



## **MECH 410Q/540G: Introduction to Optimization for Engineers**

**University of British Columbia**

**Department of Mechanical Engineering**

**Course Instructor: Dr. Dominic Liao-McPherson**

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**Office location:** KAIS 3105

**Office hours:** 10:00 – 11:00 Mo/We, KAIS 3105

### **Contact Information**

- Technical questions should be posted on Piazza (so that everyone can see and benefit from the answer). I will try to answer questions within 2 - 3 (working) days.
- Students with questions that cannot be posted to the forum, (e.g., those involving personal or private information) should email the instructor directly.
- When contacting the instructor please include the course code in your subject heading [MECH410Q/540G], and include your name and student number in all communications.

### **Course Requirements/Prerequisites**

MECH 359 or MECH 358 (or equivalent)

### **Class Meeting Time and Location**

Mo/We 8:30am – 10:00am, CEME 1204

UBC's Point Grey Campus is located on the traditional, ancestral, and unceded territory of the xwməθkwəyəm (Musqueam) people.

### **Course Structure**

The course consists of:

- In-person lectures
- Homework Assignments (3x)
- Midterm exam (during class time)
- Final exam (during the exam period)

Lectures are in-person and will not be recorded or otherwise made available online.



## Learning Outcomes or Objectives

This is an introductory course in numerical optimization. The main goal of the course is to teach students how to *solve engineering problems using optimization techniques*. The course focuses mostly on design, data fitting, and trajectory generation problems arising mechanical and aerospace engineering but is applicable much more broadly.

At the end of the course, students will be able to:

1. Translate engineering objectives into optimization problems
2. Classify different types of optimization problems and
  - a. derive optimality conditions for each class
  - b. understand what features leads to well vs. ill posed problems
  - c. understand how different features impact “solvability”
3. Solve simple optimization problems by hand
4. Analyze common optimization algorithms from a theoretical perspective
5. Implement optimization algorithms in software
6. Deploy standard software and algorithms to solve more complex problems

## Course Schedule and Topics

Week	Topics
1	Introduction, a taxonomy of optimization problems, and examples of engineering applications.
2-3	Review of calculus and linear algebra
4	Formulating and manipulating optimization problems, examples
5-8	Optimality conditions for unconstrained and constrained problems
9-10	Optimization Algorithms
11	Software
12-13	Trajectory optimization

## Learning Activities

- **Attend lectures:** Students are expected to attend the in-person lectures whenever possible, and to ask questions whenever they have any in and outside of class.
- **Complete assignments:** Students are expected to complete four homework assignments
- **Use Software:** Students should use MATLAB and the MATLAB optimization toolbox to complete homework assignments



## Learning Materials

All materials (lecture slides, homework assignments etc.) will be posted on Canvas.

The assignments require a computer with MATLAB installed. (MATLAB is available for free for UBC students.) <https://it.ubc.ca/services/desktop-print-services/software-licensing/matlab#getMATLAB>)

Required Textbooks: None.

Optional textbooks:

- Wright, Stephen, and Jorge Nocedal. "Numerical optimization." *Springer Science* 35.67-68 (1999): 7. **(Available online at the UBC library)**

## Assessment, Evaluation, and Grading

- Homework assignments (3x) 30%,
- Midterm 35%,
- Final 35%

Undergraduate students must achieve a weighted average of at least 50% on the midterm and final to pass the course as per MECH department policy<sup>1</sup>.

**Homework assignments:** Assignments will be given periodically. Unless otherwise noted, assignments must be submitted as *hard copies* and will be collected at the beginning of class.

- The instructor will not help students solve the homework assignments.
- Assignments are to be done **individually**. Potential penalties include failing the course and code submissions will be checked for plagiarism.

**Late hand-in policy:** A 25% penalty will be levied on late assignments received by the beginning of the next class. After this they will be assessed a mark of 0.

**Exam policies:** Closed-book. One-page double-sided letter-size hand-written cheat sheet is allowed. Calculators are not allowed.

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<sup>1</sup> In undergraduate MECH courses where at least 50% of the final grade is assigned to examinations, students may only pass the course if they achieve a weighted average examination grade of at least 50% for undergraduate students, 60% for master's students, and 68% for doctoral students. The "examination grade" includes scores from the final examination, midterms, and other tests done individually in a classroom setting. In the event of a student receiving an "examination grade" of less than 50% for undergraduate students, 60% for master's students, and 68% for doctoral students, the "examination grade" total will be entered as their final grade for the course.



## Concession Requests

Under certain circumstances, students may be eligible for an academic concession, which, if approved, is an allowance determined by your instructors for you to make up missed coursework or an assessment. Academic Concessions can be requested for in-term work (all graded assignments, quizzes, and midterms during the UBC term dates) and final exams (exams scheduled during the UBC exam period). Before applying for a concession, students should:

- Review UBC's policy on Academic Concession (<https://vancouver.calendar.ubc.ca/campus-wide-policies-and-regulations/academic-concession>)
- Ensure the reason that you are requesting an academic concession fits within one of the following approved categories:
  - Conflicting responsibilities
  - Medical circumstances
  - Compassionate grounds

**How to Submit a Request:** please complete online reporting of in-term concessions ('self-declaration' for short-term illnesses without need for a medical note) within 72 hours of the missed deadline of exam time. A copy of the request will automatically be forwarded to the instructor for verification and approval (double check the instructors email address). Academic concessions are not guaranteed and submitting a request does not mean it will be approved. A concession request is only approved when the student has received confirmation of approval from the instructor.

<https://academicservices.engineering.ubc.ca/form-request-for-academic-concession-in-term-work/>

- **For missed lectures:** You don't need to complete the online form. Please read the notes, discuss with your colleagues, and consider attending office hours.
- **For missed homework assignments:** Depending on the length of the academic concession, the instructor will decide how to handle the missed homework assignments (e.g., a deadline extension based on the discussion, or moving the weight of a missed assignment to other combination of assignments).
- **For a missed midterm:** The weight will be transferred to the final.
- **For a missed final exam:** We will follow the UBC Senate Policy on Academic Concessions<sup>2</sup>.

## Academic Misconduct

Academic honesty is a fundamental requirement of your studies. It is the obligation of all students to inform themselves of the applicable standards for academic integrity. Students must be aware that standards at UBC may be different from those in secondary schools or at other institutions. Breaching those

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<sup>2</sup> Students requesting academic concession for a missed final exam should read through the information, policy, and application procedure for Standing Deferred (SD) academic concession requests at <https://academicservices.engineering.ubc.ca/exams-grades/academic-concession/>. A request for a Standing Deferred academic concession should be made as soon as a student is aware that they will miss their scheduled exam."



expectations or failing to follow the applicable policies, regulations, rules, or guidelines with respect to academic integrity constitutes academic misconduct and may have serious consequences. More information about UBC's policy on academic misconduct is available at <http://calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,0>].

### **Respectful and Inclusive Environment**

The University of British Columbia envisions a climate in which students, faculty and staff are provided with the best possible conditions for learning, researching and working, including an environment that is dedicated to excellence, equity and mutual respect. The University of British Columbia strives to realize this vision by establishing employment and educational practices that respect the dignity of individuals and make it possible for everyone to live, work, and study in a positive and supportive environment, free from harmful behaviours such as bullying and harassment.

The Department of Mechanical Engineering is committed to providing a respectful and inclusive learning experience, and affirms the UBC Statement on Respectful Environment (<https://www.hr.ubc.ca/respectful-environment/files/UBC-Statement-on-Respectful-Environment-2014.pdf>). Students are encouraged to contact their instructor should situations arise that are not consistent with this expectation. Students are also invited to advise the instructor if they wish to be addressed by or referred to with particular pronouns.

Students are expected to conduct themselves professionally and ethically. It is the obligation of all students to inform themselves of the applicable standards for appropriate conduct as a student and UBC community member. More information is available at: <https://vancouver.calendar.ubc.ca/campus-wide-policies-and-regulations/student-conduct-and-discipline/discipline-non-academic-misconduct-student-code-conduct>. Students who have concerns about non-academic misconduct can contact the department by emailing [concerns@mech.ubc.ca](mailto:concerns@mech.ubc.ca) or speak to any Mechanical Engineering faculty member or staff member.

### **Policies and Resources to Support Student Success**

UBC provides resources to support student learning and to maintain healthy lifestyles but recognizes that sometimes crises arise and so there are additional resources to access including those for survivors of sexual violence. UBC values respect for the person and ideas of all members of the academic community. Harassment and discrimination are not tolerated nor is suppression of academic freedom. UBC provides appropriate accommodation for students with disabilities and for religious, spiritual and cultural observances. UBC values academic honesty and students are expected to acknowledge the ideas generated by others and to uphold the highest academic standards in all of their actions. Details of the policies and how to access support are available [here](#).

Mechanical Engineering has a Student Services Office ([students@mech.ubc.ca](mailto:students@mech.ubc.ca)), located in CEME 2205, where there are staff who can provide support, academic advising, and refer students to appropriate resources. They are open Monday-Friday, 8:00am-4:00pm.