ENGPHYS 2CM4
Computational Multiphysics
Undergraduate Studies
Fall/Winter 2021/22
Course Outline

Current as of Thu 2021-08-19 15:19:29; see the course Forum for the most up-to-date version of this document

CALENDAR/COURSE DESCRIPTION

Mathematical modelling and computational multiphysics for engineering design synthesizing E&M, thermodynamics, statics, dynamics, and quantum mechanics.
Three lectures, one lab (two hours each); second term

PRE-REQUISITES AND ANTI-REQUISITES

Prerequisite(s): ENGPHYS 2P04, MATH 2Z03, and credit or registration in ENGPHYS 2A04 and MATH 2ZZ3
Antirequisite(s): None

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Matt Minnick
BSB/B106
minnick@mcmaster.ca
ext. 24546

Office Hours:
All the time asynchronously via the course forum
Live via course forum during class time
Use the forum! :-)

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

See the Course Forum for TA info

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

Course Forum: Microsoft Teams

COURSE INTENDED LEARNING OUTCOMES

Upon successful completion of the course, you will be able to

1. look at any real world problem and tackle it using mathematical modelling (meaning that you understand how to apply the theory in your math & physics courses in a real-world context, and understand how to use modern tools to make the process more efficient than not mathematically modelling),
2. see the links between the physics content in mechanics, electromagnetics, heat transfer, fluid mechanics, quantum mechanics, and solid state physics in a way that lets you understand all areas more strongly, and
3. use scripting languages to automate computational tasks: e.g. setting up, running, and analyzing simulations.

MATERIALS AND FEES

COMPUTER:

Students should have a desktop or laptop capable of simultaneously running FlexPDE, Maple, and Microsoft Word (Windows machines are recommended, price point of $300 or up should be fine). You will be required to use this for all deliverables in the course.

SOFTWARE:

Python, newest stable release (free online), FlexPDE Student Version (free online), Maple (Version 15 or higher), MS Word (2007 or newer), MS Teams (current version).

REFERENCE TEXTS:

-[Required] Course notes (free online)

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows.
Resources:
-Lecture notes & examples (online)
-Worked Example Practice Problems (online)
-Course videos explaining the notes & some practice problems each week (on YouTube)
-The forum, where you can get help from me, the TAs, and each other

Students are expected to regularly review the forum for new information and participate in the learning community it establishes by asking (and where possible answering) questions there.

FORMAT OF CONTENT WEEKS

The course is divided into **five** topics (each lasting two weeks) followed by an independent design project:

1. Course intro and Advanced Dynamics Problems with Scripting
2. Heat transfer (understanding PDEs and vector calculus in general; flux etc.)
3. E&M in dielectrics and conductors
4. Thermal Expansion and Piezoelectrics, reminding of the structure and Voigt notation basics to deal with piezoelectricity, and beam bending.
5. Beam resonance and eigenvalue analysis
6. Design project: computational multiphysics (design project using mathematical modelling to design a solution to a potential engineering design problem. Can include content from any and all earlier areas, but is *not* just an extensive HX.2 like the 2P final project. See detailed description below)

The schedule for each two-week topic (for the 10 weeks before the design project) is as follows (all meetings are on Teams):

1. Monday 1730 Lecture → Live lecture introing the topic
2. Wednesday 1730 Lecture → time to watch the video - live office hours.
3. Thursday 1730 Lecture → time to do practice problems - live office hours. *Prepare to be able to do practice problems yourself to get ready for the first Lab.*
4. Friday 1430 Lab

   a. Meet with your TA who will run a practice problem session, introing the problem and helping you along, sending you to breakout rooms with other students to work on it.
   b. You'll submit a write-up of the practice problem: **HX.1**. "Due" at 1620, but can be submitted as late as 2359 without penalty if something goes wrong.
5. Monday 1730 Lecture → Live Review Lecture for topic
6. Wednesday 1730 Lecture → Live office hours
7. Thursday 1730 Lecture → Time to finalize **HX.2** (creating and solving your own practice problem on the week's content)- (live office hours are available)
   a. Practice problem HX.2 is "due" at 1820 (but can be handed in as late as 2359)
8. Friday 1430 Lab:
   a. Meet with your TA; TA will have picked two of the best HX.2s for the group to tackle: half the group will tackle one of them and the other half will tackle the other one (if your problem was one of the two picked you'll be in the half doing the other problem!)
   b. Work on the solution to the problem and a reflection of the whole topic to hand in as **HX.3**, "due" at 1620 (can be submitted as late as 2359 without penalty if something goes wrong).

RUBRICS FOR CORE CONTENT TOPICS HOMEWORK

Homework 1 (HX.1): Example of solving a problem enabled by this topic (started off by TA in the first lab of each 2-week block. "due" at the end of that lab but can be handed in as late as the end of the day without penalty):

Solved the problem correctly /5
Used their own solution /5
Explained their process and thinking /5
Reflect on and explain the meaning of the answer (not just a number - look back and say what it means and why) /10
Formatting and clarity /5

Homework 2 (HX.2): Created practice problem ("due" at the end of the last class before each lab, but can hand it in as late as the end of that day)

Problem:
Unambiguous and clearly explained (using diagrams where necessary) problem: /10
Clearly and appropriately aligned within the weeks' content: /10

Solution:
Solved the problem correctly /5
Used their own solution /5
Explained their process and thinking /5
Reflect on and explain the meaning of the answer (not just a number - look back and say what it means and why) /10

Formatting and overall clarity /10

Homework 3 (HX.3): solve a peer's problem assigned by the TA and reflect on the whole two weeks (work on during the lab; can and should work together to understand the problem as well as possible, as long as you hand in an individual solution. "Due" at the end of the lab, but if something goes wrong you can submit it as late as the end of the day)

Peer problem:

Solved the problem correctly /5
Used their own solution /5
Explained their process and thinking /5
Reflect on and explain the meaning of the answer (not just a number - look back and say what it means and why) /10
Formatting and clarity /5
Reflection on topic:
Explain: What do you feel are the most important concepts of this topic and why? /10

FORMAT AND RUBRICS FOR DESIGN PROJECT

Design project weeks are instructor office hours every lecture and TA live coaching time during the lab for help on the topics.

Task: Select a hypothetical (or real if possible) engineering design decision that you'd like to make which requires mathematical modelling, and model it (i.e., using python scripting of a FlexPDE simulation of it to find the optimum value of a parameter [or parameters] for your particular design). You'll deliver an extensive report on the design project, as well as a 3-5 minute video and a live presentation on it to your TA for Q&A on its content.

Report Deliverables (all page length estimates include figures, which are often expected)

1. 1-3 pages: Explanation of the background of the particular application you're designing something for, including explaining the constraints and thing to optimize (e.g., maximize or minimize what subject to what?)
2. 2-5 pages: Explain the background of the physics you're going to use to solve the problem
3. 2-5 pages: Explain incorporating the model into FEM software and testing a known case and how results scale with changing your parameter(s) to verify that it makes sense
4. 2-8 pages: Explain how you scripted running the model and show how it zeroed in on the optimum design choice.
5. 1-3 pages: Discuss the results and their meaning for your modelling question
6. ? pages: References (use IEEE journal article or similar style for citations).
7. Digitally submit full code used as separate files.

Report marks (60% of the project grade) are based on how clearly and concisely you present a report that satisfies these criteria, how extensively you've applied computational multiphysics to solve a substantially challenging problem, the accuracy, believability, and insightfulness of your analysis, and the overall joy to read as an engineering report.
Modeling problem & goals description: /5
Background physics: /8
Programming and testing the model: /10
Optimization and results: /10
Discussion and final meaning: /5
Presentation & Formatting: /5
Overall impression: /10

Tips:
When writing, emphasize clarity - it's much more important to be clear about what you mean than it is to be formal (e.g., passive voice and even avoiding first-person isn't required)

Rather than "A thermal strap will be used to cool an on-board computer system."
Or "A thermal strap has been used to cool an on-board computer system."
This is better because it's much more clear: "In this design project I want to design a thermal strap to cool an on-board computer system."

Read the NIST formatting guide and incorporate it into your equation writing:
https://physics.nist.gov/cuu/Units/checklist.html
Use a reference manager like Zotero https://www.zotero.org/

Video: (20% of the final project grade)
Clearly explained and well-formed design problem: /5
Clearly explained solution approach: /5
Solution makes clear use of mathematical modelling: /5
Mathematical modelling approach is clearly valid: /5
Solutions are clearly presented: /5
Clear reflection on solution and its meaning in the context of the problem: /5
Video is engaging and polished: /5

Live Discussion: (20% of the final project grade)
Professionalism: /5
Project quality in light of discussion: /5
Project knowledge present: /5
Clearly demonstrated mastery of content: /10

Self-Reflection Surveys

At the start, middle, and end of the course students also submit a self-reflection survey to aid in their experiential learning. These surveys are required and due on certain dates. Surveys ask students to rate their current achievement level towards GA indicators and form one measurement of student achievement of those indicators (since student opinion of their abilities is highly correlated with their abilities).

Participation Bonus

Participation in the course is key to success so to help you maximize your engagement in all aspects of the course there is an up-to-10% participation course weight replacement option. i.e., if your participation is excellent you'll get 10%; if it's good you'll get 7%, if it's OK you'll get 3%, and if it's poor you'll get 0%. Whatever % you get, it will replace that amount of your final grade with a 100% mark. e.g.,
Excellent participation: Grade = 10% + 90%*(rest of course grade)
OK participation: Grade = 3% + 97%*(rest of course grade)
Poor participation: Grade = rest of course grade (i.e., normal grading)

There are several ways to positively participate including:

1. Asking (and especially answering) meaningful honest questions in the forum to the best of your ability

2. Consistently attending classes and labs and positively participating (including having your camera on, working with groups in labs to tackle the content together, etc.)
3. Offering (and obtaining) live peer help in the class forum

You don't necessarily need to participate in all possible ways to achieve "good" or even "excellent" participation.

COURSE SCHEDULE

Date	Topic	Due	Daily Activity
Mon 10 Jan	Advanced Dynamics Problems with Scripting		Live Lecture
Wed 12 Jan			Watch Video & Live office hour
Thu 13 Jan			Live Office Hour & Practice Problems
Fri 14 Jan		H1.1+S1	Lab for TA Problem
Mon 17 Jan			Review Lecture
Wed 19 Jan			Live Office Hour
Thu 20 Jan		H1.2	Time to Finish Assignment
Fri 21 Jan		H1.3	Peer Problem Test Lab
Mon 24 Jan	Heat Transfer		Live Lecture
Wed 26 Jan			Watch Video
Thu 27 Jan			Live Office Hour & Practice Problems
Fri 28 Jan		H2.1	Lab for TA Problem
Mon 31 Jan			Review Lecture
Wed 2 Feb			Live Office Hour
Thu 3 Feb		H2.2	Time to Finish Assignment
Fri 4 Feb		H2.3	Peer Problem Test Lab
Mon 7 Feb	E&M		Live Lecture
Wed 9 Feb			Watch Video
Thu 10 Feb			Live Office Hour & Practice Problems
Fri 11 Feb		H3.1+S2	Lab for TA Problem
Mon 14 Feb			Review Lecture
Wed 16 Feb			Live Office Hour
Thu 17 Feb		H3.2	Time to Finish Assignment
Fri 18 Feb		H3.3	Peer Problem Test Lab
Mon 21 Feb	***Mid-term Recess***		
Wed 23 Feb			***Review PDEs of statics from 2P04***
Thu 24 Feb			***Review Flexure from 2P04***
Fri 25 Feb			***Review Voight Notation from 2P04***

Date	Topic	Due	Daily Activity
Mon 28 Feb	Thermal Expansion & Piezoelectrics		Live Lecture
Wed 2 Mar			Watch Video
Thu 3 Mar			Live Office Hour & Practice Problems
Fri 4 Mar		H4.1	Lab for TA Problem
Mon 7 Mar			Review Lecture
Wed 9 Mar			Live Office Hour
Thu 10 Mar		H4.2	Time to Finish Assignment
Fri 11 Mar		H4.3	Peer Problem Test Lab
Mon 14 Mar	Beam Resonance & Eigenvalue Analysis		Live Lecture
Wed 16 Mar			Watch Video
Thu 17 Mar			Live Office Hour & Practice Problems
Fri 18 Mar		H5.1	Lab for TA Problem
Mon 21 Mar			Review Lecture
Wed 23 Mar			Live Office Hour
Thu 24 Mar		H5.2	Time to Finish Assignment
Fri 25 Mar		H5.3	Peer Problem Test Lab
Mon 28 Mar	Final Design Project		Live Office Hours
Wed 30 Mar			Live Office Hours
Thu 31 Mar			Live Office Hours
Fri 1 Apr		TCM1	**TA Consultation Meeting #1**
Mon 4 Apr			Live Office Hours
Wed 6 Apr			Live Office Hours
Thu 7 Apr			Live Office Hours
Fri 8 Apr		TCM2	**TA Consultation Meeting #2**
Mon 11 Apr	Design Project "Due"	DP & S3	Live Office Hours; **Submit final project & reflection survey**
Wed 13 Apr			Classes over!
Fri 15 Apr	(last day to submit the project)*		

*The design project is "Due" at the end of the last class at 1120 on Monday April 11th, but can be submitted as late as Friday April 15th at 23:59 without penalty.

ASSESSMENT

Assessment Item	Each	Number	Total
HX.1	2%	5	**10%**
HX.2	6%	5	**30%**
HX.3	4%	5	**20%**
Self Reflections	1%	3	**3%**
Final Design Project Coaching Meetings	3%	2	**6%**
Final Design Project	31%	1	**31%**
Participation			Special bonus
Grand Total			**100%**

ACCREDITATION LEARNING OUTCOMES

The Learning Outcomes defined in this section are measured for Accreditation purposes only and will not be directly taken into consideration in determining a student's grade in the course.

Outcomes	Indicators
Can examine an engineering problem in any field and decide how to optimally tackle it with programming, with a CAS like Maple, and/or with FEM like with FlexPDE	04.1 - Recognizes and follows an engineering design process.(This means an iterative activity that might include recognizing the goal, specifying the constraints and desired outcomes, proposing solutions, evaluating alternatives, deciding on a solution, and implementing.)
Is able to successfully propose creative solutions for open-ended design projects	04.4 - Employs appropriate techniques for generation of creative ideas such as brainstorming and structured inventive thinking.
Demonstrates dedication to truly engineering solutions to meaningful problems in final design project	08.1 - Demonstrates an understanding of the role of the engineer in society, especially in protection of the public and public interest.
Able to seek external resources and extend course knowledge to solve exciting problems leveraging all tools available	12.1 - Critically evaluates and applies knowledge, methods and skills procured through self directed and self identified sources, including those that lie outside the nominal course curriculum.

For more information on Accreditation, please visit: https://www.engineerscanada.ca

EQUITY, DIVERSITY, AND INCLUSION

Every registered student belongs in this course. Diversity of backgrounds and experiences is expected and welcome. You can expect your Instructor to be respectful of this diversity in all aspects of the course, and the same is expected of you.

The Department of Engineering Physics is committed to creating an environment in which students of all genders, cultures, ethnicities, races, sexual orientations, abilities, and socioeconomic backgrounds have equal access to education and are welcomed and treated fairly. If you have any concerns regarding inclusion in our Department, in particular if you or one of your peers is experiencing harassment or discrimination, you are encouraged to contact the Chair, Associate Undergraduate Chair, Academic Advisor or to contact the Equity and Inclusion Office.

PHYSICAL AND MENTAL HEALTH

For a list of McMaster University's resources, please refer to the Student Wellness Centre.

ACADEMIC INTEGRITY

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity. **It is your responsibility to understand what constitutes academic dishonesty.**

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university. For information on the various types of academic dishonesty please refer to the *Academic Integrity Policy*, located at https://secretariat.mcmaster.ca/university-policies-procedures-guidelines/

The following illustrates only three forms of academic dishonesty:

1. plagiarism, e.g. the submission of work that is not one's own or for which other credit has been obtained.
2. improper collaboration in group work.
3. copying or using unauthorized aids in tests and examinations.

COURSES WITH AN ON-LINE ELEMENT

McMaster is committed to an inclusive and respectful community. These principles and expectations extend to online activities including electronic chat groups, video calls and other learning platforms.

Some courses may use on-line elements (e.g. e-mail, Avenue to Learn (A2L), LearnLink, web pages, capa, Moodle, ThinkingCap, etc.). Students should be aware that, when they access the electronic components of a course using these elements, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in a course that uses on-line elements will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure, please discuss this with the course instructor.

CONDUCT EXPECTATIONS

As a McMaster student, you have the right to experience, and the responsibility to demonstrate, respectful and dignified interactions within all of our living, learning and working communities. These expectations are described in the *Code of Student Rights & Responsibilities* (the "Code"). All students share the responsibility of maintaining a positive environment for the academic and personal growth of all McMaster community members, **whether in person or online**.

It is essential that students be mindful of their interactions online, as the Code remains in effect in virtual learning environments. The Code applies to any interactions that adversely affect, disrupt, or interfere with reasonable participation in University activities. Student disruptions or behaviours that interfere with university functions on online platforms (e.g. use of Avenue 2 Learn, WebEx or Zoom for delivery), will be taken very seriously and will be investigated. Outcomes may include restriction or removal of the involved students' access to these platforms.

ACADEMIC ACCOMMODATION OF STUDENTS WITH DISABILITIES

This course has been universally-designed and has pre-included resources normally requiring academic accommodations into its design universally for everyone. In particular,
-All course content is delivered via both written notes and captioned videos explaining them, and
-Course assessments directly target essential requirements and allow all resources you would reasonably be expected to have in your career when doing similar tasks.
Because of this universal course design and true assessments of essential requirements, in most cases further academic accommodations are unnecessary, and students will not need to even identify to the instructor via SAS that they normally have any accommodation needs. However, it is possible that extreme circumstances could warrant additional accommodations in some regard this course design does not account for, in which case students should contact Student Accessibility Services (SAS) at 905-525-9140 ext. 28652 or sas@mcmaster.ca to make arrangements with a Program Coordinator. For further information, consult McMaster University's *Academic Accommodation of Students with Disabilities* policy.

COURSE POLICY ON MISSED WORK, EXTENSIONS, AND LATE PENALTIES

It is the students' responsibility to regularly check the course forum for updates and announcements. Under normal circumstances, missed deadlines correspond to a reduction in grade as per the assessment section.

SUBMISSION OF REQUEST FOR RELIEF FOR MISSED ACADEMIC WORK

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar "Requests for Relief for Missed Academic Term Work".

1. Relief for missed academic work worth less than 25% of the final grade resulting from medical or personal situations lasting up to three calendar days:
   - Use the McMaster Student Absence Form (MSAF) on-line self-reporting tool. No further documentation is required.
   - Students may submit requests for relief using the MSAF once per term.
   - An automated email will be sent to the course instructor, who will determine the appropriate relief. Students must immediately follow up with their instructors. Failure to do so may negate the opportunity for relief.
     - **a.** Normal MSAF policy for 2CM4 is a no-penalty 3-day extension on the deliverable, meaning you can hand it in up to 72 hours later than it was originally due (not the grace period, just the original due date) without deduction.
     - b. Relief on the final design project report & video (3-day grace period extension to Friday April 16th) has been pre-allocated to everyone - further relief is not possible under normal circumstances.
   - The MSAF cannot be used to meet a religious obligation or to celebrate an important religious holiday.
   - The MSAF cannot be used for academic work that has already been completed or attempted.
   - An MSAF applies only to work that is due within the period for which the MSAF applies, i.e. the 3-day period that is specified in the MSAF; however, all work due in that period can be covered by one MSAF.

- The MSAF cannot be used to apply for relief for any final examination or its equivalent. See *Petitions for Special Consideration* above.

2. For medical or personal situations lasting more than three calendar days, and/or for missed academic work worth 25% or more of the final grade, and/or for any request for relief in a term where the MSAF has been used previously in that term:
   - Students must report to their Faculty Office to discuss their situation and will be required to provide appropriate **supporting documentation**.
   - If warranted, the Faculty Office will approve the absence, and the instructor will determine appropriate relief.

Normal MSAF policy for 2CM4 is a no-penalty 3-day extension on the deliverable, meaning you can hand it in up to 72 hours later than it was originally due (not the grace period, just the original due date) without deduction.

ACADEMIC ACCOMMODATION FOR RELIGIOUS, INDIGENOUS OR SPIRITUAL OBSERVANCES (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the RISO policy. Students should submit their request to their Faculty Office ***normally within 10 working days*** of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

COPYRIGHT AND RECORDING

Students are advised that lectures, demonstrations, performances, and any other course material provided by an instructor include copyright protected works. The Copyright Act and copyright law protect every original literary, dramatic, musical and artistic work, **including lectures** by University instructors

The recording of lectures, tutorials, or other methods of instruction may occur during a course. Recording may be done by either the instructor for the purpose of authorized distribution, or by a student for the purpose of personal study. Students should be aware that their voice and/or image may be recorded by others during the class. Please speak with the instructor if this is a concern for you.

EXTREME CIRCUMSTANCES

The University reserves the right to change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc.). Changes will be communicated through regular McMaster communication channels, such as McMaster Daily News, A2L and/or McMaster email.