

Engineering Physics  
ENGPHYS 2CM4  
Computational Multiphysics  
*Winter 2025*



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**ENGINEERING**

### Instructor Information

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**Office Hours:**

Wednesdays 10-12, NRB B120 and on MSTeams

### TA Information

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## Class Times

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Timeslot	Activities	
Lecture	- Watch recordings - Group discussion of topics - Tutorial on a practice problem	1:30-2:20 Mondays, Wednesdays, and Thursdays
Lab	- Project work / additional help	8:30-11:30 Thursdays

## Class Format

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In Person is preferred for tutorials.

We will be adopting the *Flipped Classroom* approach and aiming to keep to the reserved class times.

- Lectures will be prerecorded for students to get the information:  
<https://www.youtube.com/@ENGPHY2CM4>
- The 'lecture' timeslot becomes a tutorial for students to assimilate the lesson through group discussion and practice problems.
- The 'Lab' timeslot will be available for project work.

This approach aligns with the Engineering Synthesis theme of this class, placing the onus of learning on the students. Students are encouraged to bring topics from their other classes or activities to model, and will be supported in doing so.

**Course Dates:** 01/06/2025 - 04/08/2025

**Units:** 4.00

**Course Delivery Mode:** In Person

**Course Description:** Mathematical modelling and computational multiphysics for engineering design synthesizing E&M, thermodynamics, statics, dynamics, and quantum mechanics. Three lectures, one lab (three hours); second term Prerequisite(s): ENGPHY 2CD4, 2P04, MATH 2Z03, and credit or registration in ENGPHY 2A04 and MATH 2ZZ3

## Instructor-Specific Course Information

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Communication: MSTEams Channel

Project submission and grade tracking: <https://avenue.mcmaster.ca/>

## Important Links

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- [Mosaic](#)
- [Avenue to Learn](#)
- [Student Accessibility Services - Accommodations](#)
- [McMaster University Library](#)
- [eReserves](#)

[COMSOL Multiphysics learning centre](#)

[Multiphysics Modeling Using COMSOL 5 and MATLAB](#)

[COMSOL for engineers](#)

[Modelling Organs, Tissues, Cells and Devices Using MATLAB and COMSOL Multiphysics](#)

## Course Learning Outcomes

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- Understand the nature of real-world engineering and physics problems.
- Deduce the relevant physical phenomena present in the problem.
- Couple physics together to model the behaviour of the whole system.

- Use modern computational tools to simulate the system.
- Complete engineering-design with computer-aided parameterization, sensitivity analysis and optimization.
- Professionally communicate the results of your engineering analysis via reports, presentations, and/or demos.

## Graduate Attributes

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The Canadian Engineering Accreditation Board (CEAB) is a division of Engineers Canada and is responsible for accrediting undergraduate engineering programs across Canada. Accreditation by the CEAB ensures that the engineering programs meet a national standard of quality and cover essential educational requirements. Graduate Attributes are a set of qualities and skills that the CEAB expects engineering graduates to possess. These attributes are a benchmark for the learning outcomes of accredited engineering programs. This section lists the Graduate Attribute Indicators associated with the Learning Outcomes in this course.

## Lab Safety

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As this is a computer-lab, please consider ergonomics during prolonged use: [Laptop ergonomics video](#)

## Course Schedule

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Pragmatically, we will develop the skill of computational multiphysics modelling through practical examples on specific topics. In actuality, all concepts are applicable to all topics.

The order of concepts covered and their linked topics are subject to change as the course is developed and feedback is incorporated.

Week	Topic	Concepts
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Week	Topic	Concepts
1	Introduction to COMSOL Multiphysics	COMSOL model process, geometry creation, meshing, physics, solving, visualization.
2	Heat/mass/charge diffusion	Parameterization of models, dissipative processes, boundary conditions, solver settings, visualization.
3	Solution methods	Time-stepping, probes, coupling variables, parametric sweeps, sensitivity analysis, PDE-constrained optimization.
4	Momentum (Fluid dynamics)	Lagrange / Eulerian frames of reference, momentum diffusion, moving meshes, advanced solving schemes.
5	Elasticity	Infinitesimal / large deformation formulations, hyperelasticity, anisotropy, nullspace elimination
6	Multiphysics coupling	Mixing physical timescales, segregated solvers, variable scaling
Midterm break		
7	Electromagnetism	Wave propagation, skin-effects, vector calculus, skin effects
8	Phase change	Lumped properties, sharp interface, phase-field, nanotechnology
9	Acoustics / Quantum	Eigenvalue problems, resonance, modal analysis
10	Particle / ray tracing	Ray tracing, radiative transport, discrete ordinates method, ray optics
11	Particle / ray tracing	Ray tracing continued.
12	Advanced COMSOL topics	Application builder, Weak form, Weak constraints (Lagrange multipliers)
13	Design project	

## Required Materials and Texts

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**Textbook Listing:** <https://textbooks.mcmaster.ca>

### **Software: COMSOL Multiphysics®**

Freely available to course participants as a 'Class kit'. Follow directions in MSTeams > General > Files> COMSOL installation > Installation instructions.docx

### **Computer**

Suggested hardware requirements for COMSOL Multiphysics® 6.2

- A working network card and internet connection for installation
- At least 4 GB of RAM
- 2–20 GB of disk space, depending on your licensed products and installation options
- The following processors:
  - An Intel® or AMD® 64-bit processor based on the Intel® 64 or AMD64 architecture with the SSE4 instruction set
    - Intel® processors released in 2009 or later and AMD® processors released in 2012 or later satisfy this requirement.
  - Apple silicon processors (M1 and later); supported with macOS
  - ARM64 processors; supported with Linux®

In addition, Adobe Acrobat® Reader is required to view and print the COMSOL documentation in PDF format.

## Course Evaluation

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10 x Tutorial comprehension questions - 1% each - Spot-check on your progress

- Comprehension / modification question on the daily tutorial problem.
- Performed in the lecture timeslot upon request
- 1 attempt per tutorial. Repeatable.

- At least 5 attempts by the end of week 7.

4 x Group design projects - 15% each - Evaluate team work, report writing, and understanding

- Randomly assigned groups of 4-5, assigned topic
- Full report style - Introduction, Model development, Implementation, Analysis / validation, Discussion / conclusions
- Following the initial submission, you will be provided feedback and an opportunity to revise for half the value.
- Confidential peer-review

Individual design project - 30% - Evaluate individual ability for project proposal and report writing

- Propose an individual project
- Generate a report as with the group projects
- Optional presentation / demonstration
- **A passing mark (50%) on this report is required for your passing this course.**

## Grading Scale

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The McMaster 12 Point Grading Scale

Grade	Equivalent Grade Point	Equivalent Percentages
A+	12	90-100
A	11	85-89
A-	10	80-84
B+	9	77-79
B	8	73-76
B-	7	70-72
C+	6	67-69
C	5	63-66
C-	4	60-62

Grade	Equivalent Grade Point	Equivalent Percentages
D+	3	57-59
D	2	53-56
D-	1	50-52
F	0	0-49

## Late Assignments

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10% off the report mark per day unless otherwise cleared by the professor.

## Absences, Missed Work, Illness

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You are expected to conduct yourself in a professional manner.

- If you have a planned absence, notify your group members and make arrangements.
- If you are 'ill' on the last day of your report and didn't contribute anything beforehand, this is obviously suspect. This will be reflected in your peer evaluation mark, and should be flagged to the professor by your group.

The individual design project report is mandatory.

## Generative AI: Unrestricted Use

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Students may use generative AI throughout this course in whatever way enhances their learning; no special documentation or citation is required.

Your participation in periodic discussions on GenAI is welcome.

## APPROVED ADVISORY STATEMENTS

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### **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](https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/), located at <https://secretariat.mcmaster.ca/university-policies-proceduresguidelines/>

The following illustrates only three forms of academic dishonesty:

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

## **Courses with an On-line Element**

***Some courses may*** use on-line elements (e.g. e-mail, Avenue to Learn, 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.

## **Online Proctoring**

***Some courses may*** use online proctoring software for tests and exams. This software may require students to turn on their video camera, present identification, monitor and

record their computer activities, and/or lock/restrict their browser or other applications/software during tests or exams. This software may be required to be installed before the test/exam begins.

## **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.

## **Equity, Diversity, and Inclusion**

The Faculty of Engineering 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 Faculty, 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](#).

## **Academic Accommodation of Students with Disabilities**

Students with disabilities who require academic accommodation must contact [Student Accessibility Services](#) (SAS) at 905-525-9140 ext. 28652 or [sas@mcmaster.ca](mailto:sas@mcmaster.ca) to make

arrangements with a Program Coordinator. For further information, consult McMaster University's [Academic Accommodation of Students with Disabilities](#) policy.

### **Academic Advising**

For any academic inquires please reach out to the Office of the Associate Dean (Academic) in Engineering located in JHE-Hatch 301.

Details on academic supports and contact information are available from:

<https://www.eng.mcmaster.ca/programs/academic-advising>

### **Requests for Relief for Missed Academic Term Work**

In the event of an absence for medical or other reasons, students should review and follow the [Policy on Requests for Relief for Missed Academic Term Work](#).

### **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, Avenue to Learn and/or McMaster email.