

**Earth Sciences 3321a - PHYSICS OF THE EARTH'S INTERIOR I  
Fall 2014**

**1. COURSE INFORMATION**

3 Lectures per week (M W F 12:30-13:20PM in KB 208)

1 Lab/Tutorial per week (Tues 14:30 - 16:30) BG 0184

**1a. Prerequisites** [Earth Sciences 2220A/B](#) or the former 2221A/B or special permission.

Unless you have either the requisites for this course or written special permission from your Dean to enrol in it, you may be removed from this course and it will be deleted from your record. This decision may not be appealed. You will receive no adjustment to your fees in the event that you are dropped from a course for failing to have the necessary prerequisites

**2. INSTRUCTOR INFORMATION** Prof. Rick Secco (BG Rm 0178) [secco@uwo.ca](mailto:secco@uwo.ca)

**3. COURSE SYLLABUS** An introduction to physics of the Earth's interior. Major topics are: Earth structure from seismic observations, heat flow, the physics of minerals under high temperatures and pressures, equations of state, seismological, thermal and compositional models.

**Antirequisite(s):**

**Prerequisite(s):** [Earth Sciences 2220A/B](#) or the former 2221A/B.

**Corequisite(s):**

**Pre-or Corequisite(s):**

**Extra Information:** 3 lecture hours, 2 tutorial hour, 0.5 course.

i. **Solar System**

formation of planetary system

- **solar system** characteristics
- orbital **gravitational** mechanics of gas
- building the planets
- **accretionary** sequence, T-Tauri solar stage, Snow Line, accretion time estimates
- non-gravitational aspects of very small objects

**meteorites**

- **chondrites, achondrites, stony-irons, irons**
- **carbonaceous chondrites** - primitive composition
- irons - Widmanstätten structure, kamacite, taenite, cooling rates vs. parent body

size

ii. **Global Seismology**

**elasticity and equations of state**

Adams-Williamson equation, **density** models  
earth structure from body wave data

### **free oscillations**

### **PREM - Preliminary Reference Earth Model**

internal constitution

- compositional Earth models from seismological models
- **mineralogy models** of the mantle
- **core** compositional models
- inner core **elastic anisotropy**, super-rotation

### iii. **Thermal State**

**thermal conduction** (lattice and electronic)

**heat flow** density

heat conduction equation

- 1-d with/without heat production

surface temperature variation (propagation dependence on depth and time)

- sinusoidal (daily, annual)
- step function (impact, dike intrusion, deglaciation)
- arbitrary

heat transport

heat flow measurement

oceanic and continental heat flow

**global heat flow** map

**geotherm**

- upper mantle constraints: **peridotites, kimberlites, olivine-spinel, spinel - perovskite + magnesiowustite, periclase**
- lower mantle constraints: **adiabat, high P,T** melting experiments on perovskite and magnesiowustite
- core constraints: high P,T melting experiments on iron at inner core boundary conditions, adiabat

**mantle convection**

- layered vs. whole mantle

core convection

### iv. **Physics of Minerals**

**transport properties** overview

- driving force, flux, material properties

**electrical conduction**

- band theory concepts
- **metallic and semi-conduction**
- ionic, hopping (vacancy and intervalence charge transfer) conduction
- **ionic diffusion**, Nernst-Einstein equation

mantle electrical conductivity structure

- high P,T experiments
  - lower mantle conductivity derived from geomagnetic variations (1969 Jerk)
- core electrical conductivity
- high P,T experiments
  - **geodynamo** constraints - magnetic Reynolds number, lower bound
  - thermal constraints - estimate of outer core thermal conductivity, electrical conductivity calculation from Weidemann-Franz Law

#### **4. COURSE MATERIALS**

There is no text book for this course but the lecture material may be found in the general and more specific reference books listed below.

##### **General Reference Books**

FUNDAMENTALS OF GEOPHYSICS, W. Lowrie, Cambridge University Press, 1997.  
 PHYSICS OF THE EARTH 3rd ed., F. D. Stacey, Brookfield Press, 1992.  
 THE SOLID EARTH C.M.R. Fowler, Cambridge University Press, 1990.  
 THE APPLICATION OF MODERN PHYSICS TO THE EARTH AND PLANETARY INTERIORS. S.K. Runcorn ed. Wiley, 1969.  
 THE INTERIOR OF THE EARTH, 2nd ed., M.H.P. Bott, Edward Arnold, 1982.  
 INTRODUCTION TO GEOPHYSICS, G.D. Garland, W.B. Saunders Co., 1979.  
 THE EARTH, H. Jeffreys, Cambridge University Press, 6th edition, 1976.

##### **Specific Reference Books**

###### **Section 1**

ORIGIN OF THE EARTH AND MOON, A.E. Ringwood, Springer Verlag, 1979.  
 METEORITES; THEIR RECORD OF EARLY SOLAR SYSTEM HISTORY, J.T. Wasson, Freeman, 1985.  
 AN INTRODUCTION TO PLANETARY PHYSICS, W.M. Kaula, Wiley, 1968.

###### **Section 2**

THE EARTH'S DENSITY, K.E. Bullen, Wiley, 1975.  
 DEEP INTERIOR OF THE EARTH, J.A. Jacobs, Chapman & Hall, 1992.  
 THE EARTH'S CORE, 2nd edition, J.A. Jacobs, Academic Press, 1987.

###### **Section 3**

THE INACCESSIBLE EARTH, 2nd ed., G.C. Brown and A.E. Mussett, Chapman & Hall, 1993.  
 THEORY OF THE EARTH, D.L. Anderson, Blackwell Sci. Pubs., 1989.

###### **Section 4**

INTRODUCTION TO THE PHYSICS OF THE EARTH'S INTERIOR, J-P. Poirier, Cambridge University Press, 1991.  
 INTRODUCTION TO THE PHYSICS OF ROCKS, Y. Gueguen and V. Palciauskas, Princeton Univ. Press, 1994.

#### **5. METHODS OF EVALUATION**

##### **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 above (or any other book). Marks will be reduced on late assignments at a rate of 20%/day. Missed assignments will receive a grade of zero. There will be an assignment after each major lecture section (i.e. a total of 4 assignments or one approximately every 3 weeks) as well as short assignments approximately every week. Each lecture section will occupy approximately 25% of the total lecture time.

### **Seminar**

Each student will be required to present a 20 minute seminar and hand in a written report (approximately 10 pages of text) on an approved topic of her/his choice. Seminars will be given at a date to be determined near the end of term. Details will follow.

### **Midterm Test**

A midterm test will follow immediately after completion of the first two sections of the course.

### **Final Exam**

A 3 hour final exam will be set during the December exam period.

### **Grade**

The final grade will be calculated with the following approximate distribution :

Assignments	15%
Seminar	20%
Midterm	30%
Final Exam	35%

## **6. ADDITIONAL STATEMENTS**

### **i. Use of Electronic Devices.**

Use of electronic devices (cell phones, music players and cameras) will not be permitted during class or during the midterm test or exam.

### **ii. Use of Personal Response Systems (Clickers)** - not applicable

### **iii. Academic Offences**

Scholastic offences are taken seriously and students are directed to read the appropriate policy, specifically, the definition of what constitutes a Scholastic Offence, at the following Web site: [http://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/scholastic\\_discipline\\_undergrad.pdf](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholastic_discipline_undergrad.pdf)

All required papers may be subject to submission for textual similarity review to the commercial plagiarism detection software under license to the University for the detection of plagiarism. All papers submitted for such checking will be included as source documents in the reference database for the purpose of detecting plagiarism of papers subsequently submitted to the system. Use of the service is subject to the licensing agreement, currently between The University of Western Ontario and Turnitin.com (<http://www.turnitin.com> ).

### **iv. Support Services**

The website for the registrar's office <http://www.registrar.uwo.ca>

#### **v. Student's Responsibilities in the Event of a Medical Issue**

If you are unable to meet a course requirement due to illness or other serious circumstances, you must provide valid medical or other supporting documentation to the Dean's office as soon as possible and contact your instructor immediately. It is the student's responsibility to make alternative arrangements with their instructor once the accommodation has been approved and the instructor has been informed. In the event of a missed final exam, a "Recommendation of Special Examination" form must be obtained from the Dean's Office immediately. For further information please see: <http://www.uwo.ca/univsec/handbook/appeals/medical.pdf>

A student requiring academic accommodation due to illness, should use the Student Medical Certificate when visiting an off-campus medical facility or request a Records Release Form (located in the Dean's Office) for visits to Student Health Services.

The form can be found here: [https://studentservices.uwo.ca/secure/medical\\_document.pdf](https://studentservices.uwo.ca/secure/medical_document.pdf)

Students who are in emotional/mental distress should refer to Mental Health@Western <http://www.uwo.ca/uwocom/mentalhealth/> for a complete list of options about how to obtain help.