GEOL498A – Planetary Geology (Fall 2018)

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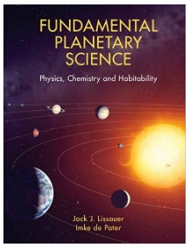
COURSE DESCRIPTION

This course is a 400-level elective designed for the new **'Space Resources' graduate degree program** at Mines, although anyone is eligible to enrol. The course provides an introduction to the geology of planets, moons, and other bodies within and beyond our solar system, focusing on topics such as **(a)** the origin and composition of our solar system and its constituent materials, **(b)** geologic processes occurring on planetary surfaces (e.g. cratering) and shallow and deep interiors (e.g. volcanism, mantle convection), **(c)** methods of solar system exploration, and potential for resource discovery and utilization on near-neighbors and asteroids, and **(d)** comparative planetology (thermal histories, evidence for plate tectonics, origin and retention of atmospheres, exobiology). This course will have a focus on petrology and so it is recommended that students have taken GEOL307 (Petrology) or equivalent. This is a **three-credit-hour course** and will involve **two hours of lectures** and **one three-hour lab** per week.

RECOMMENDED READING AND OTHER REQUIRED MATERIALS

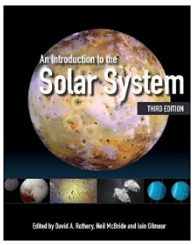
Two texts will be referred to during this course, and if you have an interest in reading around the materials presented in class, I recommend purchasing a copy (although this is **not** a requirement):



Lissauer and de Pater (2013)

Fundamental Planetary Science: Physics, Chemistry and Habitability, 1st edition

https://www.amazon.com/Fundamental-Planetary-Science-Chemistry-Habitability/dp/052161855X



Rothery *et al*. (2018)

An Introduction to the Solar System, 3rd edition

https://www.amazon.com/Introduction-Solar-System-David-Rothery/dp/1108430848/ref=dp_ob_title_bk

Note that some lecture topics are not covered by either of these texts, and I will recommend additional sources for background reading in these cases. For the laboratory component of this class, please bring along stationery (e.g. protractor, ruler) and a calculator. A laptop would be beneficial, but is not always necessary; however, I will let you know in advance about any labs the *require* a computer. In these cases, if you don't have a personal computer to bring, you can take the lab to one of the computer labs in Berthoud Hall or your own department, as necessary.

SCHEDULING

Lectures will take place at 09:00–09:50 every Monday and Wednesday in Berthoud Hall, room BE 106. Labs will be held on Friday afternoons (13:00–15:50) mostly in Berthoud Hall, room BE 204, except for those in weeks 4 and 8, which will be in the microscope lab (BE 401). Be aware of public holidays/non-class days that will disrupt this schedule somewhat (see the timetable end of this document).

I understand that there will be occasions where you cannot attend class for perfectly good reasons. I do not enforce attendance, but I may make note of who is present each week for my own interest. If you do miss a class, download the session's material from Canvas, borrow a classmate's lecture notes, as they will have (hopefully) made many additional notes that are not explicitly printed on the slides or handouts, or drop by my office/email me to clarify anything you didn't understand. I do not have set office hours: come any time.

CLASSROOM CONDUCT

Lectures: Please keep cell phone usage to a minimum, and preferably have them on silent or vibrate. If you have to make a call, please leave the room (you do not need to ask permission: just be discrete and don't disturb the flow). Laptops and tablets are permitted only if being used to take notes. Please don't have conversations while I am speaking, which can be disruptive. However, I welcome questions about what is being discussed, which are best asked at the time that the material is on the projector screen. You don't have to wait until the end! Simply wait for a natural break in my speaking to interrupt.

Labs: Three hours is a long time to concentrate and sit in one place: I encourage you to take breaks as and when you need to. The atmosphere in the labs will be much relaxed than lectures; feel free to chat to each other to problem-solve, although all work you turn in must be your own.

WORK OUTSIDE OF CLASS

This is a senior-level class and will require you to dedicate some of your time outside of class to strengthening your knowledge and learning. There is no good way to judge how much time each person will spend per week, as everybody learns in different ways and at different paces, but a rough estimate would be 4–6 hours. This work may include reviewing lecture notes, reading journal articles, completing lab exercises, and working on independent and group assignments. Additionally, please check the Canvas course page and your email regularly. N.B. Most of the above-described work outside of class will require the use of a computer; for example, to download and read papers, make presentations, perform calculations etc. If this will be a problem for you, please let me know before semester starts: we will work something out.

ASSIGNMENTS AND GRADING

The following criteria will be used to grade performance during this course:

- Laboratory exercises (30% of final grade)

Friday's laboratory exercises should be handed in to me (or sent electronically) before the start of the next week's Friday session (i.e. it is not essential that you finish the exercises during the allotted lab time; you will

have seven days afterwards to complete them at your leisure). An average grade for the entire semester's lab work will be based on the percentage table shown below. This value will then represent 30% of your final grade. For example, if your lab work carries an average of 90% (i.e. an A−), this will count as 27% towards your final grade for the course. Late assignments are not accepted, and are marked as zero, unless you have a compelling justification (e.g. medical issue).

- Individual and group presentations (30% of final grade)

Effective oral presentation is a critical skill for all university students to acquire, whatever they choose to do after graduation. As such, there will be two main opportunities to present to the class on topics related to global tectonics: once in pairs (or larger groups, depending on the class size) and once individually. Presenters will be marked on criteria such as their ability to clearly explain concepts to their peers and effective time management (i.e. don't create too few or too many slides for the amount of time allocated!). The audience will be expected to ask at least one question of the presenters during the lab. Of the 30% of the total grade for the course, 10% will come from the paired presentation and 20% will come from the individual presentation.

- Midterm (15%) and Final (25%) exams

This class will have a Midterm exam in week 8 (October 12th, 2018) and a Final exam during week 18 (starting December 10th, 2018). The time and date for the Final will be organized closer to the time according to the University schedule. I will inform you of this as soon as it has been organized.

Final grades will be assigned according to the following, standard mark scheme (%):

A = 100–94	**A− = 93.9–90**	**B+ = 89.9–87**	**B = 86.9–83**	**B− = 82.9–80**
C+ = 79.9–77	**C = 76.9–70**	**D+ = 69.9–67**	**D = 66.9–60**	**F < 59.9**

ACADEMIC INTEGRITY AND STUDENT NEEDS

Academic dishonesty includes – but is not limited to – cheating and plagiarism, and is a very serious issue. I am obligated to report any students found guilty of committing such offenses on course-related activity to the Office of Academic Affairs. There will be no exceptions, and you will automatically fail the course. As there is a fine line between paraphrasing what is written in an academic paper and simply copying it verbatim, for example, please visit my office to discuss this further if you require clarification. Furthermore, it is your responsibility to familiarize yourself with CSM's Policy on Academic Integrity/Misconduct (https://ccit.mines.edu/POGO-Student) and your attendance of this course assumes that you have done so.

The Colorado School of Mines is committed to ensuring the full participation of all students in its programs, including students with disabilities. If you are registered with Disability Support Services (DSS) and I have received your letter of accommodations, please contact me at your earliest convenience so we can discuss your needs in this course. For questions or other inquiries regarding disabilities, I encourage you to visit disabilities.mines.edu for more information.

Note: the information provided in this document is subject to change at any point up until the beginning of class in Fall 2018. This version was produced on Thursday, 16 August 2018.

Week	Date	Lecture/Lab	Topic
1	Aug 20, 2018	Lecture 1	Course outline and solar system overview
	Aug 22, 2018	Lecture 2	Brief history of planetary science and the methods of solar system exploration
	Aug 24, 2018	Lab 1	Basic concepts of planetary geology; history of solar system exploration (BE 204)
2	Aug 27, 2018	Lecture 3	Orbital dynamics and gravity: solar system organization, measuring and predicting the motion of bodies
	Aug 29, 2018	Lecture 4	Origin of the solar system 1; the solar nebula, elemental abundances, stellar classification
	Aug 31, 2018	Lab 2	Kepler's Laws, Newtonian Gravitation, clockwork of the solar system (BE 204)
3	Sep 3, 2018	NO LECTURE	LABOR DAY
	Sep 5, 2018	Lecture 5	Origin of the solar system 2: origin of the Sun and planets, short-lived radionuclides and early chronology
	Sep 7, 2018	Lab 3	Isotope geochronology exercises; age of the Earth and solar system materials (BE 204)
4	Sep 10, 2018	Lecture 6	Sources and transfer of thermal energy within planets
	Sep 12, 2018	Lecture 7	The Earth 1: internal structure, geochemistry, differentiation
	Sep 14, 2018	Lab 4	Petrological Lab 1 – Earth materials from different tectonic environments (not graded) (BE 401)
5	Sep 17, 2018	Lecture 8	The Earth 2: atmosphere–hydrosphere–lithosphere interactions, magnetism
	Sep 19, 2018	Lecture 9	The Earth 3: plate tectonics, changing regimes throughout Earth history
	Sep 21, 2018	Lab 5	Landing site selection (BE 204)
6	Sep 24, 2018	Lecture 10	Meteorites: general classification, history, and geochemistry
	Sep 26, 2018	Lecture 11	Impacts and impactors; cratering
	Sep 28, 2018	Lab 6	Meteorites, cratering, and early solar system evolution (BE 204)
7	Oct 1, 2018	Lecture 12	The Moon 1: formation, differentiation, and general geology
	Oct 3, 2018	Lecture 13	The Moon 2: landforms of the lunar surface, isotopic dating, lunar meteorites
	Oct 5, 2018	Lab 7	Group oral presentations on key topics of planetary science interest (BE 204)
8	Oct 8, 2018	Lecture 14	The Moon 3: volatile content, utilization of lunar resources
	Oct 10, 2018	Lecture 15	Recap of weeks' 1–8 lecture and lab material in preparation for Midterm
	Oct 12, 2018		MIDTERM
9	Oct 15, 2018	NO LECTURE	FALL BREAK
	Oct 17, 2018	Lecture 16	The geology of Mercury: history of observations, pre- and post-MESSENGER views and models
	Oct 19, 2018	Lab 8	Petrological Lab 2 – Earth material analogues for extraterrestrial lid-tectonic regimes (BE 401)
10	Oct 22, 2018	Lecture 17	Venus: atmosphere, surface, and interior; current and past plate tectonics
	Oct 24, 2018	Lecture 18	Mars 1: history of investigation (telescopic and spacecraft exploration), general geology of surface and interior
	Oct 26, 2018	Lab 9	Mars evolution, and petrological calculations on volatile abundance and transport (BE 204)
11	Oct 29, 2018	Lecture 19	Mars 2: atmosphere, volcanoes, geological and geomorphological evidence for volatiles
	Oct 31, 2018	Lecture 20	Mars 3: Martian meteorites, impact cratering, geological history, potential for resource exploration and colonization
	Nov 2, 2018	Lab 10	Origin and behavior of asteroids (not graded) (BE 204)
12	Nov 5, 2018	Lecture 21	Asteroids: formation, classification, and resource potential
	Nov 7, 2018	Lecture 22	Jupiter 1: formation, physical and orbital properties, atmosphere, and rings
	Nov 9, 2018	Lab 11	Geochemistry of the Earth and its various spheres (BE 204)
13	Nov 12, 2018	Lecture 23	Jupiter 2: Galilean satellites (Io, Europa, Ganymede, and Callisto)
	Nov 14, 2018	Lecture 24	Saturn, Titan, and regular satellites
	Nov 16, 2018	Lab 12	Individual student oral presentations (1): review of key paper on planetary science (BE 204)
14	Nov 19, 2018	Lecture 25	Uranus, Neptune, and Pluto
	Nov 21, 2018	NO LECTURE	NO-CLASS DAY PRE-THANKSGIVING
	Nov 23, 2018	NO LAB	THANKSGIVING
15	Nov 26, 2018	Lecture 26	Comets: anatomy, short- and long-period sources, chemical composition
	Nov 28, 2018	Lecture 27	Origin of life on Earth and its possibility elsewhere in the solar system
	Nov 30, 2018	Lab 13	Individual student oral presentations (2): review of key paper on planetary science (BE 204)
16	Dec 3, 2018	Lecture 28	Exoplanets
	Dec 5, 2018	Lecture 29	Course summary, future directions, open discussion
	Dec 7, 2018	Lab 14	Recap of weeks' 9–16 lecture and lab material; revision session for final exam (not graded) (BE 204)
	Week starting Dec 10, 2018		FINAL