

ERTH 4801/5701 – Physics of the Earth

“... if geophysics requires mathematics for its treatment, it is the Earth which is responsible, not the geophysicist.” (Sir Harold Jeffreys: “The Earth”, 1962)

The course is subject-oriented and is delivered in a seminar/discussion form requiring the active participation of the students. We shall deal with the main fields of geophysics (gravity field and isostasy, seismicity and seismic wave propagation, heat flow and temperature distribution in the interior, plate tectonics, geodynamics and rheology of the Earth) not by covering these sub-disciplines one by one, but by examining the present knowledge of the properties and dynamics of the Earth and the geophysical evidence upon which this knowledge is based. There will be an emphasis on seismology and how it is a particularly useful tool in understanding the Earth’s interior. This course provides an in-depth treatment of various aspects of geophysics that are important to understand the theory of Plate Tectonics and the workings of the Earth’s deep interior.

Prerequisites: EARTH 2105 or permission from the instructor. Some familiarity with calculus and physics is necessary. Two lectures a week, each 1.5 hours.

Instructor: Mareike Adams

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Teaching Assistants: Navid Saeidi

navidsaeidi@cmail.carleton.ca

Office hours: Wednesday 1:00 pm - 3:00 pm via BigBlueButton, or by appointment

Lectures: Tuesdays & Thursdays from 6:05 – 7:25 pm, will take place live (synchronously) on Zoom, and then the recorded lectures will be posted on Brightspace:

Topic: Mareike Adams's Personal Meeting Room

Join Zoom Meeting

<https://carleton-ca.zoom.us/j/5086475674?pwd=RUN1YXdIUjR6RlJQdUFQYWFCYjNOUT09>

Meeting ID: 508 647 5674

Passcode: catsRkool

Course Texts (suggested):

Ranalli, G. *Some problems of geodynamics*, lecture notes.

Fowler, C. M. R. (2005). *The Solid Earth*, 2nd edn. Cambridge University Press.

Ranalli, G. (1995). *Rheology of the Earth*, 2nd edn. Chapman & Hall, London.

Turcotte, D. L. & Schubert, G. (2002), *Geodynamics*, 2nd edn. Cambridge Uni. Press.

Learning Objectives:

- Learn the tools needed to understand the conceptual underpinnings of plate tectonics
- Understand the fundamental processes of Earth’s interior deformation and touch on interactions between the interior and the plates through geologic time

- Build a solid foundation of the main geophysical features of the Earth such as gravity anomalies and isostasy, glacioisostatic rebound, surface heat flow and temperature distribution in the interior, etc.
- Use continuum mechanics to describe the lithosphere: stress, strain and strain rate tensors, rheological equations, brittleness and ductility, etc.
- Understand temperature profiles through the Earth
- Develop an understanding of the interior of the Earth (mantle and core) including physical properties and composition of the mantle
- Use seismological tools such as tomography to learn about the rheology of the mantle and seismic velocity distribution

Grading Scheme:

Practical assignments	35%
Final project & Presentation	30%
Take-home Final Exam	30%
Participation	5%

The assignments will be a combination of theoretical problems and more practical applications solved on the computer. They will be posted on Brightspace and are due two weeks afterwards via email.

You are encouraged to discuss problems for this class with your classmates, but it is absolutely imperative that any work you submit for this class is your own. Plagiarism, defined as an *attempt by a student to represent the work of another as her or his own*, is strictly against the policies of academic fairness and integrity of this University. This means you must clearly attribute any quotations or copied figures (citing name + year + publication of any sources). You should always mention any classmates with whom you have collaborated (a brief marginal note will suffice), and it is not EVER permitted to copy another student's work. If you are found to be in violation of this policy, there are very serious consequences.

There will be one larger project focusing on a region of interest to you. This project will comprise the application of the concepts that we discuss in class to a particular locality (of your choosing). This project will be due at the end of the quarter, but you will be guided to work progressively on various aspects of it throughout the semester. Everyone will present their final projects in the last week of the course, and a lively discussion is encouraged.

There will be a take-home final exam posted to the course website in the last class and due during the Final Exam Period via Brightspace that will consist of long answer questions.

For all labs and exams *always* show your full working for mathematical problems. As well as making it much easier to judge where/if you made any errors, I will not award full marks if the logic and work-flow of the answer is not clear. Make sure to properly highlight your final answer to each problem. Answers should be mathematically *correct*, i.e. if you write an "equals sign", both things on either side of it must be equal. This sounds totally obvious, but it is often not done, leading to avoidable errors and marks deducted. **Get in the practice of being meticulous with your mathematics!**

If you miss an assignment or exam, then you must contact the instructor within 3 days of the deadline and provide appropriate documentation in order to obtain an extension.

Course Requirements:

- The practical component of the course must be passed in order to pass the course.
- The final exam must be passed in order to pass the course.
- Assignments must be handed in on time. Late labs will be accepted in the instance of illness, with a medical note, or in the instance of emergencies
- It is the student's responsibility to come to classes prepared. Reading assignments are mandatory
- Regularly log onto the Brightspace course website to check for announcements, course information, practical assignments and lecture material.

Tentative Schedule (note: it is subject to change):

- ***Week 1 - Introductory meeting (Sept. 9)***
Course outline, requirements and expectations, introduction to Geodynamics and the GeoMapApp (I suggest you download it sooner rather than later
<http://www.geomapapp.org/>)
- ***Weeks 2-4 (Sept. 14 – 30): Introduction to Earth physics (review) & the Lithosphere***
Continuum mechanics description of the lithosphere; stress, strain, and strain rate tensors; rheological equations (elasticity; linear and nonlinear viscosity); equations of equilibrium and continuity; brittleness and ductility; conduction and advection of heat; conservation of energy; temperature in oceanic and continental lithosphere; high-temperature creep; rheology of the lithosphere.
- ***Weeks 5 - 7 (Sept. 28 – Oct. 21): Special topics in Seismology & Guest Lectures***
Ray theory, global body waves, surface waves, normal modes, deep Earth seismology, attenuation, anisotropy, scattering, seismic structure of the lithosphere and internal structure of the Earth
- ***Week 8 – Fall Reading Week***
- ***Weeks 9-10 (Nov. 2 – Nov. 11): The interior of the Earth – Rheology of the Mantle***
Spherically symmetric Earth models; physical properties and composition on the mantle; temperature and solidus temperature; lateral variations: seismic tomography and its interpretation; rheology of the mantle: postglacial rebound and inferences on viscosity; thermal convection in the mantle: critical Rayleigh numbers; creep mechanisms, Newtonian and non-Newtonian viscosity.
- ***Weeks 11 – 12 (Nov. 16 – Nov. 25): Continental & Oceanic extension and Subduction***
Oceanic spreading transition, asthenospherization, time dependence of negative buoyancy and the subduction of continental lithosphere, initiation of subduction
- ***Week 13 (Nov. 30 – Dec. 2) Deep interior of the Earth***

Convection in the core, generation of the Earth's magnetic field, PREM model, the Earth density model

- ***Presentations (Dec. 7 – 9)***
- ***Dec. 11 – 23 – Final Exam Period***
Take home final exam.

ACADEMIC INTEGRITY

It is your responsibility to review Carleton's policy on Academic Integrity - Section 14 of the Calendar.

<http://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/acadregsuniv14/>

Plagiarism

The instructor is required to report all incidents (or suspected incidents) of plagiarism to the Dean.

All work handed in must be your own. Plagiarism and cheating are viewed as being particularly serious and the sanctions imposed are accordingly severe. Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy. The Policy is strictly enforced and is binding on all students. Plagiarism and cheating – presenting another's ideas, arguments, words or images as your own, using unauthorized material, misrepresentation, fabricating or misrepresenting research data, unauthorized co-operation or collaboration or completing work for another student – weaken the quality of the graduate degree. Academic dishonesty in any form will not be tolerated. Students who infringe the Policy may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; a refusal of permission to continue or to register in a specific degree program; academic probation; or a grade of Failure in the course.

REQUESTS FOR ACADEMIC ACCOMMODATION

Please review the Carleton's Student Guide to Academic Accommodations at

<http://carleton.ca/equity/wp-content/uploads/Student-Guide-to-Academic-Accommodation.pdf>, and the websites therein.

For Students with Disabilities:

“The Paul Menton Centre for Students with Disabilities (PMC) provides services to students with Learning Disabilities (LD), psychiatric/mental health disabilities, Attention Deficit Hyperactivity Disorder (ADHD), Autism Spectrum Disorders (ASD), chronic medical conditions, and impairments in mobility, hearing, and vision.

If you have a disability requiring academic accommodations in this course, please contact PMC at 613-520-6608 or pmc@carleton.ca for a formal evaluation.

If you are already registered with the PMC, contact your PMC coordinator to send me your ***Letter of Accommodation at the beginning of the term, and no later than two weeks before the first in-class scheduled test or exam requiring accommodation.*** After requesting accommodation from PMC, meet with me to ensure accommodation arrangements are made. Please consult the PMC

website (www.carleton.ca/pmc) for the deadline to request accommodations for the formally-scheduled exam . “

For Religious Observance:

1. *As soon as you receive your course syllabus*, identify any potential conflicts between your religious obligations and course requirements.

2. Make a formal written request to your instructor indicating the nature of the religious obligation and suggest possible alternative dates and/or means of satisfying the academic requirements.

NOTE: Such request should be made during the first two weeks of the term, or as soon as possible after a need for accommodation is known to exist, but in no case later than the second last week of classes for that term.

For detailed information on Religious Obligations please visit our website at: carleton.ca/equity/accommodation/

For Pregnancy or Parental Leave:

A. For final exams. Identify and discuss your needs for final examinations with your professors. When an agreement is reached fill out and submit the online **Pregnancy Accommodation Final Exam Request Form** at: carleton.ca/equity/accommodation. Equity Services will forward the request to Exam Services to coordinate the accommodation.

B. For in-class accommodations ONLY. If you anticipate you will only require in-class accommodations, discuss them directly with your course instructor. This request should be made in the first two weeks of the academic term. For detailed information on pregnancy and parental leave policies please visit the website at: carleton.ca/equity/accommodation/academic/

Parental leave:

Either parent may request up to three terms of leave, which must be completed within 12 months of the date of birth or custody or request for leave for health-related family responsibilities.

For detailed information on pregnancy and parental leave policies please visit the website at: <https://carleton.ca/equity/policies-procedures/>

Equity and PMC Contact information:

- Department of Equity and Inclusive Communities
613-520-5622
3800 Carleton Technology & Training Centre
equity@carleton.ca
Website: carleton.ca/equity
- Paul Menton Centre for Students with Disabilities
613-520-6608
pmc@carleton.ca
500 University Centre
Website: carleton.ca/pmc