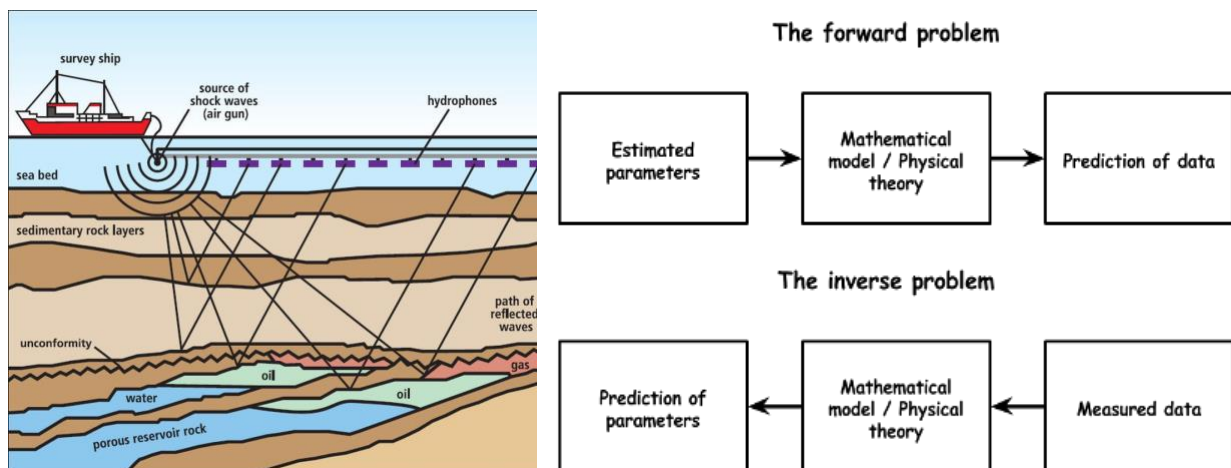


Dalhousie University
Faculty of Science/Department of Earth and Environmental Sciences
ERTH 6353/03 Credit Hours/Quantitative Methods in Earth and Environmental Sciences
Fall Term 2021

Instructor(s): Miao Zhang
Office: LSC 2636 (Oceanography Wing)
Office Phone: 902-494-2831
Email: miao.zhang@dal.ca (preferred)
Lectures: 10:05 – 11: 25 pm, Mondays and Wednesdays (online synchronous)
Laboratories: 50 min lab following the first lecture each week
Course Delivery: Lectures and Laboratories will be delivered synchronously and recorded.

Course Description

The course focuses on the understanding and application of key quantitative methods in Earth and Environmental Sciences. This course introduces quantitative methods and their application including data processing and analysis, numerical modelling methods, inversion methods, etc. Labs provide practical exercises for strengthening understanding of the quantitative methods. Necessary software or computer codes will be provided.



Course Pre-requisites, Co-requisites and/or other Restrictions

This course is restricted to current graduate students majoring in Earth and Environmental Sciences. Calculus ([MATH 1000](#) or similar) and linear algebra ([MATH 1030](#) or similar) are required prerequisites. Students need to get permission from the instructor and their supervisor before they register for the course.

Similar prerequisite courses for self-learning:

- Calculus: <https://ocw.mit.edu/courses/mathematics/18-01sc-single-variable-calculus-fall-2010/index.htm>
- Linear Algebra: <https://ocw.mit.edu/courses/mathematics/18-06-linear-algebra-spring-2010/>

Course Rationale and/or Other Restrictions and Requirements

It is recommended that students have a working knowledge of one or more programming languages (e.g., MATLAB). Students should have their computer and MATLAB at the lab classes.

- MATLAB downloading from Dalhousie: <https://software.library.dal.ca/>
- MATLAB programming for self-learning: <https://www.coursera.org/learn/matlab>

Learning Management System Site Information

Lecture materials, handouts and announcements will be posted on the course Brightspace page.

Course Learning Outcomes

By the end of this course, students will be able to:

- Evaluate quantitative methods and uncertainty/error
- Design mathematical/physical models for specific problems
- Employ numerical modelling for simulating specific processes
- Practice problem solving using various inversion methods
- Assess the strengths and weaknesses of different methods
- Solve problems through computer software/programming

Required Text(s)

Essential reading material will be emailed or handed out in class or posted on Brightspace.

Recommended textbook for Unit 1: MATLAB® Recipes for Earth Sciences, fourth version

Course Schedule

Classes will be scheduled in the Fall semester. The first class of each week will be followed by a 50-minute lab.

Date	Lecture	Lab
	Unit 1. Review of Prerequisites	
09/07	1.1 Introduction	
09/13	1.2 MATLAB Programming I	Lab 1
09/15	1.3 MATLAB Programming II	
09/20	1.4 Review of Matrix Algebra	Lab 2
09/22	1.5 Review of Calculus	
	Unit 2. Data Processing and Analysis	
09/27	2.1 Uncertainty and Error	Lab 3
09/29	2.2 Frequency Analysis	
10/04	2.3 Filtering and Correlation	Lab 4
10/06	2.4 Data Distribution and Fitting	
10/13	2.5 Principal Component Analysis and Cluster Analysis	Lab 5
	Unit 3: Numerical Modelling	
10/18	3.1 Partial Differential Equation (PDE)	
10/20	3.2 Examples of Important PDEs	Lab 6
10/25	3.3 First Order Finite-difference Method	
10/27	3.4 High Order Finite-difference Method	Lab 7
11/01	3.5 Pseudospectral Method	
11/03	3.6 Accuracy, Stability and Boundary Condition	Lab 8
	Unit 4: Inverse Problem	
11/15	4.1 Least Squares Inversion	
11/17	4.2 Regularization Methods	Lab 9
11/22	4.3 Deterministic Inversion I: Newton's Method	
11/24	4.4 Deterministic Inversion II: Gradient Descent	Lab 10
11/29	4.5 Stochastic Inversion I: Monte Carlo	
12/01	4.6 Stochastic Inversion II: Simulated Annealing	Lab 11

Course Assessments

The final grade of the class will be based on the following:

Assignments (4)	60%
Take-home Final Examination	35%
Participation	5%

Detailed descriptions could be found as below:

1. Assignments

Assignment 1, coverage: review of prerequisites, lessons 1.1-1.5, Due date: TBD	(15%)
Assignment 2, coverage: data processing and analysis, lessons 2.1-2.5, Due date: TBD	(15%)
Assignment 3, coverage: numerical modelling, lessons 3.1- 3.6, Due date: TBD	(15%)
Assignment 4, coverage: inversion problem, lessons 4.1- 4.6, Due date: TBD	(15%)

For assignments, necessary MATLAB codes will be provided. Students will work on the performance comparison of the method with different parameter settings. For some problems, students may need to modify the codes as needed. Synthetic or field data would be provided if applicable.

2. Take-home Final Examination

Solve comprehensive problems with quantitative methods (e.g., data processing -> forward modelling -> inversion -> error analysis). Necessary open-source software/codes and synthetic/field data will be provided. (35%)

3. Participation

Active participation in discussions and question sessions. Also see course policies. (5%)

Graduate Courses Grading Scale

Conversion of numerical grades to Final Letter Grades follows the Dalhousie Common Grade Scale

A+ (90-100)	B+ (77-79)	F (0-69)
A (85-89)	B (73-76)	
A- (80-84)	B- (70-72)	

Course Policies

Assignments handed in late will be deducted 10% per day. Assignments handed in more than 5 days late will not be graded. Discussion is encouraged, but plagiarism is not. There will be NO make-up assignments and exams. If you must miss them because of extenuating circumstances (e.g., illness), your assignments and exams will be worth the balance of your mark. Additional information is in the supplemental syllabus.

University Policies and Statements

This course is governed by the academic rules and regulations set forth in the University Calendar and by Senate

Academic Integrity

At Dalhousie University, we are guided in all of our work by the values of academic integrity: honesty, trust, fairness, responsibility and respect (The Center for Academic Integrity, Duke University, 1999). As a student, you are required to demonstrate these values in all of the work you do. The University provides policies and procedures that every member of the university community is required to follow to ensure academic integrity.

Information: https://www.dal.ca/dept/university_secretariat/academic-integrity.html

Accessibility

The Advising and Access Services Centre is Dalhousie's centre of expertise for student accessibility and accommodation. The advising team works with students who request accommodation as a result of a disability, religious obligation, or any barrier related to any other characteristic protected under Human Rights legislation (Canada and Nova Scotia).

Information: https://www.dal.ca/campus_life/academic-support/accessibility.html

Student Code of Conduct

Everyone at Dalhousie is expected to treat others with dignity and respect. The Code of Student Conduct allows Dalhousie to take disciplinary action if students don't follow this community expectation. When appropriate, violations of the code can be resolved in a reasonable and informal manner—perhaps through a restorative justice process. If an informal resolution can't be reached, or would be inappropriate, procedures exist for formal dispute resolution.

Code: https://www.dal.ca/dept/university_secretariat/policies/student-life/code-of-student-conduct.html

Diversity and Inclusion – Culture of Respect

Every person at Dalhousie has a right to be respected and safe. We believe inclusiveness is fundamental to education. We stand for equality. Dalhousie is strengthened in our diversity. We are a respectful and inclusive community. We are committed to being a place where everyone feels welcome and supported, which is why our Strategic Direction prioritizes fostering a culture of diversity and inclusiveness

Statement: <http://www.dal.ca/cultureofrespect.html>

Recognition of Mi'kmaq Territory

Dalhousie University would like to acknowledge that the University is on Traditional Mi'kmaq Territory. The Elders in Residence program provides students with access to First Nations elders for guidance, counsel and support. Visit or e-mail the Indigenous Student Centre (1321 Edward St) (elders@dal.ca).

Information: https://www.dal.ca/campus_life/communities/indigenous.html

Important Dates in the Academic Year (including add/drop dates)

https://www.dal.ca/academics/important_dates.html

University Grading Practices

https://www.dal.ca/dept/university_secretariat/policies/academic/grading-practices-policy.html

Student Resources and Support

Advising

General Advising https://www.dal.ca/campus_life/academic-support/advising.html

Science Program Advisors: <https://www.dal.ca/faculty/science/current-students/academic-advising.html>

Indigenous Student Centre: https://www.dal.ca/campus_life/communities/indigenous.html

Black Students Advising Centre: https://www.dal.ca/campus_life/communities/black-student-advising.html

International Centre: https://www.dal.ca/campus_life/international-centre/current-students.html

Academic supports

Library: <https://libraries.dal.ca/>

Writing Centre: https://www.dal.ca/campus_life/academic-support/writing-and-study-skills.html

Studying for Success: https://www.dal.ca/campus_life/academic-support/study-skills-and-tutoring.html

Copyright Office: <https://libraries.dal.ca/services/copyright-office.html>

Fair Dealing Guidelines <https://libraries.dal.ca/services/copyright-office/fair-dealing.html>

Other supports and services

Student Health & Wellness Centre: https://www.dal.ca/campus_life/health-and-wellness/services-support/student-health-and-wellness.html

Student Advocacy: <https://dsu.ca/dsas>

Ombudsperson: https://www.dal.ca/campus_life/safety-respect/student-rights-and-responsibilities/where-to-get-help/ombudsperson.html

Safety

Biosafety: <https://www.dal.ca/dept/safety/programs-services/biosafety.html>

Chemical Safety: <https://www.dal.ca/dept/safety/programs-services/chemical-safety.html>

Radiation Safety: <https://www.dal.ca/dept/safety/programs-services/radiation-safety.html>

Scent-Free Program: <https://www.dal.ca/dept/safety/programs-services/occupational-safety/scent-free.html>

Dalhousie COVID-19 information and updates: <https://www.dal.ca/covid-19-information-and-updates.html>