

**ENGPYHS 2CM4
Computational Multiphysics
Undergraduate Studies
Winter 2023
Course Outline**

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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): ENGPYHS 2CD4, 2P04, MATH 2Z03, and credit or registration in ENGPYHS 2A04 and MATH 2ZZ3
Antirequisite(s): None

INSTRUCTOR OFFICE HOURS AND CONTACT INFORMATION

Dr. Matt Minnick ext. 24546
BSB/B106 Office Hours: TBA
minnick@mcmaster.ca

TEACHING ASSISTANT OFFICE HOURS AND CONTACT INFORMATION

See the course forum for TA info

COURSE WEBSITE/ALTERNATE METHODS OF COMMUNICATION

The primary method of communication will be

1. Avenue To Learn (ATL, <http://avenue.mcmaster.ca/>) content - make sure to set your ATL email settings so it emails these updates to you.
2. MS Teams ("Course Forum") for announcements, questions, etc.
3. Email for individual messages (but anything that's not private info specifically about *you* should be a forum post instead. Especially technical or administrative questions – please post to the forum rather than sending a direct message to the instructor or a TA).

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,
3. use scripting languages to automate computational tasks: e.g. setting up, running, and analyzing simulations,
4. complete engineering design with computer-aided optimization through simulation-enhanced analysis, and
5. professionally communicate results of your engineering analysis via reports, videos, and live demos.

MATERIALS AND FEES

COMPUTER:

Students should have a laptop computer (needed for in-person practical demos) capable of simultaneously running FlexPDE, Maple, and Microsoft Word (Windows machines are recommended, price point of \$500 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).

REFERENCE TEXTS:

-[Required] Course notes (free online via ATL)

COURSE FORMAT AND EXPECTATIONS

The course is organized as follows.

Resources:

- Lecture notes & examples (online)
- Worked Example Practice Problems (online)
- Select course videos explaining the notes & some practice problems each week (on [YouTube](#))

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.

The course is divided into **five** topics (for which you'll complete Design Assignments (DAs)) followed by a design project (DP):

1. [3 weeks] Advanced dynamics problems reminder, scripting, and programming tips
 - a. (running programs from command line; python scripting to set up & run other programs, and export and process their results; scripting of solving complex dynamics problems associated with rocketry, fluidic drag, universal gravitational & coulomb force)
2. [2 weeks] Heat transfer and vector calculus
 - a. (grad & div, Laplace's equation, time-dependent heat equation, convection & radiation boundaries, rectangular, cylindrical, and spherical geometries, symmetry arguments)
3. [2 weeks] E&M
 - a. (Gauss's law in vacuum, insulators, dielectrics, and conductors, polarization, free & bound charge; steady-state conduction, current density, & Joule's law)
4. [2 weeks] Beam flexure reminder, General elasticity, Thermal Expansion & Piezoelectrics
 - a. (Reminder of statics content including stiffness & compliance matrices, extensions for general elasticity, adding in internal sources of strain and explaining their physical foundations; thermal expansion, piezoelectricity)
5. [2 weeks] Resonance reminder, modal analysis & applications; Beam Resonance, time-independent Schrödinger
 - a. (Resonance reminder; wave equations, modes of strings, acoustics, time-independent Schrödinger equation solutions and interpretations, beam resonance via modal analysis and its meaning)
6. [2 weeks] Design project: Mathematical modelling for engineering design
 - a. Use your skills to solve your own design problem of interest in a group, possibly combining previous topics; e.g., resonant frequency impact from stress-induced by thermal strain due to heat transfer caused by Joule-heating.

You'll work in groups of 4-5 to complete a design task given a setup problem description we'll provide during the DA intro lecture (for the DAs) or that you'll generate yourselves (for the DP). For each DA or DP, you'll

1. write a [group] Engineering Report that documents your
 - a. understanding of the problem,
 - b. analysis & validation,
 - c. scripting & optimization, and
 - d. conclusions,
2. make a brief [individual] video showcasing your project and clarifying your work on it, and
3. answer TA/Instructor questions on your project during a live demo.

See the schedule & assessment sections below, and the Deliverable Contents and Rubrics document on A2L for more details.

COURSE SCHEDULE

<u>Date</u>	<u>Topic</u>	<u>Due</u>	<u>Daily Activity</u>
Mon 9 Jan	Engineering Design with Computer-Aided Optimization through Simulation-Enhanced Analysis; for Advanced Dynamics Problems with Scripting		Live Lecture
Tue 10 Jan			Live Lecture
Thu 12 Jan			Live Lecture
Fri 13 Jan			Lab software intro & practice time
Mon 16 Jan			Live Lecture
Tue 17 Jan			Live Lecture
Thu 19 Jan			DA1 Intro
Fri 20 Jan			DA1 Support Lab
Mon 23 Jan			Live Lecture
Tue 24 Jan			Live Lecture
Wed 25 Jan			DA1 Report & Video
Thu 26 Jan			Demo Prep
Fri 27 Jan			DA1 Demo
Mon 30 Jan		Heat Transfer	
Tue 31 Jan			Live Lecture
Thu 2 Feb			DA2 intro
Fri 3 Feb			DA2 Support Lab
Mon 6 Feb			Live Lecture
Tue 7 Feb			Live Lecture
Wed 8 Feb			DA2 Report & Video; and R1
Thu 9 Feb			Demo Prep
Fri 10 Feb			DA2 Demo
Mon 13 Feb	E&M		Live Lecture
Tue 14 Feb			Live Lecture
Thu 16 Feb			DA3 Intro
Fri 17 Feb			DA3 Support Lab
Mon 20 Feb	Mid-term Recess		Think about Design Project
Tue 21 Feb			Review PDEs of statics from 2P04
Thu 23 Feb			Review Flexure from 2P04
Fri 24 Feb			Review Voight Notation from 2P04
Mon 27 Feb	E&M		Live Lecture
Tue 28 Feb			Live Lecture
Wed 1 Mar			DA3 Report & Video
Thu 2 Mar			Demo Prep
Fri 3 Mar			DA3 Demo

<u>Date</u>	<u>Topic</u>	<u>Due</u>	<u>Daily Activity</u>	
Mon 6 Mar	Thermal Expansion & Piezoelectrics		Live Lecture	
Tue 7 Mar			Live Lecture	
Thu 9 Mar			DA4 Intro	
Fri 10 Mar			DA4 Support Lab	
Mon 13 Mar			Live Lecture	
Tue 14 Mar			Live Lecture	
Wed 15 Mar			DA4 Report & Video; and R2	
Thu 16 Mar				Live Lecture
Fri 17 Mar			DA4 Demo	
Mon 20 Mar		Beam Resonance & Eigenvalue Analysis		Live Lecture
Tue 21 Mar			Live Lecture	
Thu 23 Mar			DA5 Intro	
Fri 24 Mar			DA5 Support Lab	
Mon 27 Mar			Live Lecture	
Tue 28 Mar			Live Lecture	
Wed 29 Mar			DA5 Report & Video	
Thu 30 Mar				DA5 Demo
Fri 31 Mar			DA5 Demo	
Mon 3 Apr	Final Design Project			DP Support Lecture / Workshop
Tue 4 Apr			DP Support Lecture / Workshop	
Thu 6 Apr			DP Support Lecture / Workshop	
Fri 7 Apr			Good Friday (School Closed)	
Mon 10 Apr			DP Support Lecture / Workshop	
Tue 11 Apr			DP Support Lecture / Workshop	
Wed 12 Apr			DP Report & Video; and R3	
Thu 13 Apr			DP Demo Day	

Wednesday deadlines are 23:59. Demos take place during the Friday lab period (except the DP Demo, which will take place Thursday April 13th from 2:30-5:20 instead); schedule will be posted by the end of Thursday.

ASSESSMENT

Grading ramps up over the term, with report:video:demo worth 2%:2%:2% at start, increasing by 1% each to #5, then doubling for final DP:

Assessment Item	Report	Video	Demo	Reflection	Total
Design Assignments:					
DA1	2%	2%	2%		6%
DA2	3%	3%	3%	1%	10%
DA3	4%	4%	4%		12%
DA4	5%	5%	5%	1%	16%
DA5	6%	6%	6%		18%
Final Design Project (DP)	12%	12%	12%	2%	38%
Grand Total					100%

Note: the MSAF policy this term is as follows. Email Shayan if you need to MSAF anything.
 If you need to MSAF only the demo, you can do it the following week during the lab period. If you need to MSAF the demo and video (but contributed fairly to the report prior to that) you can submit the video 7 days later and do the demo the following week.
 If you need to MSAF all 3, you can do all 3 the following week (i.e., 7 days later), but will need to work alone on the report.

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
Demonstrates ability to iterate on solution method during optimization problems	4.3 Develops models/prototypes; tests, evaluates, and iterates as appropriate.
Ability to use FEM tools to analyze a variety of engineering problems from different physics domains	5.1 Evaluates engineering tools, identifies their limitations, and selects, adapts, or extends them appropriately.
Reflects on progress throughout the course and selects design project topic to address shortcomings	12.1 Critically assesses one's own educational needs and opportunities for growth.

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 of 10% per hour.

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 relief policy for this course is covered in the assessment section.**
 - 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.

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.