GP9507 ADVANCED MINERAL PHYSICS

Instructor: Sean Shieh, B&GS room 1066 (email: sshieh@uwo.ca)
Course Format: 2 lecture hours, 3 laboratory hours
Lectures: Tue, Thu 11:30-12:30
Lab: Thu 1:30 - 4:30 PM

COURSE DESCRIPTION

This course introduces the elementary properties and applications of geological and planetary materials using solid state theory, thermodynamics, elasticity, equations of state, stress and strength, phase transformations, and high-pressure/high-temperature science and techniques, with a focus on the mineral physics of the mantle and core. The course aims to teach students how to study the physical and mechanical properties of materials under both ambient and extreme conditions, and how these properties can be applied to natural and industrial systems.

PREREQUISTITES: N/A

LEARNING OUTCOME:
Upon successful completion of this course students will be able to:

- Explain the basic concept of the thermodynamics and their relations to the properties of materials
- Explain the basic concept of the crystal chemistry and physics and their responses to extreme pressure and temperature conditions
- Explain the basic concept of the equation of state and spectroscopy and their relations to elastic property of the materials
- Explain the basic concept of the stress and stress and their relations to mechanical property of the materials
- Explain the basic concept of the high pressure apparatus and their applications to the study of formation and evolution of the planetary bodies.
- Apply the knowledge of mineral physics to the synthesis, structure and elasticity of the materials under ambient and extreme conditions

COURSE OUTLINE

The following topics represent a general overview of the course.
However, readings that will be assigned and may cover other topics as well.

Thermodynamics of Solids

Thermodynamic potentials
Maxwell relations
Elastic moduli
Thermoelasticity (lattice harmonicity / anharmonicity)
Grüneisen parameter

Physical Properties of Solids

Elasticity

Bonding property
Equations of state
Thermoelasticity
Stress and strength

High Pressure and Temperature Generating Devices

Static methods (large volume press, diamond-anvil cell)
Dynamic methods (shock wave)
Pressure determination
Lattice vibration

Transport Properties

Melting
Electrical conductivity
Thermal conductivity
Viscosity
Mantle rheology

Mineral Physics Constraints on Mantle and Core

Properties
Composition
Interaction

ASSIGNMENTS

Assignments on topics related to the above sections, though not necessarily specifically discussed in the lectures, will be set during term time. Some questions may require extra reading/study and you are therefore encouraged to refer to the books listed below (or any other book).

SEMINAR

You will be required to present a seminar on an approved topic of your choice which is related to topic of this course. Seminars will be given at a date to be determined near the end of term. Details will follow.

FINAL REPORT

You will be required to hand in a written report on an approved topic of your choice which is related to topic of this course. The report should be no more than 10 pages, including figures and tables but not references. Format: Time New Roman, font size 12, double spacing,

MIDTERM

Midterm will be held around but not in the reading week.

GRADE

The final grade will be calculated with the approximate breakdown as follows:

Assignments 30%
Midterm 25%
Seminar 25%

Final report 20%

TEXT BOOK (Recommended)
Introduction to the Physics of the Earth's Interior, J-P. Poirier, Cambridge University Press, 2000 (2nd ed.).

REFERENCE BOOKS
Physics of the Earth 3rd ed., F. D. Stacey, Brookfield Press, 1992. (library has 2nd edition, 1977)
New Theory of the Earth, D.L. Anderson, Cambridge University Press, 2007.
Advances in High-Pressure Mineralogy, E. Ohtani, GSA, 2007.
The Physics of High Pressure, P.W. Bridgman, G. Bell and Sons, 1958.
Kittel, C., Introduction to Solid State Physics, 5th Edition, John Wiley and Sons, New York, 1976.

Essential Learning Requirements
Even when Academic Consideration is granted for missed coursework, the following are essential to earn a passing grade in this course:

- a minimum 6 of completed labs on the laboratory component to ensure that students demonstrate sufficient mastery of those technical skills to progress,
- full participation in the seminar.

When a student has not demonstrated proficiency in an essential learning requirement listed above, and when the shortfall results from a granted Academic Consideration, they will be withdrawn (WDN) from the course. The student may appeal to the Associate Dean (Academic) for reinstatement with an Incomplete (INC) standing. Where an appeal for INC is granted, their maximum course load may be reduced during the term in which they complete the outstanding course requirements.

Information about Missed Coursework
Students must familiarize themselves with the *University Policy on Academic Consideration – Undergraduate Students in First Entry Programs,* posted on the Academic Calendar: https://uwo.ca/univsec//pdf/academic_policies/appeals/academic_consideration_Sep24.pdf,

This policy does not apply to requests for Academic Consideration submitted for **attempted or completed work**, whether online or in person. The policy also does not apply to students experiencing longer-term impacts on their academic responsibilities. These students should consult Accessible Education.

For procedures on how to submit Academic Consideration requests, please see the information posted on the Office of the Registrar's webpage: https://registrar.uwo.ca/academics/academic_considerations/ All requests for Academic Consideration must be made within 48 hours after the assessment date or submission deadline.

Special Examination
Per university policy, Academic Consideration requests with supporting documentation are required for the final examinations scheduled during official examination periods by the Registrar's Office.

If the student has been approved by the Academic Advising Office to write a Special Examination (SPC) and the final exam is their only outstanding course component, an SPC will be assigned to them and scheduled by the instructor per university policy.
If the student misses their SPC exam and is approved for Academic Consideration, they will be withdrawn from the course without academic penalty. If they experienced extenuating circumstances such as prolonged illness, they may appeal to the Associate Dean (Academic), on a case-by-case basis, for the opportunity to write the final exam the next time the course is offered. An outstanding SPC will reduce their course load for the term in which the exam is deferred, as outlined in the Definitions of Types of Examinations policy.
If the student misses their SPC exam and Academic Consideration is not approved, or was not requested, they will receive a grade of zero on the exam.

Additional Statements (PLEASE READ)

Religious Accommodation

When a recognized religious holiday either requires a student to be absent from the University, or requires or prohibits an activity that makes it impossible for them to complete an academic requirement scheduled that day, they are entitled to accommodation. No student will be penalized for an absence for religious reasons, and an alternative means of satisfying the requirement will be arranged. This accommodation is provided in accordance with the University's policy on Accommodation for Religious Holidays:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

The student should submit their requests through the Student Absence Portal (SAP), identifying the conflict and the specific course component(s) affected (e.g., test, midterm, exam).

> **Midterms and Tests**: If a religious observance conflicts with a midterm test, they must submit their request no later than **one week** before the test. Their instructor will arrange an early sitting of the test. As set out above, no makeup test is offered for any other reason; this early sitting is available specifically for this accommodation.
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> **Final Examinations**: If a religious observance conflicts with the final exam, the student must submit their request no later than **two weeks** before the exam. Their instructor will arrange a Special Examination to take place no later than one month after the end of the examination period.

Students are responsible for finding out what was covered in any class they miss due to a religious observance, and for taking the appropriate steps to keep up with the course.
If a suitable arrangement cannot be reached between a student and their instructor, they should consult the Undergraduate Chair of the department offering the course, and if necessary, the Associate Dean (Academic) of the Faculty of Science.
For a list of recognized religious observances, please visit the calendars posted on the Equity, Diversity & Inclusion website - https://www.edi.uwo.ca (About Us – Resources – Additional Resources – Calendars).

Academic Accommodation Policies

Students with disabilities are encouraged to contact Accessible Education, which provides recommendations for accommodation based on medical documentation or psychological and cognitive testing. The policy on Academic Accommodation for Students with Disabilities can be found at:
https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic Accommodation_disabilities.pdf.

General Academic Policies
The website for Registrar Services is https://www.registrar.uwo.ca/.
Use of @uwo.ca email: In accordance with policy, https://www.uwo.ca/univsec/pdf/policies_procedures/section1/mapp113.pdf, the centrally administered e-mail account provided to students will be considered the individual's official university email address. It is the responsibility of the account holder to ensure that emails received from the University at their official university address are attended to in a timely manner.
Requests for Relief (formally known as "appeals")
Policy on Request for Relief from Academic Decision:
https://uwo.ca/univsec//pdf/academic_policies/appeals/requests_for_relief_from_academic_decisions.pdf
Procedures on Request for Relief from Academic Decision (Graduate):
https://uwo.ca/univsec//pdf/academic_policies/appeals/graduate_requests_for_relief_procedure.pdf

Scholastic Offences
Policy on Scholastic Offences:
https://uwo.ca/univsec//pdf/academic_policies/appeals/scholastic_offences.pdf
Procedures on Scholastic Offences (Graduate):
https://uwo.ca/univsec//pdf/academic_policies/appeals/graduate_scholastic_offence_procedure.pdf

Use of Electronic Devices During Assessments
In courses offered by the Faculty of Science, the **possession** of unauthorized electronic devices during any in-person assessment (such as tests, midterms, and final examinations) is strictly prohibited. This includes, but is not limited to: mobile phones, smart watches, smart glasses, hidden cameras and wireless earbuds.
Unless explicitly stated otherwise in advance by the instructor, the presence of any such device at a student's desk, on their person, or within reach during an assessment will be treated as a scholastic offence, **even if the device is not in use**.
Effective September 2026, the typical penalty for this offence is a failing grade in the course AND a 12-month prohibition on retaking the course.
Only devices expressly permitted by the instructor (e.g., non-programmable calculators) may be brought into the assessment room. It is their responsibility to review and comply with these expectations.

Use of Generative AI Tools
Unless otherwise stated, the use of generative AI tools (e.g., ChatGPT, Microsoft Copilot, Google Gemini, or similar platforms) is **not permitted** in the completion of any course assessments, including but not limited to: assignments, lab reports, presentations, tests, and final examinations.
Using such tools for content generation, code writing, problem solving, translation, or summarization—when not explicitly allowed—will be treated as a **scholastic offence**.
If the use of generative AI is permitted for a particular assessment, the conditions of use will be specified by the instructor in advance. If no such permission is granted, students must assume that use is

prohibited. It is the student's responsibility to seek clarification before using any AI tools in academic work.

Support Services

Academic Advising. Please visit the Science & Basic Medical Sciences Academic Advising webpage for information on adding/dropping courses, academic considerations for absences, requests for relief, exam conflicts, and many other academic-related matters: https://www.uwo.ca/sci/advising/.

Mental Health Support. Students who are in emotional/mental distress should refer to Mental Health@Western (https://uwo.ca/health/) for a complete list of options about how to obtain help.

Gender-Based and Sexual Violence. Western is committed to reducing incidents of gender-based and sexual violence (GBSV) and providing compassionate support to anyone who has gone through these traumatic events. If a student has experienced GBSV (either recently or in the past), they can find information about support services for survivors, including emergency contacts, at:
https://www.uwo.ca/health/student_support/survivor_support/get-help.html.
To connect with a case manager or set up an appointment, please contact support@uwo.ca.

Accessibility for Coursework. A student may contact the course instructor if they require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to them. If they have any questions regarding accommodations, they may also contact Accessible Education at http://academicsupport.uwo.ca/accessible_education/index.html

Learning Development and Success. Learning-skills counsellors at Learning Development and Success (https://learning.uwo.ca) are ready to help students improve their learning skills. The facility offers strategies for improving time management, multiple-choice exam preparation/writing, textbook reading, and more. Individual support is offered throughout the Fall/Winter terms in the drop-in Learning Help Centre, and year-round through individual counselling.

Student Councils.

Student-run support services are offered by the University Students' Council (https://westernusc.ca) and the Science Students' Council (https://www.westernssc.ca).