

# [MATH 462/562, COSC 419K: Derivative Free Optimization]

## 2020 Winter Term 1

### Academic Calendar Entries

#### **MATH 462 (3) Derivative-Free Optimization**

Mathematical analysis and development of derivative-free optimization methods. Heuristic methods, direct search methods, model-based methods, convergence analysis, topics in implementation and testing. Credit will be granted for only one of MATH 462 or MATH 562\*. [3-0-0]

Prerequisite: All of MATH 200, MATH 220, MATH 221. MATH 303 or COSC 303 is recommended.

#### **MATH 562 (3) Derivative-Free Optimization**

Mathematical analysis and development of derivative-free optimization methods. Heuristic methods, direct search methods, model-based methods, convergence analysis, topics in implementation and testing. Credit will be granted for only one of MATH 562 or MATH 462\*. [3-0-0]

Prerequisite: Graduate student standing.

#### **COSC 419K (3) Topics in Computer Science**

Advanced or specialized topics in computer science. Consult the department for the specific topic to be offered in any given year. Credit will be granted for only one of COSC 419 or COSC 519 when the subject matter is of the same nature\*.

Prerequisite: Fourth-year standing.\*

\* Note: graduate students must enroll in MATH 562.

\* In 2020: Credit will be granted for only one of MATH 462 or MATH 562 or COSC 419K

### Course Information

**Instructor:** Dr. Warren Hare – [warren.hare@ubc.ca](mailto:warren.hare@ubc.ca)

**Scheduled Time:** Wed 10:00-11:30, Thur 9:00-10:30 (see Course Structure and Evaluation)

**Office Hours:** Email for appointment.

**Textbook:** C. Audet and W. Hare. Derivative-Free and Blackbox Optimization. Springer Series in Operations Research and Financial Engineering, Springer International Publishing, Berlin, 302 pages, DOI 10.1007/978-3-319-68913-5. – Electronic version available (UBC CWL required)

<https://link-springer-com.ezproxy.library.ubc.ca/book/10.1007/978-3-319-68913-5>

**Other course material:** All students are required to have a reliable computer with a good internet connection. All students must have a web-cam with microphone. It is advantageous for students if their web-cam can also double as a document camera.

### Course Overview, Content, and Objectives

This course will cover the mathematical analysis and development of Derivative Free Optimization (DFO) methods. Topics will include

- Heuristic Methods
- Direct Search Methods
- Model Based Methods

For each method, we will outline the method and examine mathematical convergence theory. Mathematics students will be expected to understand the theory of convergence and analyze asymptotic algorithmic behaviour. Computer science students will be expected to implement various algorithms (or portions thereof) and understand numerical issues. Graduate students will be expected to achieve both goals.

## Learning Outcomes

After completing this course, students should be able to:

- Determine which framework a DFO method falls into.
- Critically examine a DFO method, understand its convergence analysis, stopping tests, and implementation issues.

## Course Structure and Evaluation

<b>Assignments</b>	40%
<b>Project</b>	20%
<b>Oral Exams (6)</b>	40%

Students must pass at least 4 out of 6 oral exams to pass this course.

## Lecture Material and Scheduled Time

Lecture material will be provided as pre-recorded videos available on UBC canvas. A reliable computer with good internet access is required to download and view these lectures.

Some classes will be held using collaborate ultra<sup>†</sup>. Students are expected to watch the week's lectures before attending these sessions. During the session, students may request further information on any course material. If no questions are raised, then the instructor will provide some challenge questions that students may work on alone or in small groups. These sessions are optional, but attendance highly recommended.

Other classes will consist of oral examinations. Oral exams will be done in zoom<sup>†</sup> and consist of a 1-on-1 sessions between a student and the instructor. Students will be informed at least 1 week ahead of time which days they will have exams and which time slot they are scheduled to attend. Students are expected to respect their time slot, show up on time, and not interrupt other student time slots. If enrollment is too high to allow all oral exams to be held in the scheduled class time slot, then alternate time slots will be arranged with individual students. Oral exams require a computer with a reliable internet connection, a web cam, and the ability to share live-writing of notes. A web-cam that doubles as a document camera is ideal, but collaborate ultra has a virtual whiteboard that can also be used.

A schedule of which classes will be open question, and which will be oral exams, will be posted on the course webpage.

Exam questions will be taken from the assignments with minor changes. All oral exams are open book, so students are encouraged to have their assignment completed before the exam begins.

<sup>†</sup> **Note:** Classes and oral exam sessions will be recorded and stored for 1 year. Class videos will be available to all students. Oral exam videos will be confidential between student and professor.

## Assignments

There will be  $n$  assignments. If any assignment is not handed in on time, then it will be given a grade of zero and used in calculating the assignment grade. **MATH 462** and **COSC 419K** students will be graded on their best  $n - 2$  out of  $n$  assignments. **MATH 562** students will be graded on their best  $n - 1$  out of  $n$  assignments. MATH 462 assignments will have added focus on mathematical theory. COSC 419K assignments will have added focus on implementation. MATH 562 assignments will cover both foci. MATH 562 assignments may have additional (graduate level) questions that will require reading portions of the textbook that are not covered in lecture.

## Projects

Working in groups of up to 3 students, complete any project from textbook Chapters 3 through 15. Projects will be presented in the form of a pre-recorded lecture, 15 to 20 minutes long. The final week of the year will include a class wide Q&A regarding projects.

No two groups may do the same project, so project selection must be cleared with the professor by the 2nd week of class. If two or more groups wish to try the same project a random number generator will be used to decide which group gets first choice.

## Course Schedule

Apprx. # wks	Topic
1.5	Chpt 1 & 2 (Introduction and Mathematical Background)
1	Chpt 3 (The beginning of DFO algorithms)
1	Chpt 4 (Genetic Algorithms)
1	Chpt 5 (Nelder-Mead)
1.5	Chpt 6 (Positive Bases and Nonsmooth optimization)
1	Chpt 7 (Generalized Pattern Search)
0.5	Chpt 8 (MADS)
1.5	Chpt 9 (Building Linear and Quadratic Models)
1	Chpt 10 (Model-based Descent Methods)
1	Chpt 11 (Model-based Trust Region Methods)
0.5	Appendix (Comparing Optimization Methods)
1	Project Q&A

## Academic Integrity

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the Presidents Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.

A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar at <http://okanagan.students.ubc.ca/calendar/index.cfm?tree=3,54,111,0>.

## UBC Okanagan Disability Resource Centre

The Disability Resource Centre ensures educational equity for students with disabilities and chronic medical conditions. If you are disabled, have an injury or illness and require academic accommodations to meet the course objectives, please contact Earlene Roberts, the Diversity Advisor for the Disability Resource Centre located in the University Centre building (UNC 214). UNC 214 250.807.9263 email [earlene.roberts@ubc.ca](mailto:earlene.roberts@ubc.ca) Web: <http://www.students.ok.ubc.ca/drc>

## Ombuds Office

The Ombuds Office offers independent, impartial, and confidential support to students in navigating UBC policies, processes, and resources, as well as guidance in resolving concerns related to fairness.

UBC Vancouver Ombuds Office: email: [ombuds.office@ubc.ca](mailto:ombuds.office@ubc.ca) Web: <http://www.ombudsoffice.ubc.ca>

## UBC Okanagan Equity and Inclusion Office

UBC Okanagan is a place where every student, staff and faculty member should be able to study and work in an environment that is free from discrimination and harassment. UBC prohibits discrimination and harassment on the basis of the following grounds: age, ancestry, colour, family status, marital status, physical or mental disability, place of origin, political belief, race, religion, sex, sexual orientation or unrelated criminal conviction. If you require assistance related to an issue of equity, discrimination or harassment, or to get involved in human rights work on campus, please contact the Equity and Inclusion Office.

UNC 216 250.807.9291 email: [equity.ubco@ubc.ca](mailto:equity.ubco@ubc.ca) Web: <http://www.equity.ok.ubc.ca>

## Health & Wellness

At UBC Okanagan health services to students are provided by Health and Wellness. Nurses, physicians and counsellors provide health care and counselling related to physical health, emotional/mental health and sexual/reproductive health concerns. As

well, health promotion, education and research activities are provided to the campus community. If you require assistance with your health, please contact Health and Wellness for more information or to book an appointment.

UNC 337 Web: <http://www.students.ok.ubc.ca/health-wellness>