

**Course Syllabus**  
**ASTRONOMY 2201b : Planetary Systems**  
**Winter 2024**

**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:** Prerequisite(s): (Physics 1202A/B or Physics 1402A/B or Physics 1502A/B, or the former Physics 1029A/B or the former Physics 1302A/B); (Calculus 1000A/B or Calculus 1500A/B or Numerical and Mathematical Methods 1412A/B or the former Applied Mathematics 1412A/B) and (Calculus 1501A/B, or Calculus 1301A/B with a minimum mark of 60% or Numerical and Mathematical Methods 1414A/B or the former Applied Mathematics 1414A/B), or the former Applied Mathematics 1413. Integrated Science 1001X with a minimum mark of 60% can be used in place of Physics 1202A/B and Calculus 1301A/B.

**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](mailto:pbrown@uwo.ca)) phone: 661-2111 extension 86458

**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.

**Teaching Assistant:**

Cole Gregg ([cgregg2@uwo.ca](mailto:cgregg2@uwo.ca))

**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)

**Course Website:** All course material will be posted to OWL: <http://owl.uwo.ca>.

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. Lecture notes and assignments are posted on Owl and assignments are to be submitted through Owl.

If students need assistance with the course OWL site, they can seek support on the OWL Help page. Alternatively, they can contact the Western Technology Services Helpdesk. They can be contacted by phone at 519-661-3800 or ext. 83800.

### **Office hours:**

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

**Required materials/Textbook:** The *required e-textbook* is "Fundamental Planetary Science: Physics, Chemistry and Habitability" (Updated edition - 2019) by Jack J. Lissauer and Imke de Pater. You should use the Owl link for Perusall to purchase an electronic copy. You will also require a Sharp EL-510RB scientific calculator.

### **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 reading. You will be graded based on:

- Starting the reading early
- Breaking the reading into chunks (instead of trying to do it all at once)
- Reading all the way to the end of the assigned reading
- Posing thoughtful questions and comments that elicit responses from classmates
- Answering questions from others
- Upvoting thoughtful questions and helpful answers on how thoughtful your comments and questions are.

You will be anonymous to one another, but identified to me. You will receive full marks for the reading if you follow the requirements of these bullet points. Aim for at least one comment every ~3-5 pages of text. 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 first 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 examine the processes which shape

planetary interiors, surfaces and atmospheres and examine each planet in turn through this lens. We also consider the nature and significance of comets, asteroids and meteorites in the solar system and finally examine other planetary systems. We will end the course with a detailed examination of our current understanding of planetary system formation through synthesis of observations and theory. 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 physical understanding and interpretation.

### **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 before lectures which outlines specific learning objectives for the material. These course notes are meant 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.

**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. The chapter readings in Perusall are only open for the first part of the week so you must complete these before the final class each week discussing the material.

**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 Geoscience, eds McSween et al., 2019

A good, modern introduction to Planetary science with a strong geoscience emphasis – good figures and illustrations.

- 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

- Atmospheric Evolution on the Inhabited and Lifeless Worlds, 2017, Catling and Kasting

Advanced and detailed discussion of planetary atmosphere formation and evolution.

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

### **Grade Evaluation :**

15% Perusal reading  
20% Mid-term test  
30% Assignments (4)  
35% 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 test: 120 minutes long, worth 20% of final mark. Will include all material covered up to just before reading week.
- Final examination: Will be cumulative – but with more emphasis on material since the mid-term (Ch 11 and onwards).

### 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 30% of the total course mark, each consisting of ~3-5 numerical problems. Problem sets will be posted to Owl together with due dates.

**Course Significant Dates (Assignment due dates approximate):**

Date (2024)	Event
Jan 9	First class
Jan 16	Add deadline for course
Jan 26	Assign #1 due ONLINE [OWL] (PDF ONLY)
Feb 9	Assign #2 due ONLINE [OWL](PDF ONLY)
Feb 19-Feb 23	Reading Week – no classes
<b>Feb 27</b>	<b>Mid-term test</b>
Mar 7	Drop deadline for course
Mar 15	Assign # 3 due ONLINE [OWL](PDF ONLY)
Apr 4	Last Class
Apr 8	Assign #4 due ONLINE [OWL] (PDF ONLY)
Apr 8	Last day of classes
Apr 11 – 30	Exam period

**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

**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. **Assignments more than 5 days late will receive an automatic mark of 0%.** To account for situations of short term illness, there is no late penalty for the first 48 hrs. As all assignments are due on Friday, the weekend counts as these 2 flex days i.e. submitting the assignment after the deadline but before Monday at 4:00 pm will not result in penalty, but each day thereafter will accrue a 10% penalty AND the assignment must be handed in before the Wed of the following week at the latest to receive marks.

**Missed midterm test:** you must provide valid medical or supporting documentation to the Academic Counselling Office of your Faculty of Registration as soon as possible. For further information, please consult the University's medical illness policy at

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/academic\\_consideration.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/academic_consideration.pdf)

The Student Medical Certificate is available at

[https://www.uwo.ca/univsec/pdf/academic\\_policies/appeals/medicalform.pdf](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/medicalform.pdf).

This documentation must be provided to the instructor in order for you to receive permission to choose to either write a make-up test or have the mid term test weight placed on the final exam. 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.

## **Absences from Final Examinations**

If you miss the Final Exam, please contact the Academic Counselling office of your Faculty of Registration as soon as you are able to do so. They will assess your eligibility to write the Special Examination (the name given by the University to a makeup Final Exam).

You may also be eligible to write the Special Exam if you are in a “Multiple Exam Situation” (e.g., more than 2 exams in 23-hour period, more than 3 exams in a 47-hour period).

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 must be submitted to the Academic Counselling office of a student's Home Faculty.**

If a student fails to write a scheduled Special Examination, the date of the next Special Examination (if granted) normally will be the scheduled date for the final exam the next time this course is offered. The maximum course load for that term will be reduced by the credit of the course(s) for which the final examination has been deferred. See the Academic Calendar for details (under [Special Examinations](#)).

## **Academic Policies**

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

In accordance with policy,

[https://www.uwo.ca/univsec/pdf/policies\\_procedures/section1/mapp113.pdf](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 e-mail address. It is the responsibility of the account holder to ensure that e-mail received from the University at their 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 during tests/exams. 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](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](http://www.uwo.ca/univsec/pdf/academic_policies/appeals/scholoff.pdf)

## **Accommodation and Accessibility**

### **Religious Accommodation**

When a course requirement conflicts with a religious holiday that requires an absence from the University or prohibits certain activities, students should request an accommodation for their absence in writing at least two weeks prior to the holiday to the course instructor and/or the Academic Counselling office of their Faculty of Registration. Please visit the Diversity Calendars posted on our university's EDID website for the recognized religious holidays:

<https://www.edi.uwo.ca>.

### **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](https://www.uwo.ca/univsec/pdf/academic_policies/appeals/Academic_Accommodation_disabilities.pdf).

### **Support Services**

Please visit the Science & Basic Medical Sciences Academic Counselling webpage for information on adding/dropping courses, academic considerations for absences, appeals, exam conflicts, and many other academic related matters: <https://www.uwo.ca/sci/counselling/>.

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.

Western is committed to reducing incidents of gender-based and sexual violence and providing compassionate support to anyone who has gone through these traumatic events. If you have experienced sexual or gender-based violence (either recently or in the past), you will find information about support services for survivors, including emergency contacts at

[https://www.uwo.ca/health/student\\_support/survivor\\_support/get-help.html](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](mailto:support@uwo.ca).

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 Accessible Education at



[http://academicsupport.uwo.ca/accessible\\_education/index.html](http://academicsupport.uwo.ca/accessible_education/index.html)

if you have any questions regarding accommodations.

Learning-skills counsellors at the Student Development Centre (<https://learning.uwo.ca>) 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.

Western University is committed to a thriving campus as we deliver our courses in the mixed model of both virtual and face-to-face formats. We encourage you to check out the Digital Student Experience website to manage your academics and well-being: <https://www.uwo.ca/se/digital/>.

Additional student-run support services are offered by the USC, <https://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. 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.