Course outline
PHYS 4202/PHYS 5402: Cosmology - Winter 2026

We, the people of the Faculty of Science at Carleton University, acknowledge that our campus is located on the traditional, unceded territories of the Algonquin Anishinabeg people. Miigwetch for your hospitality and stewardship of this territory and the teachings that come from it. We are grateful for this land, the air that we breathe, and the water that sustains us all as well as for the animals, plants and other living beings: these enable us to research, teach, mentor, support, study, and learn. We recognize our responsibility to our natural environment and to reconciliation with Indigenous peoples.

Instructor: Thomas Grégoire (HP 3378, thomasgregoire@cunet.carleton.ca)

Student Hours: Students are welcome to attend student hours at my office to ask questions related to the course material or the problem sets. The times will be posted on Brightspace, but if you can't make it during the allotted time, you can schedule an appointment.

Lectures: Tuesday-Thursday, 11:35 am - 12:55 pm. First lecture on Tuesday January 6 and last lecture on Thursday Dec. 4 2025.

Calendar Description: Observational evidence for the Big Bang. Cosmological space-time, expansion dynamics and contents of the universe. Physical processes in the expanding universe, inflation, nucleosynthesis, the cosmic microwave background, dark matter, and dark energy.

Prerequisites: PHYS 3701, PHYS 3606 or PHYS 3608, and PHYS 2401 or PHYS 4409, or permission of the Department. (PHYS 3606 or PHYS 3608 and PHYS 4409 may be taken concurrently).

Suggested textbook: Barbara Ryden, "Introduction To Cosmology", Second Edition, Cambridge University Press ($66.95 at the Carleton bookstore, $72.12 on Indigo, $ 66.95 on Amazon)

Other references: :

- Scott Dodelson, "Modern Cosmology", Academic Press Incorporated
- Edward Kolb and Michael Turner, "The Early Universe",CRC Press.
- Cosmology, lecture notes by David Tong, `https://www.damtp.cam.ac.uk/user/tong/cosmo.html`

Course Modality: This course will be an in-person course only and is not suitable for remote learning. The lectures will be delivered mainly on the blackboard and will not be recorded. If a student cannot attend class for a limited period of time due to health issues, reference material will be provided.

Website: I will use Brightspace (`https://brightspace.carleton.ca/`) as the course website. I will post a tentative schedule of the semester as well as problem sets.

Content of the course and learning objectives: The goal of this course is to give a description of the evolution of the universe from the Big Bang to today, tracking its expansion history and composition. I am planning to cover the following topics:

- Fundamental observations (ch. 2)
- Aspects of General Relativity (ch. 3)
- Cosmic Dynamics (ch. 4)
- ΛCDM model (ch. 5)
- Dark Matter (ch. 7)
- Thermodynamics in an Expanding Universe
- Cosmic Microwave Background (ch. 8)
- Big Bang Nucleosynthesis (ch. 9)
- Inflation (ch. 10)

The learning objectives are:

- To understand the basic observations that lead to our current understanding of the evolution of the universe.
- To be able to mathematically describe the expansion of the Universe.
- To relate mathematically the content of the universe to the expansion rate.
- To understand the content of the universe at different epoch and calculate the abundance of the various particles in the universe.
- To understand how nuclei formed in the early universe and the parameters that influence their abundance,
- To understand the physics behind the cosmic microwave background and qualitatively relate its spectrum to the parameters of the ΛCDM model.
- To understand the observational evidence for the presence of dark matter.

Important Dates: Some important dates: (For the full list please consult the official calendar.)

- January 16 2026: Last day for registration and course changes (including auditing) in full winter and late winter courses.
- January 31 2026: Last day to withdraw from full winter courses and the winter portion of fall/winter courses with a full fee adjustment
- February 16-20 2026: Winter break, no classes.
- March 15 2026 : Last day to request Formal Examination Accommodations for April full winter, late winter, and fall/winter final examinations from the Paul Menton Centre for Students with Disabilities. Note that it may not be possible to fulfil accommodation requests received after the specified deadlines.
- April 3 2026: Statutory holiday. University closed.
- April 8 2026: Winter term ends, classes follow a Friday schedule.
- April 11-23 2026:Final examinations in full winter, late winter, and fall/winter courses will be held. Examinations are normally held all seven days of the week.

Assessment

Your final grade will be based on the following conversion

$A+ = 90-100$	$B+ = 77-79$	$C+ = 67-69$	$D+ = 57-59$
$A = 85-89$	$B = 73-76$	$C = 63-66$	$D = 53-56$
$A- = 80-84$	$B- = 70-72$	$C- = 60-62$	$D- = 50-52$
$F =$ below 50			

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Homework assignements (30 %): There will be approximately 9 problem sets during the term and the worst problem set will be dropped from the average. You are encouraged to work on your assignments together, but the work that is handed in **must be your own**. You should not look for solutions to the problems on the internet, in particular it is strictly forbidden to use 'homework help' websites or AI tools to solve the problems. Each student is allowed one late problem set without penalty if handed in within 3 calendar days of the due date. Other late problem sets will have a 5% deduction per day late, up to 3 calendar days, after which it will not be accepted without a valid reason.

Midterms (30 %) There will be two midterms, each worth 15 %. The midterms will be during class time.

Final (40 %): There will be a formally scheduled final exam during the examination period.

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Homework assignments: 20 % (see above for the description)

Midterm exams: 25 % (half for each midterm)

Class Presentation: : 15 %. Graduate students will give an in class 20 minutes presentation on a topic of their choice related to cosmology. The topic should be discussed with me before the Winter Break and the presentation will be scheduled during the next to last class.

Final: 40 %

Academic integrity: Students are expected to uphold the values of academic integrity, which include fairness, honesty, trust, and responsibility. Examples of actions that that compromise these values include but are not limited to plagiarism, accessing unauthorized sites for assignments or tests, unauthorized collaboration on assignments or exams, and using artificial intelligence tools such as ChatGPT when your assessment instructions say it is not permitted. Students are expected to familiarize themselves with and follow the Carleton University Student Academic Integrity Policy. Academic dishonesty in any form will not be tolerated. Students who infringe the Policy may be subject to one of several penalties including: expulsion; suspension from all studies at Carleton; suspension from full-time studies; a refusal of permission to continue or to register in a specific degree program; academic probation; or a grade of Failure in the course. Informations on academic integrity and the list of standard sanctions can be found here

Use of AI: : It is strictly prohibited to use AI (Large language models such as ChatGPT) while working on the problem sets or the class presentation. The problem sets are meant to improve your problem solving skills and deepen your understanding of the material by actively thinking about it and questioning it. Using AI to do the problems will defeat this purpose.

You are allowed to use AI to help you understand the material or to learn about further topics, when not working on problems. However I would encourage you instead to ask colleagues or come to office hours.

Academic policy: University rules regarding registration, withdrawal, appealing marks, and most anything else you might need to know can be found on the university's website, here: http://calendar.carleton.ca/undergrad/regulations/academicregulationsoftheuniversity/

Academic accommodation: Carleton University is committed to providing access to the educational experience in order to promote academic accessibility for all individuals. Academic accommodation refers to educational practices, systems and support mechanisms designed to accommodate diversity and difference. The purpose of accommodation is to enable students to perform the essential requirements of their academic programs. At no time does academic accommodation undermine or compromise the learning objectives that are established by the academic authorities of the University. More information can be found at: `https://students.carleton.ca/course-outline/`

Student Rights & Responsibilities Students are expected to act responsibly and engage respectfully with other students and members of the Carleton and the broader community. See the Rights and Responsibilities Policy for details regarding the expectations of non-academic behaviour of students. Those who participate with another student in the commission of an infraction of this Policy will also be held liable for their actions.

Student Concerns If a concern arises regarding this course, your first point of contact is me: Email or drop in during student hours and I will do my best to address your concern. If I am unable to address your concern, the next points of contact are the the Undergraduate Chair, the Departmental Chair and finally, the Office of the Dean.

Accommodations for Missed Work Carleton recognizes that students may be experiencing greater stress and other life factors that are not in their control. As a result, Carleton has put into place a protocol for students to apply for accommodations using a self-declaration form in the event of missed work. Note that these forms should be used for short-term concerns related to missed work; if you are experiencing chronic, ongoing challenges which necessitate a broader solution, I recommend reaching out to the Paul Menton Centre and/or the Care Support team. In case of miss work, the following policies will apply to the various component of the course:

- Homework: In case of a missed homework, the corresponding mark will be dropped from the homework average. Regular homework are an important part of the course and are needed to meet the learning objective of the course, and as such, accommodation (for legitimate reasons) can be granted for a maximum of 2 homework.
- If one of the two midterm is missed for a valid reason, the weight of that midterm will be transferred to the other midterm. If both midterms are missed for valid reasons, a makeup midterm will be arranged.

- For the final exam, accommodation must be arranged through the registrar's office.

Assitsance for students: The following resources might be useful :

- Important dates and Deadlines.
- Academic and Career Development Services.
- Centre for Student Academic Support (CSAS).
- Science Student Success Centre.
- Math Tutorial Centre.

Important Information:

- Student or professor materials created for this course (including presentations and posted notes, labs, case studies, assignments and exams) remain the intellectual property of the author(s). They are intended for personal use and may not be reproduced or redistributed without prior written consent of the author(s).
- Students must always retain a hard copy of all work that is submitted.
- Standing in a course is determined by the course instructor subject to the approval of the Faculty Dean. This means that grades submitted by the instructor may be subject to revision. No grades are final until they have been approved by the Dean.
- Carleton University is committed to protecting the privacy of those who study or work here (currently and formerly). To that end, Carleton?s Privacy Office seeks to encourage the implementation of the privacy provisions of Ontario?s Freedom of Information and Protection of Privacy Act (FIPPA) within the university.
- In accordance with FIPPA, please ensure all communication with staff/faculty is via your Carleton email account. To get your Carleton Email you will need to activate your MyCarletonOne account through Carleton Central. Once you have activated your MyCarletonOne account, log into the MyCarleton Portal.