

Course Syllabus
ASTRONOMY 2201b : Planetary Systems
Winter 2021

Description: An examination of planets and their environments, both in our own Solar System and in planetary systems around other stars. Celestial mechanics; dynamics of the Earth; the Earth-Moon System; planets, including atmospheres and interiors; satellites; comets; meteors; the interplanetary medium; detection, origin and evolution of planetary systems.

The course is mathematical and is directed at students with a mathematics and physics background.

Prerequisites: (Physics 1028A/B or Physics 1301A/B or Physics 1401A/B or Physics 1501A/B) and (Physics 1029A/B or Physics 1302A/B or Physics 1402A/B or Physics 1502A/B); Calculus 1000A/B or Calculus 1500A/B, and Calculus 1501A/B (or Calculus 1301A/B with a minimum mark of 85%). Integrated Science 1001X with a minimum mark of 60% can be used in place of Physics 1302A/B and Calculus 1301A/B.

Lectures online – One weekly Zoom synchronous meeting every Thursday starting on Thurs, Jan 14, 2021 @1330-1530.

Location: Zoom [<https://westernuniversity.zoom.us/j/98957302759>]

The in-person lectures for this course will be on Zoom [<https://westernuniversity.zoom.us/j/98957302759>]. You must join with your uwo email or you will be denied entry. I encourage you to use your full [preferred] name as your screen name, but if you prefer to use a pseudonym you may do so, if you email me ahead of time and tell me what it is. The lectures will be recorded and posted to the OWL site within 48 hours of the lecture. You are encouraged to ask questions throughout the lecture: you may raise your hand and ask with audio and/or video, or you may post a question in the chat, either to the whole class or to me privately. If you send the question privately, I will read it to the class but I will not include your name. If you ask a question and do not wish your face or voice to be included in the lecture recording, I will edit you out of the video before posting it: you can let me know for specific lectures or give me your preference for the entire term. I will post public comments with the lecture video, but I will edit out private comments.

The purpose of posting the lecture recordings is to allow students who have a conflict to attend classes asynchronously. It is not to provide an archive of classes for studying. For this reason, **class recordings will be deleted after 10 days**. You are responsible for viewing missed lectures in a timely way, and for getting notes from a colleague if you are not able to view the lecture.

Note that these synchronous lectures each week will be structured as follows: I will summarize and provide an overview of the topic for the week with a focus on learning objectives for the material; I will solve numerical problems related to topics for the week and I will provide time for questions about the material topic for the week.

Note: Unless you have either the prerequisites for this course or written special permission from your Dean to enroll 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.

Instructor:

Dr. Peter Brown (pbrown@uwo.ca) **When contacting me by e-mail, please use your UWO e-mail account.** Other accounts (such as gmail, hotmail and yahoo) are often tagged as spam and may not reach me.

General Course Topics (Roughly follows first 15 Chapters in textbook, except Ch 3, 7, 10 and 13)

1. Introduction – Overview of the solar system (Ch 1)
2. Celestial Dynamics (Ch 2)
3. Solar Heating and Energy Transport (Ch 4)
4. Planetary Atmospheres (Ch 5)
5. Planetary Surfaces / Interiors : Individual worlds (Giant + Terrestrial planets)(Ch 6 & 8-9)
6. Meteorites (Ch 11)
7. Minor Planets and Comets (Ch 12)
8. Extrasolar Planets (Ch 14)
9. Planet Formation (Ch 15)

Teaching Assistants:

Hadi Papei (hpapei@uwo.ca) and Bethany Schefter (bschefte@uwo.ca).

Course Website: Students should check OWL (<http://owl.uwo.ca>) on a regular basis for news and updates. This is the primary method by which information will be disseminated to all students in the class. Students are responsible for checking OWL on a regular basis. Lectures, lecture notes and assignments are posted on Owl and assignments are to be submitted through Owl.

Office hours:

To be given on the Owl site once the class decides a preferred time block.

Textbook: The *required e-textbook* is "Fundamental Planetary Science: Physics, Chemistry and Habitability" (Updated edition - 2019) by Jack J. Lissauer and Imke de Pater.

Reading comments:

Each week, you will be assigned textbook sections and notes to read. You must then log on to Perusall through the Perusall tab in OWL and leave comments on the textbook. You will be graded by AI on how thoughtful your comments and questions are. You may answer other students' questions and comment on their comments; at the moment, you will be anonymous to one another, but identified to me. You will receive full marks for the reading if you enter enough thoughtful comments, and will receive 0 if you do not meet the threshold. Aim for at least one comment every ~5 pages of text. Your lowest two grades for readings will be dropped, but try not to miss a week. I will use the comments to direct the lectures, focusing on material which is the greatest source of confusion. Note that to log on to Perusall, you must enter your Western user ID (the first part of your email without the @uwo.ca) so that you will receive credit. **DO NOT USE YOUR STUDENT NUMBER.**

Course Objectives and Prerequisites: The course is intended to offer a detailed survey of what is presently known about the origin, evolution and current makeup of our solar system and other planetary systems. It is also designed as an introductory overview of modern planetary science. We start with a summary of the planets and their motions, and then study stars in the context of their role in planetary system formation as well as the properties of extra-solar planets. Along the way we will review the important building blocks of solar system bodies at the atomic and molecular levels as well as examine their mineralogical characteristics. We then consider the nature and significance of comets, asteroids and meteorites in the solar system, and finally examine planetary interiors, surfaces and atmospheres as well as other planetary systems. Throughout the course, we will try to understand how objects have formed and evolved and the main physical processes which are key in shaping our modern solar system and how this relates to other planetary systems. An important objective of the course is to discover the large range of interesting problems you can solve using your first year physics. The course stresses physical understanding as opposed to rigorous mathematics.

Some of the course material will of course be descriptive. This is partly because a descriptive knowledge of what is known is a necessary background for understanding how objects in the solar system have formed and changed. It is also partly because much of this material is in itself quite interesting; it is hard to imagine here on earth the variety of bodies found orbiting our sun. However, you should always focus your attention particularly on the aspects of the material that require understanding, and resist the temptation to memorize large amounts of insignificant factual material.

Learning Outcomes:

- Understand, contrast and critique the ancient and modern understandings of the nature of our Solar System.
- Identify and explain the fundamental scientific principles that determine the dynamical behavior, formation, evolution, surface features, interior structure of planets and small bodies in the solar system, and apply these principles to other planetary systems.
- Quantitatively solve numerical problems to apply fundamental scientific principles to the interpretation of processes and phenomena occurring in the solar system

Class Format: A large fraction of the time you spend on this course will be devoted to understanding and reading the primary class textbook, " Fundamental Planetary Science " by Lissauer and De Pater and providing comments and questions through Perusall. Each week we will cover roughly one chapter in the text. For each chapter/topic covered in the text I will upload to Owl a set of lecture notes which outlines specific learning objectives for the material as well as a video lecture using these course notes to guide your study of this material and explain the subject in a way which complements the text. The textbook also covers some material in ways which differ from our approach in class helping to solidify concepts.

These asynchronous classes will be supplemented with the synchronous Zoom classes on Thursday where I will summarize aspects of the topic covered in a particular week as well as discussion of the readings. I will also solve problems during the synchronous sessions in addition to other problems I will solve during the recorded lectures.

You are expected to keep up with the reading assignments. One of the primary purposes of this course is to develop good scientific reading skills. My intention is to help you learn to read intelligently, critically and with real comprehension. I expect you to come to class with a well thought-out idea of what the assigned reading is about, and be prepared to discuss its strengths and weaknesses and answer questions that I and other students raise. Gaining a critical understanding of the material in the text is essential for doing well in the course.

Other Reference Material: Most of the material that you will require can be gleaned from the course notes supplemented with the text. All introductory Astronomy books (of which there are a number in the library) have sections of varying quality on the Solar System. Some internet resources can be useful, but much information may be dated or incorrect; be **very cautious in using any internet-based information in conjunction with this course.** A few books dealing specifically with various aspects of the Solar System are (in no particular order):

- An Introduction to the Solar System, eds. D. Rothery, N. McBride and I. Gilmour, 2nd co-edition, 2011.

This book covers the descriptive aspects of our course at a similar level minus any of the mathematics.

- Planetary Surface Processes, J. Melosh, 2011. Cambridge University Press

Very advanced textbook about planetary surfaces. Many excellent quantitative descriptions.

- Atmospheres, R.M. Goody & J.C.G. Walker, 1972. Prentice-Hall.

A short introduction to the physics of planetary atmospheres. Very clear

- Encyclopedia of the Solar System 3rd Edition, Spohn, T., Johnson, T and D. Breuer, 2014. Academic Press.

Grade Evaluation :

30% Perusal reading
20% Mid-term exam
25% Assignments (4)
25% Final Exam

All marks will be posted on the website - more details will be given in class and on the website. You cannot pass this course without a minimum grade of 50% on the weighted average of the midterm and final exam. Any student who does not score at least 50% on the weighted average of the midterm and final exam will not receive a final course grade higher than 49%. Course marks may, in some cases, be adjusted in order to conform to the meaning of course marks described in the Western Academic Calendar and in order to conform to Department policy

Examinations:

- Mid-semester examination: 120 minutes long, worth 20% of final mark. During zoom class **Thursday, Mar 4, 2021 (1330 – 1530)**.
- Final examination: Will be cumulative – but with more emphasis on material since the mid-term (Ch 8) and will consist of a 3 hour zoom proctored exam.
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Use of electronic devices for exams:

The only allowed calculator for exams is the Sharp EL-510RB scientific calculator.

Assignments: There will be a total of 4 problem sets worth 25% of the total course mark, each consisting of 3-4 numerical problems. Problem sets will be posted to Owl together with final dates.

Course Significant Dates (Assignment due dates approximate):

Date (2021)	Event
Jan 14	First Zoom Class
Jan 19	Add deadline for course
Jan 29	Assign #1 due ONLINE [OWL] (PDF ONLY)
Feb 12	Assign #2 due ONLINE [OWL](PDF ONLY)
Feb 13-Feb 21	Reading Week – no classes
Mar 4	Mid-term exam (in class)
Mar 14	Drop deadline for course
Mar 19	Assign # 3 due ONLINE [OWL](PDF ONLY)
Apr 9	Assign #4 due ONLINE [OWL] (PDF ONLY)
Apr 8	Last synchronous Zoom Class
Apr 12	Last day of classes

Problem solving - presentation of solutions:

You must submit assignment solutions through Owl as PDF files under the “Assignments” tab. Note **ONLY** PDF files will be accepted! If you take photos of your written problem solutions they must be converted to a single PDF document and submitted as one file.

The following are some thoughts which you should keep in mind as you work through the problem sets:

- **Write down what you are doing using words** and then give the mathematics. It is very hard to follow an argument which starts with an algebraic manipulation, especially if you make a mistake. Do not fill pages with math and provide no words of explanation!
- State, and justify if necessary, any assumptions that you make (including stating from whence came the formula that you are using).
- Don't blindly apply formulae in the hope that they will miraculously solve the problem, e.g., applying the formula for circular motion when the motion is clearly not circular.
- Explain what the variables are. You can use **B** for radial distance if you tell me that it is just that, conversely don't assume that I will know what **r** is. (A nicely annotated diagram can be very useful in this regard.)

- Don't put in numerical values until you require a numerical answer: you will lose accuracy and may miss cancellation of terms. It is also much harder for someone marking to see what is happening in the mathematics.
- Clearly indicate your final answer to the problem. **Think about your final answer: does it make sense physically?** For example, if you are finding the density of an asteroid and end up with an answer of $10^{20} \text{ kg m}^{-3}$ you should recognize that this is not realistic.
- When you do give a numerical answer think about the number of digits that you should quote. **Pay attention to significant figures in your final answer.**
- Answer all parts of the question\dash in order; leave a space at missing pieces.
- Write out your solutions **legibly**, leaving enough space on the page for the markers comments. Problem assignments may contain portions of typewritten output from computer programs as appropriate, but the bulk of each problem assignment is to be completed in your own handwriting.
- Pay attention to these points. I mark according to them, as well as to whether or not you got the correct answer. Further, if you didn't get the correct answer you will get credit for approaching the problem in the correct way; the more details you give and the clearer your steps the more credit you may expect to receive.
- Note that the marking will include corrections to your answer or sketch the steps in the solution if you get it wrong. I will not post solutions to the assignments – it is your responsibility to ensure you understand where you went wrong in your problem sets; in most cases you will be able to work through the correct answer with the feedback given, but if this is not the case please contact me or the TA to ensure you understand where you went wrong.

Course Policies

Online class and Zoom Etiquette

All of the remote learning sessions for this course may be recorded. The data captured during these recordings may include your image, voice recordings, chat logs and personal identifiers (name displayed on the screen). The recordings will be used for educational purposes related to this course, including evaluations. The recordings may be disclosed to other individuals participating in the course for their private or group study purposes. Please contact the instructor if you have any concerns related to session recordings.

Participants in this course are not permitted to record the sessions, except where recording is an approved accommodation, or the participant has the prior written permission of the instructor.

Some components of this course will involve online interactions. To ensure the best experience for both you and your classmates, please honour the following rules of etiquette:

- “arrive” to class on time
- use your computer and/or laptop if possible (as opposed to a cell phone or tablet)
- ensure that you are in a private location to protect the confidentiality of discussions in the event that a class discussion deals with sensitive or personal material

- to minimize background noise, mute your microphone for the entire class until you are invited to speak, unless directed otherwise
- In order to give us optimum bandwidth and web quality, turn off your video camera for the entire class unless you are invited to speak
- please be prepared to turn your video camera off at the instructor's request if the internet connection becomes unstable
- unless invited by your instructor, do not share your screen in the meeting

The course instructor will act as moderator for the class and will deal with any questions from participants. To participate please consider the following:

- If you wish to speak, use the “raise hand” function and wait for the instructor to acknowledge you before beginning your comment or question.
- Please remember to unmute your microphone and turn on your video camera before speaking.
- Self-identify when speaking.
- Please remember to mute your mic and turn off your video camera after speaking (unless directed otherwise).

General considerations of “netiquette”:

- Keep in mind the different cultural and linguistic backgrounds of the students in the course.
- Be courteous toward the instructor, your colleagues, and authors whose work you are discussing.
- Be respectful of the diversity of viewpoints that you will encounter in the class and in your readings. The exchange of diverse ideas and opinions is part of the scholarly environment. “Flaming” is never appropriate.
- Be professional and scholarly in all online postings. Use proper grammar and spelling. Cite the ideas of others appropriately.

Note that disruptive behaviour of any type during online classes, including inappropriate use of the chat function, is unacceptable. Students found guilty of Zoom-bombing a class or of other serious online offenses may be subject to disciplinary measures under the Code of Student Conduct.

Grade policy: The Department of Physics and Astronomy may, in rare cases, adjust the final course marks in order to conform to Departmental policy.

Missed assignments: All assignments are to be submitted to Owl on the due date. They must be submitted online through Owl as PDF documents. A late penalty of 10% per day is assessed on all material handed in late. The weekend counts as 2 days i.e. submitting the assignment after the deadline but before Monday at 4:00 pm = -20%. **Assignments more than 5 days late will receive an automatic mark of 0%.**

Missed midterm test: If you do not use a self-reported absence when missing the mid-term, documentation must be provided to the instructor in order for you to receive permission to write a

make-up. This process should be begun by your bringing the documentation to your student counseling office. If you miss the make-up, again documentation must be provided, and your mark will be pro-rated.

Academic Consideration for Student Absence

Students will have up to two (2) opportunities during the regular academic year to use an on-line portal to self-report an absence during the semester, provided the following conditions are met: the absence is no more than 48 hours in duration, and the assessment for which consideration is being sought is worth 30% or less of the student's final grade. Students are expected to contact their instructors within 24 hours of the end of the period of the self-reported absence, unless noted on the syllabus. Students are not able to use the self-reporting option in the following circumstances:

- for exams scheduled by the Office of the Registrar (e.g., December and April exams)
- absence of a duration greater than 48 hours,
- assessments worth more than 30% of the student's final grade,
- if a student has already used the self-reporting portal twice during the academic year

If the conditions for a Self-Reported Absence are *not* met, students will need to provide a Student Medical Certificate if the absence is medical, or provide appropriate documentation if there are compassionate grounds for the absence in question. Students are encouraged to contact their Faculty academic counselling office to obtain more information about the relevant documentation.

Students should also note that individual instructors are not permitted to receive documentation directly from a student, whether in support of an application for consideration on medical grounds, or for other reasons. **All documentation required for absences that are not covered by the Self-Reported Absence Policy must be submitted to the Academic Counselling office of a student's Home Faculty.**

For policy on Academic Consideration for Student Absences, see:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Consideration_for_absences.pdf

and for the Student Medical Certificate (SMC), see:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf

Academic Policies

The website for Registrarial Services is <http://www.registrar.uwo.ca>.

In accordance with policy, <http://www.uwo.ca/its/identity/activatenonstudent.html>, the centrally administered e-mail account provided to students will be considered the individual's official university e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at his/her official university address is attended to in a timely manner.

Cheating University policy states that cheating is a scholastic offence which can result in an academic penalty (which may include expulsion from the program). If you are caught cheating, there will be no second warning. Cheating includes having available any electronic devices other than a watch. You may not have a cell phone accessible during tests or exams, even to use it as a watch. 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.

Computer-marked multiple-choice tests and/or exams may be subject to submission for similarity review by software that will check for unusual coincidences in answer patterns that may indicate cheating.

Plagiarism Students must write their essays and assignments in their own words. Whenever students take an idea or a passage from another author, they must acknowledge their debt both by using quotation marks where appropriate and by proper referencing (such as footnotes or citations). Plagiarism is a major academic offence. 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/scholoff.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 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>

Accessibility Statement

Please contact the course instructor if you require material in an alternate format or if you require any other arrangements to make this course more accessible to you. You may also wish to contact Services for Students with Disabilities (SSD) at 661-2111 x 82147 for any specific question regarding an accommodation.

Support Services

Please contact the course instructor if you require lecture or printed material in an alternate format or if any other arrangements can make this course more accessible to you. You may also wish to contact Student Accessibility Services (SAS) at 661-2147 if you have any questions regarding accommodations.

The policy on Accommodation for Students with Disabilities can be found here:

https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic%20Accommodation_disabilities.pdf

The policy on Accommodation for Religious Holidays can be found here:

http://www.uwo.ca/univsec/pdf/academic_policies/appeals/accommodation_religious.pdf

Learning-skills counsellors at the Student Development Centre (<http://westernusc.ca/services/>) are ready to help you improve your learning skills. They offer presentations on 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.

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

Additional student-run support services are offered by the USC, <http://westernusc.ca/services>.

Code of Student Conduct

To foster a supportive and enriching academic environment that is conducive to learning and free inquiry, Western has a Code of Student Conduct (<http://www.uwo.ca/univsec/pdf/board/code.pdf>).

You can expect your instructor to promote this environment and also respect each student's unique views and opinions. Because Western is also a part of *your* environment, we expect the same from you. Activities that disturb another student's right to this environment will not be tolerated; these include talking during zoom class with mute off about matters irrelevant to the course. You can also expect your instructor to come prepared, on time, and eager to help you learn. In turn, we expect that you will come prepared, on time, and ready to learn.