University of Victoria

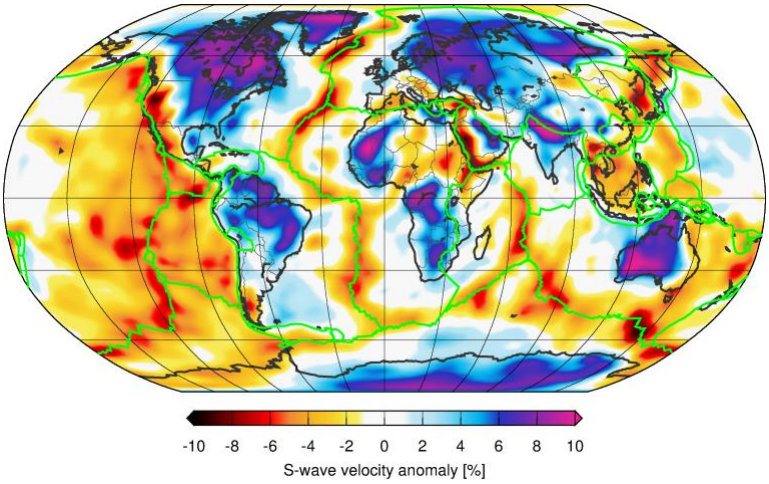
Earth and Ocean Sciences **EOS/PHYS 427 A01**
UNIVERSITY OF VICTORIA
3-0-0 (1.5 UNITS)
WINTER SESSION 2025

COURSE OUTLINE

Geophysics

Lectures: 8:30-9:20 Tues, Wed, Fridays, Room 060, Elliott Building

We acknowledge and respect the Lək̓ʷəŋən (Songhees and Esquimalt) Peoples on whose territory the university stands, and the Lək̓ʷəŋən and W̱SÁNEĆ Peoples whose historical relationships with the land continue to this day.



Example of seismic tomography: Shear-wave velocity anomalies at 100 km depth in the mantle. Positive anomalies indicate low temperatures within old continental cores (cratons). Negative anomalies indicate high temperature beneath mid-ocean ridges and other tectonically-active zones (Schaeffer & Lebedev, 2013, *Geophys J Int*).

COURSE DESCRIPTION

Calendar Description: Principles of seismology, gravity, heat flow, geochronology, and how they contribute to our understanding of Earth structure and plate tectonics.

PREREQUISITES

PHYS 321A Classical Mechanics I
PHYS 326 Electricity and Magnetism
MATH 346 Introduction to Partial Differential Equations

CONTACT INFORMATION

Instructor: **Stan Dosso**
Email: sdosso@uvic.ca (Please include "427" in the subject line)
Office: **BWC A331**
Office Hours: **1:30-3:00 Mondays**—In-person and on zoom https://uvic.zoom.us/j4863207576
Also welcome in-person or on zoom at other times (please check in via email)

COURSE MATERIALS

Text (Optional): *C.M.R. Fowler, 2005 The Solid Earth: An Introduction to Global Geophysics, 2nd Edition, Cambridge University Press.* E-Text available at UVic Bookstore for $99.95; new/used copies can be found online

for about $30–100. A copy is on reserve (2-hour loan) at McPherson Library. This is an excellent geophysics reference text and the source of much of the course material; however, class notes and figures are the basis for assignments and exams, and the text is not required.

Brightspace will be used for posting course information, notes/figures, and assignments.

Classes are in-person and will not be recorded. Course notes will be developed in class. Notes will also be posted on Brightspace at the end of each week as an additional resource—*Please attend classes and take notes*!

LEARNING OUTCOMES

Upon completion of this course, students should be able to:

- Demonstrate an in-depth understanding of how fundamental physics and advanced mathematics are applied to study the earth, particularly seismic waves, gravity, heat flow, and geochronology.
- Derive the seismic wave equation from first principles, and characterize fundamental wave types as solutions to this partial differential equation.
- Explain how global- and smaller-scale seismic-velocity and density distributions of the earth are estimated from earthquake data.
- Explain the shape of the earth as an equipotential surface (the geoid).
- Determine if geologic/tectonic features are in isostatic equilibrium based on gravity anomalies.
- Derive the heat-flow (conduction-diffusion/advection) equation together with geotherm solutions given boundary conditions, and explain how this controls ocean depth.
- Apply basic computer coding to solve geophysical problems and plot results.

EVALUATION

Weekly Assignments	**20%**
Midterm Exam 1 (Feb. 4)	**20%**
Midterm Exam 2 (March 11)	**20%**
Final Exam (within April 7-25)	**40%**

Note:

- Assignments will be assigned most weeks at Brightspace and must be submitted to Brightspace as a PDF file (photos of handwritten work converted to PDF are acceptable, provided they are fully legible). Assignments will generally be assigned on Tuesdays and due on the following Tuesday.
- Assignments are an important component of mastering course material—you are welcome/encouraged to see me at Office Hours (or otherwise) for help as needed.
- Some Assignments will involving basic computer coding in a language your choice (e.g., Matlab, Python). Coding will not be covered in class—please let me know if this is a problem for you.
- Midterms will be 50-minute, in-class exams. The Final Exam will be cumulative but weighted more heavily to material covered after Midterm 2. The Final will include roughly twice as much material as a midterm but 3 hours will be allocated to relieve time pressure.
- Mathematical formulas needed for exams will be provided on the exam—no need to memorize or prepare your own formula sheet.
- Passing the course is based on your cumulative grade as specified above.

COURSE POLICIES

Late/Missed Assignments or Exams

- Late assignments are penalized at 10%/day to a maximum of 5 days after which a zero mark is assigned.
- Late assignments may be accepted without penalty given reasonable justification (e.g., illness, travel, unusually heavy workload)—please contact me in advance of the due date with requests.
- If you miss or know you will miss a Midterm or the Final Exam, let me know as soon as possible. For justified reasons (e.g., illness) the value of a missed Midterm will be added to the Final Exam. If two Midterms are missed, a make-up exam must be scheduled. If the Final Exam is missed, a make-up exam must be scheduled. The Final Exam and at least one Midterm are essential components that must be completed to pass the course.

Academic Integrity

UVic's Policy on Academic Integrity is found at web.uvic.ca/calendar/undergrad/info/regulations/academic-integrity.html. It is every student's responsibility to be aware of this policy, including policies on cheating, plagiarism, unauthorized use of an editor, multiple submission, and aiding others to cheat. If you have any questions or doubts, please talk to me. For more information, see uvic.ca/learningandteaching/cac.

Use of AI

You are not permitted to use any form of generative AI tools, such as ChatGPT, for content generation in this course. As UVic states on its Academic Integrity Policy "Academic integrity requires commitment to the values of honesty, trust, fairness, respect, and responsibility." You are expected to comply with this course syllabus and I encourage you to enhance your academic experience in this course by refraining from use generative AI.

COURSE CALENDAR AND OUTLINE

UVic Important Dates: uvic.ca/calendar/dates/
Last day to add courses: January 22
Last day to drop a course without penalty of failure: February 28
Final exam period: April 7-25

Week	Lecture Dates	Lecture Material (Approximate)
1	Jan. 7, 8, 10	Seismic Wave Theory
2	Jan. 14, 15, 17	Seismic Wave Theory
3	Jan. 21, 22, 24	Seismic Wave Theory
4	Jan. 28, 29, 31	Seismic Wave Theory
5	Feb. 4, 5, 7	Seismic Wave Theory, **Midterm 1** (Feb. 4)
6	Feb. 11, 12, 14	Seismic Wave Theory / Earthquake Seismology
	Feb. 18, 19 21	Reading Break—No Classes
7	Feb. 24, 26, 28	Earthquake Seismology
8	March 4, 5, 7	Earthquake Seismology
9	March 11, 12, 14	Gravity and Isostasy, **Midterm 2** (March 11)
10	March 18, 19, 21	Gravity and Isostasy
11	March 25, 26, 28	Heat Flow
12	April 1, 2, 4	Heat Flow / Radioactive Decay

The following is an approximate outline for EOS/PHYS 427. The (optional) text can provide a useful reference for most of the material; however, assignments and exams are based only on the course notes. Note that several topics will be covered that are not in the text, and many topics in the text will not be included in the course.

1. **Seismic (Elastic) Wave Theory** (Text Chapter 4 and Appendix 2)
   - Infinitesimal analysis of stress and strain
   - Normal and shear strain; dilation and rotation
   - 3-D Hooke's Law for isotropic solids
   - Lamé parameters and elastic modulii
   - Vector displacement equation
   - Compressional (P) and shear (S) wave equations
   - Displacement potentials and P and S particle motion
   - Snell's law for wave refection, refraction, conversion
   - Zoeppritz equations: Elastic reflection and transmission coefficients
   - Energy partitioning (energy coefficients)
   - Surface-wave solution to wave equation: Rayleigh waves
   - Rayleigh wave particle motion, velocity, dispersion relation
   - SH resonance: Love waves; dispersion relation
   - Dispersion inversion

2. **Earthquake Seismology** (Text Chapter 4 and Appendices 3 & 4)
   - Overview of the tectonics and seismicity of Cascadia
   - Global seismic paths
   - Spherical ray tracing
   - Earth radial velocity structure from time-distance curves (Herglotz-Wiechert inversion)
   - Density and elastic modulii from seismic velocities (Adams-Williamson equation)
   - Seismic tomography

3. **Gravity and Isostasy** (Text Chapter 5)
   - Gravitational Potential
   - Shape of the Earth
   - Isostasy: Airy and Pratt hypotheses
   - Free-air and Bouguer gravity anomalies
   - Compensated and uncompensated anomalies
   - Poisson equation

4. **Heat Flow** (Text Chapter 7)
   - Heat conduction and convection
   - Heat flow (conduction-diffusion/advection) equation
   - Geotherms
   - Heat flow, isostasy and ocean depth

5. Geochronology (Text Chapter 6)
   - Theory of radioactive decay
   - Decay series
   - Age of the Earth

CHANGES DUE TO UNFORESEEN CIRCUMSTANCES

The above schedule, policies, procedures, and assignments in this course are subject to change in the event of extenuating circumstances. In the event of significant changes, a revised outline will be posted/circulated.

UVIC GRADING SYSTEM

As per the Academic Calendar:

Grade	Grade point value	Grade scale	Description
A+ **A** **A-**	9 8 7	90-100% 85-89% 80-84%	**Exceptional**, **outstanding** and **excellent** performance. Normally achieved by a minority of students. These grades indicate a student who is self-initiating, exceeds expectation and has an insightful grasp of the subject matter.
B+ **B** **B-**	6 5 4	77-79% 73-76% 70-72%	**Very good**, **good** and **solid** performance. Normally achieved by the largest number of students. These grades indicate a good grasp of the subject matter or excellent grasp in one area balanced with satisfactory grasp in the other area.
C+ **C**	3 2	65-69% 60-64%	**Satisfactory**, or **minimally satisfactory**. These grades indicate a satisfactory performance and knowledge of the subject matter.
D	1	50-59%	**Marginal** Performance. A student receiving this grade demonstrated a superficial grasp of the subject matter.
F	0	0-49%	**Unsatisfactory** performance. Wrote final examination and completed course requirements; no supplemental.
N	0	0-49%	Did not write examination or complete course requirements by the end of term or session; no supplemental.

COURSE FEEDBACK

I value your feedback on this course. Towards the end of term, as in all other courses at UVic, you will have the opportunity to complete an anonymous **Course Evaluation Survey (CES)** regarding your learning experience. The survey is important for providing feedback to me regarding the course and my teaching, as well as to help the department improve the overall program for students in the future. The survey is accessed online and can be done on your laptop, tablet, or mobile device. I will remind you and provide you with more detailed information nearer the time, but please be thinking about this important activity during the course.

APPENDICES

SCHOOL OF EARTH AND OCEAN SCIENCES INFORMATION

- SEOS Website: uvic.ca/seos
- SEOS Office: seos@uvic.ca
- SEOS Director: Dr. Jay Cullen, seosdirector@uvic.ca
- SEOS Mental Health & Wellness Contact: Dr. Andy Fraass, andyfraass@uvic.ca
- SEOS Undergraduate Advisor: Dr. Jon Husson, seosadvisor@uvic.ca
- SEOS Graduate Advisor: Dr. Roberta Hamme, seosgradadvisor@uvic.ca
- Ocean Science Mentor: Dr. Jody Klymak, seosoceansci@uvic.ca

- Climate Science Advisor: Dr. Colin Goldblatt, climateadvising@uvic.ca

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UNIVERSITY STATEMENTS & POLICIES

- Academic Calendar: Information for All Students
- Creating a respectful, inclusive, and productive learning environment
- Accommodation of Religious Observance
- Accommodation and Access for Students with Disabilities
- Student Conduct
- Non-academic Student Misconduct
- Accessibility
- Diversity / EDI
- Equity statement
- Sexualized Violence Prevention and Response
- Discrimination and Harassment Policy

STUDENT RESOURCES

POSITIVITY AND SAFETY

The University of Victoria is committed to promoting, providing, and protecting a positive and safe learning and working environment for all its members.

Student Groups & Resources

ACADEMIC RESOURCES

UVic Library - *UVic Library offers many services and resources for undergraduate and graduate students.* uvic.ca/students/academics/library-services

Learning Resources - *UVic Learn Anywhere is the primary learning resource for students that offers many learning workshops and resources to help students with academics and learning strategies.* onlineacademiccommunity.uvic.ca/LearnAnywhere/learning-strategies

Centre for Academic Communication - *Offers online and in-person one-on-one tutorials, workshops, and more.* uvic.ca/learningandteaching/cac

Math & Stats Assistance Centre - *Offers drop-in, face-to-face tutoring and a friendly, collaborative study space for 100- and 200-level math and stats courses.* uvic.ca/science/math-statistics/current-students/undergraduate/msac

MENTAL HEALTH & WELLNESS

A note to remind you to take care of yourself. Do your best to maintain a healthy lifestyle this semester by eating well, exercising, getting enough sleep, and taking some time to relax. This will help you achieve your goals and cope with stress. All of us benefit from support during times of struggle. You are not alone.

SEOS Mental Health & Wellness Contact - *Dr. Fraass is a faculty member who can act as a sympathetic ear and (more importantly) provide guidance about: how to access the multitude of University support services, and which are useful in different circumstances. Andy can be found by dropping by his office or lab (Bob Wright A431, B409). He is also available via email for questions or to arrange a time to have a chat.* andyfraass@uvic.ca

Student Wellness Centre - *Our team of practitioners offers a variety of services to support students' mental, physical, and spiritual health.* uvic.ca/student-wellness

Counselling Services - *Counselling Services can help you make the most of your university experience. They offer free professional, confidential, inclusive support to currently registered UVic students.* uvic.ca/services/counselling/

Health Services - *University Health Services (UHS) provides a full-service primary health clinic for students and coordinates healthy student and campus initiatives.* uvic.ca/services/health/

ACCESSIBILITY

Students with diverse learning styles and needs are welcome in this course. In particular, if you have a documented disability or health consideration that may require accommodations, please feel free to approach me and/or the Centre for Accessible Learning (CAL) as soon as possible.

Centre for Accessible Learning - *The CAL staff are available by appointment to assess specific needs, provide referrals and arrange appropriate accommodations. The sooner you let us know your needs the quicker we can assist you in achieving your learning goals in this course.* uvic.ca/services/cal/

ADVISING

For academic advising-related questions, students in the School of Earth and Ocean Sciences are also encouraged to meet with the SEOS Undergraduate Advisor (seosadvisor@uvic.ca) as well as an academic advisor in the Academic Advising Centre early in their studies to help map out a plan to declare a major and complete university program requirements.

Academic Advising Centre - *Academic advice and support is currently available by phone, email and virtual or in-person appointments.* uvic.ca/services/advising

Ombudsperson - *The ombuds office is an independent, impartial, and confidential resource for undergraduate and graduate students and other members of the University of Victoria community. The ombudsperson helps resolve student problems or disputes fairly.* uvicombudsperson.ca

ACADEMIC CONCESSION

You can request an academic concession if your course requirements are affected by unexpected and unavoidable circumstances, or conflicting responsibilities. Concession requests can be for an in-course extension, deferral, withdrawal under extenuating circumstances, or an aegrotat. Please speak to an advisor at the Academic Advising Centre if you have questions on how requesting a concession will affect your academic program.

Undergraduate Academic Concessions - uvic.ca/students/academics/academic-concessions-accommodations

EQUITY AND HUMAN RIGHTS AT UVIC

EQHR is a resource for students, staff, and faculty who have experienced sexualized violence, discrimination, and/or harassment and are looking for informal and/or formal resolution options as well as advice, coaching, and/or education. We are available for confidential consultations so that you can ask questions and learn your options.

EQHR – *By email at eqhr01@uvic.ca or in-person (Sedgewick C115).* uvic.ca/equity

Sexualized Violence Resource Office – *If you have been directly or indirectly impacted by sexualized violence, reach out to the SVRO for information, advice, resolution options (restorative and disciplinary) as well as support options and referrals. The SVRO is both survivor-centred and trauma-informed in their approach. You can reach us by phone at 250-721-8021 or by email at eqhr01@uvic.ca to book either an in-person (Sedgewick C119) or online appointment.* uvic.ca/svp

RESOURCES FOR INTERNATIONAL STUDENTS

International Centre for Students - *The primary office supporting international students on campus at the university-wide level.* uvic.ca/international-experiences

UVic Global Community Initiative - *Provides various supportive programming, including a Mentorship Program and Conversation Partner Program.* uvic.ca/international-experiences/get-involved/uvic-global-community

RESOURCES FOR INDIGENOUS STUDENTS

Indigenous Student Support - *UVic offers holistic services to Indigenous students throughout their academic journey. uvic.ca/students/info-for/indigenous-students*

Elders in Residence - *The Office of Indigenous Academic and Community Engagement (IACE) has the privilege of assembling a group of Elders from local communities to guide students, staff, faculty, and administration in Indigenous ways of knowing and being. uvic.ca/services/indigenous/students/programming/elders*