MATH*4270
Advanced Partial Differential Equations
Fall 2022

UNIVERSITY of GUELPH

(Revision 1: August 30, 2022)

For information on current safety protocols, follow these links: https://news.uoguelph.ca/return-to-campuses/how-u-of-g-is-preparing-for-your-safe-return/
https://news.uoguelph.ca/return-to-campuses/spaces/#ClassroomSpaces

Please note, these guidelines may be updated as required in response to evolving University, Public Health or government directives.

DISCLAIMER:

Please note that the ongoing COVID-19 pandemic may necessitate a revision of the format of course offerings, classroom schedules, and academic schedules. Any such changes will be announced via CourseLink and/or class email. This includes on-campus scheduling during the semester, mid-terms, and final examination schedules. All University-wide decisions will be posted on the COVID-19 website https://news.uoguelph.ca/2019-novel-coronavirus-information/ and circulated by email.

1 Instructional Support

1.1 Instructor

Kimberly M. Levere, Ph.D.
Office: MacN 539, ext. 56908
Email: klevere@uoguelph.ca
Office hours: Tuesdays 1:30pm – 2:30pm, Location: MACN*539
Fridays 11:00am – 12:00pm, Location: MACN*539

1.2 Teaching Assistant

Harrison (Harry) Tieman

2 LEARNING RESOURCES

2.1 Course Website

Course material, news, announcements, and grades will be regularly posted to the MATH*4270 Courselink website. You are responsible for keeping up-to-date on this site.

2.2 Required Resources

K. Levere, *MATH*4270 – Partial Differential Equations Course Manual 2nd Edition)*, available at the MacNaughton Book Store. This is the primary resource for the course and functions both as the textbook, and as a notebook that we will complete together in class as the course progresses. It can be purchased as a printed copy only. Please be sure that you have the current version, the 2nd edition, (only available in the MacNaughton bookstore) as I have made very significant changes since the last edition. Remember that this resource is protected by copyright and is not to be sold or redistributed in any form.

2.3 Recommended Resources

Not applicable.

2.4 Additional Resources

Lecture Information: All lectures will be delivered entirely face-to-face, in person. Lectures will not be recorded or streamed. Given the changes made to the course manual this year, I do not have existing lecture videos to offer. Completed lecture notes will be uploaded to the course website at the end of every week. It is, however, strongly recommended that you attend every class.

Other: Supplementary questions and other resources may be posted on the Course website as needed. Again, it is important that you check regularly to keep up-to-date.

2.5 Communication & Email Policy

Please use office hours and Courselink discussion forums as your main opportunity to ask questions about the course. Major announcements will be posted to the course website. **It is your responsibility to check the course website regularly.** As per university regulations, all students are required to check their <uoguelph.ca> e-mail account regularly: e-mail is the official route of communication between the University and its students.

2.6 Online Behaviour and Etiquette

Online Behaviour:
Inappropriate online behaviour will not be tolerated. Examples of inappropriate online behaviour include:
• Posting inflammatory messages about your instructor or fellow students
• Using obscene or offensive language online
• Disrupting a class/office hour by discussing entirely unrelated content to that of MATH*4270
• Copying or presenting someone else's work as your own
• Adapting information from the Internet without using proper citations or references
• Buying or selling term papers or assignments
• Posting or selling course materials to course notes websites
• Having someone else complete your quiz or completing a quiz for/with another student
• Making false claims about lost quiz answers or other assignment submissions
• Threatening or harassing a student or instructor online
• Discriminating against fellow students, instructors or TAs
• Using the course website to promote profit-driven products or services
• Attempting to compromise the security or functionality of the learning management system
• Sharing your username and password
• Recording lectures without the permission of the instructor

Any student that does not conduct themselves in an appropriate manner in any online lecture or office hour session will be issued a penalty of a 0.5% deduction on their final grade. This will apply each time inappropriate online conduct occurs. Please be kind to each other and conduct yourself with maturity and professionalism.

Disclaimer: Student Identity Disclosure in Recordings

The university has requested that I include the following disclaimer regarding recorded materials. While I don't anticipate the use of any videos or recordings as our class will be run entirely face-to-face, I want to ensure that we are prepared in the case that the pandemic pushes us in this direction.

By enrolling in a course, unless explicitly stated and brought forward to their instructor, it is assumed that students agree to the possibility of being recorded during lecture, seminar or other "live" course activities, whether delivery is in-class or online/remote.

If a student prefers not to be distinguishable during a recording, they may:

1. turn off their camera
2. mute their microphone
3. edit their name (e.g., initials only) upon entry to each session
4. use the chat function to pose questions.

Students who express to their instructor that they, or a reference to their name or person, do not wish to be recorded may discuss possible alternatives or accommodations with their instructor.

3 ASSESSMENT

3.1 Dates and Distribution

Your grade will be determined using the following grading scheme:

Assessment	Weight
Academic Misconduct Quiz	1%
Written Assignments (total of 3)	30% (10% each)
Term Test 1**	25%
Term Test 2**	25%
LaTeX Practice Assignments (total of 2)	4% (2% each)
Project	15%

*There is NO final exam for this course. I had originally requested a final exam from central booking but ended up changing the assessment structure to the above breakdown.

**You must receive at least 50% of the marks available, in total, on the term tests that are used to calculate your final grade. That is,

(Total marks earned on term test 1 & 2) ÷ (Total marks available on term test 1 & 2) ≥ 50%

If you do not achieve this, your maximum possible final grade will be 48%, *no matter what grade you receive on the Written Assignment and Project components*. Provided that you satisfy the above equation, your final grade will be calculated using the above listed grading scheme. Considerations may be made according to the policies listed in Section 3.2.

For example: suppose that Kevin receives 20/30 on term test 1, and 26/45 on term test 2. The above calculation for Kevin would be:

(20+26) ÷(30+45)=0.61

Since this is greater than 0.50, Kevin is eligible to pass, and his grade will be calculated according to the weighted grading scheme listed above (including his assignment marks).

On the other hand, suppose that Luke receives 13/30 on term test 1, and 20/45 on term test 2. Then for Luke:

(13+20) ÷(30+45)=0.44

Since this is less than 0.5, Luke would be awarded a maximum grade of 48% (his grade would be calculated according to the weighted grading scheme above but would then be capped at 48%).

Written Assignments: There will be 3 written assignments each contributing 10% to your final mark. The questions for each assignment will be posted on Courselink at least one week in advance of their due date and will cover the previous few weeks of material. While you may work together to think about these problems, your solutions should be composed individually. Your full solutions will be due to the Gradescope system according to the list of dates below

Assessment	Due on
Written Assignment 1	Wednesday, September 28 @1:00pm EST
Written Assignment 2	Wednesday, October 19 @1:00pm EST
Written Assignment 3	Wednesday, November 16 @1:00pm EST

Academic Misconduct Quiz: I think that written assignments are a fabulous learning tool and one that I've had students tell me that they enjoy when it comes to assessments. One of my biggest concerns with assignments is academic integrity. The fact is, there are a huge number of online resources and softwares out there that have the capability to give you the answers you need to complete written assignments. **This is not how I intend written assignments to be completed.** Remember that these assignments are here to help you learn and obtain feedback on your thought processes. They are also a response to requests from past students that have identified assignments as an assessment preference (perhaps because they induce less stress than a proctored test, for instance). I expect that you are taking this course because you are interested in the content and/or to meet a requirement of your degree. Hopefully, that alone is motivation enough to **do things honestly and without the use of any of these online tools or softwares**! It is therefore my expectation that **assignments will not be a source for academic misconduct**.

To ensure that everyone fully understands what academic misconduct is, I ask that you read the documentation on this subject on the University of Guelph website found here:

https://calendar.uoguelph.ca/undergraduate-calendar/undergraduate-degree-regulations-procedures/academic-misconduct/

After reading about Academic misconduct, you'll be required to complete a quiz that tests your understanding. This quiz will be completed in Courselink and you will have unlimited attempts (your highest score will count as your mark). You must complete this quiz with a grade of 80% or higher before any assessments are submitted for grading (that is, prior to September 23rd at noon). Failure to do so will result in a grade of 0% on any assessments that occur prior to you mastering this quiz.

Term Test 1: Thursday, October 27, 2022 (Week 7)
5:30pm-7:00pm
Location: Science Complex, Room 2315
Closed book, closed resource, independent
Content: TBA

Term Test 2: Thursday, November 24, 2022 (Week 11)
5:30pm-7:00pm
Location: Science Complex, Room 2315
Closed book, closed resource, independent
Content: TBA

*Should face-to-face instruction be shut down at any point by the administration, any assessments completed during such a shutdown will be proctored via Zoom according to the schedule above. Please ensure that you have a working web camera should we need to run assessments in this way.

Project: due Monday, December 5th by 11:00am to the Gradescope system.

A 12-week course can be rather restrictive, especially when it comes to a course like PDEs! There is SO much more to learn than what we will be able to cover together in this course. I have focused the course notes primarily on solution techniques that can be done by hand. In some ways, this is misleading since the vast majority of PDEs that you'll run into in research or otherwise will NOT be solvable by hand. PDEs get complicated very quickly! In these cases, you'll need to use a numerical method to help you to approximate the solution. I want you to have experience with this side of PDEs, as well as to gain some useful skills with academic writing and software.

The final project for MATH*4270 is to write Chapter 12 of our course manual: An Introduction to Numerical Solutions to Partial Differential Equations. Your project should represent about 1 week of lecture notes. Please submit a pdf that closely resembles the style of our course manual (with blanks 😊) that explains at least some aspects of numerical solutions to PDEs. This is a VERY broad area and one that I think you'll find in a lot of textbooks and online resources. Do not feel that you need to explain every little thing about this topic (that would be impossible!). Instead, think about where your PDEs knowledge is right now and what would be a natural level to learn about in our course. Include an explanation of the method(s) that you choose to cover and how it/they work(s) as well as examples (it might be cool to do an example that we CAN do by hand so that we can compare the true solution to the approximate one that you find using the method(s) that you teach). Since a typical week of classes gets us through about 20-25 pages of fill-in-the blank notes, you should ensure that you do not exceed this page limit. This page limit may be a big challenge to stay within, but I think it will help you to remain concise and not do too much. Your notes should be created using LaTeX (I'll be posting some help on how to do this as well as some tips and tricks as you learn this language). I think it is super useful to learn how to type-set in LaTeX, especially if you intend to do graduate school in the future. It isn't too tough and there are lots of helpful resources online as you learn the ropes. You may find that using a mathematical software to implement your method(s) is helpful. I'm open to this, but please include in your submission a copy of your code as a separate file. I wouldn't recommend including this in your lecture notes (since computer coding was not part of this course) but you can feel free to do a few steps by hand and then report the results that software finds in your lecture notes. A detailed bibliography should be included so that it is clear where you learned about the techniques that you are teaching (not only those that you pull info from, but even those that you just read to learn from; websites, books, etc.). Your final submission should include the

blank lecture notes as well as the "completed" lecture notes. This is supposed to be fun and help you to build your own writing voice. Please do not leave this to the last minute as you have a few skills to develop here, and they won't all come together overnight. You may work on this in a group of two or on your own.

LaTeX Practice Assignments: These mini assignments serve as a way to help you to practice the type-setting skills that you'll need for the project component of the course. Using resources that I provide, as well as content that you research online, you will be asked to typeset a few short pages that showcase different skills (mathematical symbols, tables, bibliography and referencing, etc.) You will be asked to submit the pdf that you create as well as the LaTeX source code (.tex) that you create. These can be completed any time during the semester but must be submitted to the Gradescope system no later than **Friday, November 4th, 2022 at noon**.

3.2 Course Grading Policies

Academic Consideration: When you find yourself unable to meet an in-course requirement because of illness or compassionate reasons, please advise the course instructor in writing, with your name, ID number, and e-mail contact. See the academic calendar for information on regulations and procedures for Academic Consideration:

https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-ac.shtml

Illness: Medical notes will not normally be required for singular instances of academic consideration, although students may be required to provide supporting documentation for multiple missed assessments or when involving a large part of a course (e.g. final exam or major assignment).

Accommodation of Religious Obligations: If you are unable to meet an in-course requirement due to religious obligations, please email the course instructor at the start of the semester to make alternate arrangements. See the undergraduate calendar for information on regulations and procedures for Academic Accommodation of Religious Obligations: http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-accomrelig.shtml

Missed assessments: Missed, assignments or term tests will receive a grade of 0%, unless they are missed due to any of the above reasons, in which case the weight of the missed assessment will be added to the final exam. There will be no makeup term tests, or assignments.

Passing grade: In order to pass the course, you must receive a final grade of at least 50%. Additionally, in order to pass this course, you must receive at least 50% of the marks available collectively, on the midterm and final exam that are used to calculate your final grade. If you do not achieve this, your maximum possible final grade will be 48%.

Group Work: You are encouraged to work together to learn the course material and complete For You to Try exercises. All quizzes, term tests and the final exam are individual assessments and must be completed independently.

Copies of out-of-class assignments: Keep paper and/or other reliable back-up copies of assignments, homework, and your midterm. You may be asked to submit this work at any time.

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4 AIMS, OBJECTIVES & GRADUATE ATTRIBUTES

4.1 Calendar Description

This course focuses on first and second-order partial differential equations, with examples and applications from selected fields such as physics, engineering and biology. Topics may include the wave equation, the heat equation, Laplace's equation, linearity and separation of variables, solution by Fourier series, Bessel, Legendre and Green's functions, an introduction to the method of characteristics and Fourier transforms. The classification of linear second-order partial differential equations is discussed.

Credit Weight: 0.5 **Department:** Mathematics & Statistics **Campus:** Guelph

Prerequisite: MATH*3100 (MATH*2200 strongly advised)

4.2 Course Aims

This is a first course in partial differential equations (PDEs). The lecture material includes theoretical content and derivations of important equations used to model real-world phenomena. More applied content that explains solution techniques and graphical explanations of the physical meaning of these solutions acts to balance the course content and to put the theory into practice. The objective of the course is to give you a strong mathematical background for mathematical modelling using PDEs as well as to teach you about various solution techniques (both closed-form and numerical if time permits) for handling basic through to more involved problems.

4.3 Learning Objectives

At the successful completion of this course, the student will have demonstrated the ability to:

1. Classify a PDE according to order, and type (elliptic, parabolic, hyperbolic, etc.)
2. Understand the derivations of common PDEs such as the heat and wave equations.
3. Solve a PDE using separation of variables.
4. Understand the limitations of separation of variables.
5. Solve variations of the heat and wave equations such as nonhomogeneous or periodic boundary conditions, or the presence of source/sink terms.
6. Use the method of eigenfunction expansion to solve PDEs.
7. Understand the limitations of eigenfunction expansion.
8. Understand Fourier series, even and odd extensions and convergence results.
9. Be able to physically interpret what a basic PDE models.

10. Be able to represent, graphically, solutions to heat and wave equations.
11. Extend above knowledge to higher order heat and wave equations.
12. Use d'Alembert's solution to solve a wave equation.
13. Understand the method of characteristics (and its limitations) for solving PDEs.
14. Understand Fourier transforms and how they can be used to solve PDEs (including limitations).

4.4 Instructor's Role and Responsibility to Students

As your instructor, I must:

1. Develop and deliver course material in a professional way that facilitates learning for a variety of students and learning styles.
2. Provide lectures, filling in the course notes as we proceed in each lecture. I will provide corresponding completed course notes on Courselink, but I strongly urge you to attend class.
3. Respond to you. This includes, as time permits, questions during office hours, or through email (where I reserve the right to reply within a timeframe of 1-2 days). You are more than welcome to contact me at any time through these means if you have questions or concerns about the course or the course material.
4. Evaluate you fairly, and fairly as compared to your peers, providing prompt feedback on your performance and justification for your grade. I must provide academic consideration, where appropriate, as described in Section 3.

4.5 Students' Learning Responsibilities

As a member of this class, you are expected to:

1. Take advantage of the learning opportunities provided during lectures;
2. Treat others with respect and dignity whenever you address them;
3. Genuinely attempt all homework in a timely manner, including the online quizzes and the practice questions on your own time;
4. Seek help if you have tried the homework and are still having difficulty with the course content. This means contacting me (*not* just at the last minute!) and possibly considering other resources as I recommend them to you;
5. Check all grades against assessments that have been returned to you, once they are posted to the Course website, to verify that the correct mark has been recorded;
6. Notify me, as described in Section 3, in the case that there are missed assessments or academic conflicts that are known in advance. If illness, work, or extra-curricular activities are causing you to struggle, you are advised to keep me up-to-date on your progress, so that I can be more helpful to you.

5 TEACHING AND LEARNING ACTIVITIES

5.1 Timetable

Lectures (in-person)

Tuesday	11:30am – 12:20pm	MINS*037
Thursday	11:30am – 12:20pm	MINS*037

5.2 Lecture Schedule

(schedule is approximate and subject to change depending on time constraints)

Lectures (Week)	Lecture Topics	References
1	Introduction & Preliminaries	Chapter 1
	The Heat Equation	Chapter 2
2	Separation of Variables	Chapter 3
3	Separation of Variables	Chapter 3
	Sturm-Liouville Theory	Chapter 4
4	The Heat Equation Revisited	Chapter 5
5	The Heat Equation Revisited	Chapter 5
	Fourier Series	Chapter 6
6	Fourier Series	Chapter 6
	Solution Techniques for Nonhomogeneous Problems	Chapter 7
7	Solution Techniques for Nonhomogeneous Problems	Chapter 7
	The Wave Equation	Chapter 8
8	The Wave Equation	Chapter 8
	D'Alembert's Solution to the Wave Equation	Chapter 9
9	D'Alembert's Solution to the Wave Equation	Chapter 9
10	D'Alembert's Solution to the Wave Equation	Chapter 9
	The Method of Characteristics	Chapter 10
11	Solving PDEs on Unbounded Spatial Domains	Chapter 11
12	Solving PDEs on Unbounded Spatial Domains	Chapter 11

5.3 Other Important Dates

First day of classes: Thursday, September 8th, 2022.
Thanksgiving: Monday, October 10th, 2022 (no classes; rescheduled to Friday, December 2nd)
Fall Study Day: Tuesday, October 11th, 2022 (no classes; rescheduled to Thursday, December 1st)

Last day of classes: Friday, December 2nd, 2022.

Drop Date: Courses that are one semester long must be dropped by the end of the last day of classes (**Friday, December 2nd, 2022)**; two-semester courses must be dropped by the last day of classes in the second semester. The regulations and procedures for Dropping Courses are available in the Undergraduate Calendar. https://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-drop.shtml

Course Evaluation Information: Near the end of the term, you will be given the opportunity to evaluate your instructor and provide comments regarding your experience. The evaluations for this class will be done in-class. Your instructor will inform you of when these are to take place.

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6 ACADEMIC MISCONDUCT

The University of Guelph is committed to upholding the highest standards of academic integrity and it is the responsibility of all members of the University community faculty, staff, and students to be aware of what constitutes academic misconduct and to do as much as possible to prevent academic offences from occurring. University of Guelph students have the responsibility of abiding by the University's policy on academic misconduct regardless of their location of study; faculty, staff and students have the responsibility of supporting an environment that discourages misconduct. Students need to remain aware that instructors have access to and the right to use electronic and other means of detection.

Please note: Whether or not a student intended to commit academic misconduct is not relevant for a finding of guilt. Hurried or careless submission of assignments does not excuse students from responsibility for verifying the academic integrity of their work before submitting it.

Students who are in any doubt as to whether an action on their part could be construed as an academic offence should consult with a faculty member or faculty advisor.

6.1 Resources

The Academic Misconduct Policy is detailed in the Undergraduate Calendar:
http://www.uoguelph.ca/registrar/calendars/undergraduate/current/c08/c08-amisconduct.shtml

A tutorial on Academic Misconduct produced by the Learning Commons can be found at:
http://www.academicintegrity.uoguelph.ca/

7 ACCESSIBILITY

The University promotes the full participation of students who experience disabilities in their academic programs. To that end, the provision of academic accommodation is a shared responsibility between the University and the student.

When accommodations are needed, the student is required to first register with Student Accessibility Services (SAS). Documentation to substantiate the existence of a disability is required, however, interim accommodations may be possible while that process is underway.

Accommodations are available for both permanent and temporary disabilities. It should be noted that common illnesses such as a cold or the flu do not constitute a disability.

Use of the SAS Exam Centre **requires students to book their exams at least 14 days in advance, and no later than November 1**. Similarly, new or changed accommodations for online quizzes, tests and exams must be approved at least a week ahead of time
More information: www.uoguelph.ca/sas

8 RECORDING OF MATERIALS

Presentations which are made in relation of course work – including lectures – cannot be recorded or copied without the permission of the presenter, whether the instructor, classmate or guest lecturer. Material recorded with permission is restricted to use for that course unless further permission is granted.

Posted online videos and course notes are the property of the instructor and are not to be otherwise disseminated beyond this course.

9 RESOURCES

The Academic Calendars are the source of information about the University of Guelph's procedures, policies and regulations which apply to undergraduate, graduate and diploma programs.

http://www.uoguelph.ca/registrar/calendars/index.cfm?index

10 MENTAL HEALTH RESOURCES

One out of every five students in Canada experiences some sort of mental health issue at some point in their academic career. If you find yourself facing a mental health crisis, or just need to talk to someone, please consider taking advantage of one of the following resources available to University of Guelph students:

Counselling Services: Visit the Counselling Services website (https://wellness.uoguelph.ca/counselling) to get information on resources available to you, both online and in-person. You can also visit them at Health Services (J.T. Powell Building, ext 53244) where they offer individual and group counselling sessions by appointment or walk-in.
Student Support Network: is located in the Wellness & Education Promotion Centre in the J.T. Powell Building and offers confidential, peer-based, drop-in support.

Good2Talk: (1-866-925-5454) is a free, 24/7 student hotline that provides professional counselling and referrals for mental health, addictions and well-being.

Here 24/7: (1-844-437-3247) specializes in assessment, referral and appointment booking and is available 24/7 for crisis support.

You are not alone and you will not be judged for asking for help.