brown.edu/academics/college/degree/policies/academic-code`.

Collaboration on homework and especially on discussion of relevant topics outside of class is encouraged, as note already. It often helps students to work together on portions of homework assignments. However, each individual must turn in his or her own solutions or write-ups, which should not be identical copies of their classmates. Tests and final exams are individual assessments of a student's ability.

Accessibility and inclusion
Brown University is committed to full inclusion of all students. Please inform me early in the term if you have a disability or other conditions that might require accommodations or modification of any of these course procedures. You may speak with me after class or during office hours. For more information, please contact Student and Employee Accessibility Services at 401-863-9588 or `SEAS@brown.edu`.

Students in need of short-term academic advice or support can contact one of the deans in the Dean of the College office.
Counseling and Psychological Services are available if you feel too stressed, have test anxiety, or for any other reason would like to speak to a counselor. For information, see `https://www.brown.edu/campus-life/support/counseling-and-psychological-services/`.