AMATH 353 Partial Differential Equations 1 Spring 2022
Course Information Sheet

Instructor: Brydon Eastman,
Office: MC 6131,
Email: b2eastma@uwaterloo.ca,
Lecture times: MWF 11:30 - 12:20, RCH 204,
Tutorial times: M 16:00 - 17:20, MC 4058,
Office hours: WF 14:30 - 15:30, MC 6131

Teaching assistant: Martin Diaz Robles,
Email: mfdiazro@uwaterloo.ca
Office hours: Th 10:30-11:30am, MC 6407

Prerequisites: A sound background in Calculus and elementary ODEs is essential. In particular, students should be familiar with elementary methods for solving ODEs and comfortable with the concepts of vector fields, line and surface integrals, Green's theorem, divergence theorem, and Stokes' theorem.

Description: Second order linear partial differential equations - the diffusion equation, wave equation, and Laplace's equation. Methods of solution - separation of variables and eigenfunction expansions, the Fourier transform. Physical interpretation of solutions in terms of diffusion, waves and steady states. First order non-linear partial differential equations and the method of characteristics. Applications are emphasized throughout. The following topics will be covered:

1. *Creation of PDEs:* Conservation laws, constitutive relations, differential operators
2. *Linear PDEs:* Classification of linear PDEs
3. *Diffusion:* Heat conduction in 1, 2, and 3 dimensions, chemical diffusion
4. *Separation of Variables:* Eigenvalues and Eigenfunctions
5. *Wave Equation:* Vibrating strings and membranes
6. *Laplace's Equation:* Sturm-Liouville Problems, Rayleigh Quotient, Completeness
7. *Fourier Transforms:* Infinite Domains
8. *Quasilinear PDEs:* Method of Characteristics, Greens Functions, etc.

Learning Outcomes By the end of this course students should be able to:

- Classify the types of partial differential equations into various groups: (linear, quasi-linear, non-linear, elliptic, parabolic, hyperbolic, etc.)

- Select appropriate solution methods for a particular problem and develop a solution using either method of characteristics, separation of variables, Fourier methods, or Sturm-Liouville expansions.
- Qualitatively interpret solutions to PDEs (including transient and asymptotic behaviour)
- Develop PDEs to explain real world phenomena

References: 1) *Course Notes on Partial Differential Equations 1 Methods in Applied Mathematics*, Poulin, Francis J. PDF version is on course webpage.
2) *Applied PDE with Fourier Series and Boundary Value Problems*, Haberman, R., Fourth Edition 2004
3) *Applied Partial Differential Equations*, Logan, J. David

While none of these texts are required, we will be following Francis Poulin's notes closely (and references will be given to the appropriate portion of the text). Students often find Haberman's text to be a useful reference (and occasional references to the text will be made).

Outline:

- Week 1-2 (May 2 - May 13): Modelling with PDEs. Assignment due May 18. Chs 1-2 of Poulin.
- Week 3-4 (May 16 - May 27): PDEs in Bounded Domains. Assignment due June 1. Ch 4 of Poulin.
- Week 5-6 (May 30 - June 10): PDEs in Bounded Domains. Assignment due June 15. Midterm covering weeks 1-6 on June 27. Ch 4 of Poulin.
- Week 7-8 (June 13 - June 24): PDEs in Bounded Domains. Assignment due ~~July 6~~ **July 8**. Ch 4 of Poulin.
- Week 9-10 (June 27 - July 8): PDEs in Unbounded Domains. Assignment due ~~July 20~~ **July 22**. Ch 5 of Poulin.
- Week 11-12 (July 11 - July 25): Quasi-linear PDEs + Presentations Ch 3 of Poulin.

Web Page: A course web page can be found at: http://learn.uwaterloo.ca

Final Grade: 30% Assignments, 10% Project, 20% Midterm Exam, 40% Final Exam.

Assignments: There will be 5 assignments throughout the course due on May 18th, June 1st, June 15th, ~~July 6th~~ **July 8th**, and ~~July 20th~~ **July 22nd** at 5:00 PM. Late assignments will be accepted with a 10% per hour late penalty. Assignments need to be submitted electronically to Crowdmark. It is your responsibility to ensure that your solutions are well organized, legible, and correctly uploaded.

Midterm Test: The **midterm** test will be held during the tutorial time on **Monday, June 27th** and will cover the content from Weeks 1 to 6.

Final Exam: The date of the final exam is TBD. The final exam will be cumulative. More information will be posted on Learn following the midterm.

Final Project: Students will work in teams of 3 to 5 for a course project. For the project, teams will study an example of a PDE application that has not been covered in class. Every team must present a short report and a 10 minute presentation of the application, modelling, and method of solution (which very well may be numerical). Students must form their groups and submit a proposed topic before the midterm (June 27th). More information will be posted on Learn following the midterm.

Academic Integrity: In order to maintain a culture of academic integrity, members of the University of Waterloo community are expected to promote honesty, trust, fairness, respect and responsibility. [Check the Office of Academic Integrity for more information.]

Grievance: A student who believes that a decision affecting some aspect of their university life has been unfair or unreasonable may have grounds for initiating a grievance. Read Policy 70, Student Petitions and Grievances, Section 4. When in doubt, please be certain to contact the department's administrative assistant who will provide further assistance.

Discipline: A student is expected to know what constitutes academic integrity to avoid committing an academic offence, and to take responsibility for their actions. [Check the Office of Academic Integrity for more information.] A student who is unsure whether an action constitutes an offence, or who needs help in learning how to avoid offences (e.g., plagiarism, cheating) or about "rules" for group work/collaboration should seek guidance from the course instructor, academic advisor, or the undergraduate associate dean. For information on categories of offences and types of penalties, students should refer to Policy 71, Student Discipline. For typical penalties, check Guidelines for the Assessment of Penalties.

Appeals: A decision made or penalty imposed under Policy 70, Student Petitions and Grievances (other than a petition) or Policy 71, Student Discipline may be appealed if there is a ground. A student who believes they have a ground for an appeal should refer to Policy 72, Student Appeals.

Note for Students with disabilities: AccessAbility Services, located in Needles Hall, Room 1401, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with AccessAbility Services at the beginning of each academic term.

Mental Health Support: The Faculty of Math encourages students to seek out mental health support if needed.

On-campus Resources

- Campus Wellness
- Counselling Services or 519-888-4567 ext. 32655
- MATES: one-to-one peer support program offered by Fedartion of Students and Counselling Services.
- Health Services service: located accross the creek from Student Life Centre, 519-888-4096

Off-campus Resources

- Good2Talk (24/7): Free confidential help line for post-secondary students. Phone: 1-866-925-5454
- Here 24/7: Mental Health and Crisis Service Team. Phone: 1-844-437-3247
- OK2BME: set of support services for lesbian, gay, bisexual, transgender or questioning teens in Waterloo. Phone: 519-884-0000 extension 213

Diversity: It is our intent that students from all diverse backgrounds and perspectives be well served by this course, and that students' learning needs be addressed both in and out of class. We recognize the immense value of the diversity in identities, perspectives, and contributions that students bring, and the benefit it has on our educational environment. Your suggestions are encouraged and appreciated. Please let us know ways to improve the effectiveness of the course for you personally or for other students or student groups. In particular:

- We will gladly honour your request to address you by an alternate/preferred name or gender pronoun. Please advise us of this preference early in the semester so we may make appropriate changes to our records.
- We will honour your religious holidays and celebrations. Please inform us of these at the start of the course.
- We will follow AccessAbility Services guidelines and protocols on how to best support students with different learning needs.