University of Victoria
Faculty of Science | Department of Mathematics and Statistics
David Turpin Building Room A425 PO Box 1700 STN CSC Victoria BC V8W 2Y2 Canada
T 250-721-7437| F 250-721-8962 | msrecept@uvic.ca | uvic.ca/science/math-statistics/

# Course Outline

**Mathematics 492[A01]/550[A02]: Topics in Applied Math: Waves in the Atmosphere and the Ocean.**

## Instructor(s)

**Lecturer** Boualem Khouider, professor

**Research Area** Applied Mathematics, Climate Modeling

**Email** email@uvic.ca[1]

**Phone** 250-721-7439 (Use only in case of emergency)

**Office** David Turpin Building A550

## General Course Information

**Number of Units** 1.5

**Pre-requisites** MATH 204 or equivalent and MATH 211 or equivalent PLUS adequate math or physics maturity. Prior knowledge of PDE theory and fluid dynamics can help though not necessary.

## Office Hours and Assistance

**Tuesday** 13:30 pm to 3:30 pm, DTB A550

**Wednesday** 2:00 pm to 4:00 pm, DTB A550

**or** By appointment (send email to book one)

**Other Help** The Mathematics & Statistics Assistance Centre is a large space where students can go to work, on their own or in groups, and to discuss math & stats problems. The Centre is staffed with talented Teaching Assistants who are happy to discuss primarily first and second year course material with you. Please see http://www.math.uvic.ca/~msassist/index.html for more information.

**Math Club** Students in Undergraduate Mathematics and Statistics (SUMS) was founded in 2014 as the reincarnation of a previous undergraduate course union that had been inactive for a few years. Please see http://www.uvic.ca/science/math-statistics/current-students/undergraduate/sums/index.php for more information.

[1] You are encouraged to send me email about everything related to the course. It is the preferred way of communication. However, don't expect immediate answer, allow at least 24 hours. I won't answer lengthy math questions via email. Please come to office hours for such questions.

## Learning Objectives

Weather and climate variability often appears as wave disturbances occurring on multiple temporal and spacial scales ranging from minutes to decades and from metres to tens of thousands of kilometres. This is due primarily to the fluid nature of our Earth's atmosphere and its oceans. Such waves occur as a manifestation of instabilities in the equilibrium between external forces acting on these fluids, such as the solar heating and Earth's rotation, and internal dynamics and thermodynamics. The mathematical studies of these phenomena are of paramount importance for our understanding of the consequences of climate change and for our ability to make future predictions. The topics course in Applied Math "Waves in the Atmosphere and the Ocean" will introduce the student to the basic theoretical concepts of waves and wave dynamics and basic flow instabilities in geophysical fluids.

## Course Material and Online Resources

**Textbooks: Recommended**

1. Joseph Pedlosky: Waves in the Ocean and Atmosphere: Introduction to Wave Dynamics, Springer-Verlag, New York; ISBN3
2. Joseph Pedlosky: Geophysical Fluid Dynamics, Springer; 2nd ed. 1992, Springer;
3. Benoit Cushman-Roisin and Jean-Marie Beckers: Introduction to Geophysical Fluid Dynamics, Physical and Numerical Aspects, Academic Press, Elsevier, 2011
4. Adrian Gill: Atmosphere-Ocean Dynamics, Academic Press, 1982
5. A. J. Majda. Introduction to PDEs and Waves for the Atmosphere and Ocean, volume 9 of Courant Lecture Notes in Mathematics. American Mathematical Society, Providence, 2003.
6. Boualem Khouider: Models for tropical climate dynamics: Waves, Clouds, and Precipitation, Manuscript to appear in Springer Series on Mathematics of Planet Earth.

**Lecture notes** posted on course website.

Course website: go to *https://www.uvic.ca/science/math-statistics/current-students/undergraduate/courses/i* and click on the course number: Math 492/550. Lecture notes, the homework assignments and other important course announcements will be posted. Check for updates regularly.

## Class Meetings

This course has no tutorials. It is important to attend the lectures. Class meets everywhere TWF from 10:30 to 11:20 in David Strong Building C126. The first lecture will be Wednesday Sept. 05, 2018.

## Specific Topics

- Derivation of Euler and Navier-Stokes equations: conservation of mass, balance of momentum, conservation of energy, entropy and potential temperature,
- Shear flow and sound waves
- Equations of motion in a rotating frame, vorticity and Kelvin's theorem
- Boussinesq and hydrostatic approximations
- Wave kinematics: plane waves, phase, phase speed, group velocity, shock waves, WKB theory
- Shallow water equations: gravity waves, Kelvin waves, Rossby waves,
- Internal waves, surface waves, quasi-geostrophic equations, vertically propagating waves
- Equatorially trapped waves

## Evaluation and Grading

There will about six (6) homework assignments handed out in class approximately once every two weeks and a final term project. The final projects can be done individually on in groups but each student has to write their own report and make a class presentation on a specific part of the project. Graduate students enrolled in MATH 550 need to do individual class projects and expected to present more substantial work on their projects.

| | Homework Assignments Bi-weekly | End of term class project |
|---|---|---|
| Undergraduate Students | 60% | 40% |
| Graduate Students | 40% | 60% |

Students are expected to spent a minimum of 3 to 4 hours a week to work on their assignments PLUS and extra one hour per lecture to prepare and review the lecture material. Reading the textbook(s) and/or the online notes before coming to class will help you focus more in class on the parts you least understand. Reviewing your notes from previous lectures will help you better connect it to the material of the upcoming lecture and be better prepared to ask questions and participate in class discussions, which I highly encourage!

**Accessibility** Students with diverse learning styles and needs are welcome in this course. In particular, if you have a disability/health consideration that may require accommodations, please feel free to approach me and/or the Centre for Accessible Learning (CAL) as soon as possible. The CAL staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations `http://uvic.ca/cal`. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.

**Grading** Percentage scores will be converted to letter grades according to the university-wide standard table (Undergraduate: `http://web.uvic.ca/calendar/undergrad/info/regulations/grading.html#`). (Graduate: `http://web.uvic.ca/calendar/grad/academic-regulations/grading.html#`).

**Final Examination** There is no formal final exam for this class.

**Supplemental Examinations.** The Department of Mathematics and Statistics does not award 'E' grades or offer Supplemental Examinations in any of its courses.

## Policies and Ethics

**Attendance** The university Calendar states 'Students are expected to attend all classes in which they are enrolled.'
Undergraduate: `http://web.uvic.ca/calendar/undergrad/info/regulations/attendance.html` Graduate: `http://web.uvic.ca/calendar/grad/academic-regulations/attendance.html#`

Our courses are conducted on that basis. If you miss an announcement (information concerning midterms, corrections to assignment, etc.) because you did not attend class, you must accept the consequences of not having learned of the change.

**Guidelines on Religious Observances** Where classes or examinations are scheduled on the holy days of a religion, students may notify their instructors, at least two weeks in advance, of their intention to observe the holy day(s) by absenting themselves from classes or examinations. Instructors will provide reasonable opportunities for such students to make up work or missed examinations.

**Missing work** Students must accomplish and submit all assigned homework questions and prepare and present an end-of-term project to pass the course. If you are unable to submit your homework by the due date because of illness, family affliction or religious observance, a reasonable extension will be granted after submission of the proper documentation, e.g a doctor's note.

**Academic Integrity** Academic integrity is intellectual honesty and responsibility for academic work that you submit individual or group work. It involves commitment to the values of honesty, trust, and responsibility. It is expected that students will respect these ethical values in all activities related to learning, teaching, research, and service. Therefore, plagiarism and other acts against academic integrity are serious academic offenses.

**The responsibility of the institution**

Instructors and academic units have the responsibility to ensure that standards of academic honesty are met. By doing so, the institution recognizes students for their hard work and assures them that other students do not have an unfair advantage through cheating on essays, exams, and projects.

**The responsibility of the student**

Plagiarism sometimes occurs due to a misunderstanding regarding the rules of academic integrity, but it is the responsibility of the student to know them. If you are unsure about the standards for citations or for referencing your sources, ask your instructor. Depending on the severity of the case, penalties include a warning, a failing grade, a record on the students transcript, or a suspension.
It is your responsibility to understand the University's policy on academic integrity:
Undergraduate:
`http://web.uvic.ca/calendar/undergrad/info/regulations/academic-integrity.html#`
Graduate:
`http://web.uvic.ca/calendar/grad/academic-regulations/academic-integrity.html`

## How to Succeed in This Course

Read the textbook(s) and/or the online lecture notes before coming to class. Review your class notes in the evening or during the day of the lecture while it is still fresh in your head. Make sure your knowledge of calculus and algebra is up to date. Having a calculus book (or your old notes) on you when studying can be handy.

## Fair Dealing