

# Physics 4553 - ASTROPHYSICS

## Fall 2024

### Description

A broad introduction to the physics of celestial objects including formation, structure and evolution of stars, the physics of the interstellar medium, stellar remnants (white dwarfs, neutron stars, black holes).

### Instructors

#### Instructor

**Professor Marco Cavaglia** [he/him]

Office: Physics 204

Office hours: Wednesday 12:00 p.m. – 1:00 p.m. or by appointment. Please confirm beforehand for availability.

Email: [cavagliam@mst.edu](mailto:cavagliam@mst.edu)

Please address your instructor with his academic title when emailing him. **Emails that do not include a proper salutation or sign-off will not be responded to.** Your instructor will answer to your emails as quickly as possible, but please keep in mind that teaching this course is only one of his many responsibilities. Please be patient with him. If you have not received a response within one working day, do not hesitate to send him a reminder.

### Meeting time and location

Monday, Wednesday, and Friday, 9:00 am. – 9:50 a.m. in Physics 127

### Prerequisites

Physics 2305 “Introduction to Modern Physics”.

## Textbook (required)

Carroll, Bradley W. and Ostlie, Dale A., *An Introduction to Modern Astrophysics*  
Cambridge University Press (2017), ISBN: 9781108422161.

## Objectives

Upon completing this course, the successful student will have an adequate comprehension of the basics of modern astrophysics.

## Evaluation

**Exams.** There will be two midterm exams on Friday, September 27th, and Friday, November 22nd, during class time. The final exam will be on Monday, December 9th from 3:00 p.m. to 5:00 p.m. The first midterm exam will cover the course material from the beginning of the course through Monday, September 23rd (inclusive). The second midterm exam will cover the course material from Monday, September 30th, through Monday, November 18th (inclusive). **The final exam will be in three sections.** Section (a) will cover the material of the first midterm exam. Section (b) will cover the material of the second midterm exam. Section (c) will consist of a problem from any topic covered in the course. **None of the sections are mandatory. If you take parts (a) and/or (b) and score higher than on the corresponding midterm exam, the section score will replace the midterm exam score. Section (c) will be treated as extra credit.**

The exams will consist of a set of problems to be worked out. All exams are open book and you will be allowed to use a *basic* calculator for *basic* algebraic operations. No notes or any other electronic devices, such as computers, tablets, smartphones, or any other internet-connected device, will be permitted. If you miss an exam because of a civil duty (e.g., jury duty or military service), official university competitions, performances, or travel, religious observations, or certain scheduled medical procedures, they should inform the instructor ahead of time to arrange an accommodation. Missing an exam without prior notification of the instructor may lead to receiving a zero. However, illnesses and other problems, which sometimes occur unexpectedly, may lead to an accommodation in this policy.

**Homework.** There will be 10 assignments over the course of the semester, each worth 50 points. **All assignments will count toward the final grade, i.e., no drops! So please plan accordingly.** Each assignment will consist of a few problems from the textbook. The assignments will be announced by the instructor in class and must be returned to the instructor **on paper** at the beginning of the class when they are due. No Canvas uploads please! **Late submissions will not be allowed.** However, if there is a valid reason (e.g., due to documented illness), you may be excused from turning in an assignment on time. If you have extended unavoidable absences, the instructor may make some adjustments to the homework policy. Requests for regrades must be submitted before the end of the second class after graded assignments are returned. **Please pay attention to the following!**

The solutions must be easy to read. Use lined  $8.5 \times 11$ -inch white paper with no torn or tattered edges. No writing with a pencil, then erasing, then rewriting, then erasing again. . . ; no writing so small that it required a magnifying glass to see; and no writing that crosses paper lines, jumps up and down, and/or makes a maze on the paper. Symbols and English words should be easily readable. If you have forgotten how to write in proper calligraphy, please type the assignment. Do not write or print in red. Staple multiple pages together. Student name and problem set number should be clearly written in the top right corner of all pages. Show all your work; the answer alone is not worth anything. Solutions must be explained with enough English to be understandable. Numerical answers should have units and a reasonable number of significant digits. All returned assignments should be kept by students until the final grade of the course has been posted by the instructor. **Transgression of the above rules may reduce your grade on the assignment.**

## Grading

Grade points will be based on assignments and exams as follows:

<b>Homework</b>	500
<b>First mid-term exam</b>	250
<b>Second mid-term exam</b>	250
<b>Final exam (section a)</b>	250 (*)
<b>Final exam (section b)</b>	250 (*)
<b>Final exam (section c)</b>	50 (†)
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<b>Total</b>	1050

(\*) If the score is higher than the corresponding midterm exam score, it replaces it. Otherwise, it counts as zero.

(†) Extra credit.

### Grading scale (points):

**A:** 895 and above

**B:** 795 – 894

**C:** 695 – 794

**D:** 595 – 694

**F:** 594 and below

## Course attendance policy

**This course is Classroom Based. You are required to attend all classes.** Please do not arrive late to class or leave early unless you have been previously excused by the instructor. Of course, if you are taken ill during class or in case of an emergency, feel free to leave. However, as soon as you feel better or the emergency is over, let the instructor know why you left. The instructor will not solicit details of the occurrence or any personal or private information.

Students with inadequate attendance may be dropped. Any student who has inadequate attendance, as evidenced by five confirmed absences or missing a total of five graded assignments of any kind (exams and/or homework), is subject to being dropped if a subsequent class or assignment is missed.

The university requires that all students have their course attendance verified at least once during the first two weeks of the semester. If your attendance is not verified, you will be dropped from the course, and any financial aid will be adjusted accordingly.

## Health and well-being

**In this course, the physical and mental well-being of all students (as well as the instructor) takes precedence over all other considerations.** The instructor will strive to keep the students safe and healthy. Your instructor hopes students will do the same for their well-being as well as the instructor's well-being. While no situation is risk-free, there are easy and effective actions you can take to protect yourself and others around you.

**If you're feeling unwell, stay at home.** Staying at home until you feel better or have been cleared to return to campus by health officers reduces the risk that you will pass on an illness to your friends, fellow students, your instructor, and others in your community. It will help ensure a smooth educational experience over the semester, as well as reduce the burden on our health services. Please contact Student Health Services at [mstshs@mst.edu](mailto:mstshs@mst.edu) and/or 573-341-4284, if you become ill or are unable to attend class or take tests on campus.

**Bugs.** To protect our campus community and each other from the risks of viral infections, Missouri S&T strongly encourages all students, faculty, and staff to be up-to-date on vaccinations. A combination of vaccination, staying home when you are sick, and seeking testing when you have symptoms will be our most effective measures to mitigate against the spread of viruses. There is no requirement to provide proof of immunization, but voluntary reporting of vaccination information can be done at <https://studenthealth.mst.edu/>. If you are isolating, you will receive an absence note from Student Health and not Student Support and Community Standards (Care Management). You will be responsible of forwarding the absence note to the instructor.

**In the event of instructor or campus emergency the course will continue online**

on the zoom platform.

## Copyright, FERPA, and use of electronic devices during class

**It is vitally important that our classroom environment promote the respectful exchange of ideas.** This entails being sensitive to the views and beliefs expressed during discussions, whether in class or online. Please obtain instructor permission before recording any class activity. It is a violation of University of Missouri policy to distribute such recordings without authorization and the permission of all who are recorded. More information is provided [online](#).

**Note on the use of internet-enabled devices in the classroom.** Your instructor's main goal in this class is to provide the best possible teaching experience. This includes mutual respect as well as cooperation among all parties (instructor and students). Students that browse the internet, chat with friends, or watch TikTok videos during class are a few instances of disrespectful student conduct. **Students that use electronic devices in the classroom will be requested to stop using them, unless there is a documented emergency. Students will be asked to leave if they do not comply. In the event of refusal, the behavior will be considered disruptive, and your instructor reserves the right to request that an appropriate disciplinary action be taken by the Campus Judicial Officer.**

## Accessibility and accommodations

It is the university's goal that learning experiences be as accessible as possible. Student Accessibility and Testing provides services and accommodations that facilitate full participation in Missouri S&T's learning experience for students with disabilities. If you anticipate or experience physical, academic, and/or digital barriers due to a disability, please contact Student Accessibility and Testing at (573) 341-6655, email [dss@mst.edu](mailto:dss@mst.edu), or visit <https://saat.mst.edu/> for information.

## Academic integrity and disruptive behavior

All students are expected to follow the [Honor Code](#). **Academic dishonesty and disruptive behavior will not be tolerated** and will be dealt with in accordance with university policies.

[Student Academic Regulations](#) describes the student standard of conduct relative to the University of Missouri System's Collected Rules and Regulations section 200.010, and offers descriptions of academic dishonesty including cheating, plagiarism, sabotage, and unauthorized use of artificially generated content, any of which will be reported to the Dean of

Students. You should familiarize yourselves with the Student Conduct Rules of the University of Missouri in [Section 200.010](#) of the [Collected Rules and Regulations](#) to review the expected standards for student academic integrity, disciplinary procedures, sanctions, and appeal procedures. Other resources for students regarding academic integrity can be found at this [link](#).

**In the event of disruptive behavior, the course instructors will request the campus Judicial Officer to take effective disciplinary action after issuing a warning.** See Student Academic Regulations at <http://registrar.mst.edu/academicregs>.

## Disability policy

The Americans with Disabilities Act prohibits discrimination against and guarantees that people with disabilities have the same opportunities as people without a disability. Missouri S&T and your instructor are committed to providing educational opportunities for all academically qualified students. Reasonable accommodations to ensure equitable access to its programs and services for individuals with disabilities will be made in compliance with the Americans with Disabilities Act.

At the beginning of the semester, students with disabilities who have had their status verified by the Office of Student Disability Services should get in touch with the instructor to go over their specific accommodation requirements.

To learn more about student disability services available to Missouri S&T students, please visit <https://dss.mst.edu/>.

## Non-discrimination, equity and Title IX

Missouri S&T is committed to the safety and well-being of our campus community, and to creating an environment free from discrimination and harassment.

The University prohibits discrimination and harassment on the basis of race, color, national origin, ancestry, religion, sex, pregnancy, sexual orientation, gender identity, gender expression, age, disability, protected veteran status, and any other status protected by applicable state or federal law. As used in this policy, the word “sex” is also inclusive of the term “gender.”

Additionally, US Federal Law Title IX states that no member of the university community shall, on the basis of sex, be excluded from participation in, or be denied benefits of, or be subjected to discrimination under any education program or activity. Sexual harassment violations of this law include quid pro quo, hostile environment, sexual assault, dating/domestic violence, and stalking. The U.S. Department of Education has stated the prohibition on discrimination on the basis of sex includes sexual orientation and gender identity.

Students who are experiencing pregnancy or pregnancy-related conditions, including the birthing parent and non-birthing parent, have rights protected under Title IX. Students should contact Student Accessibility and Testing or the Office of Equity and Title IX to learn more about their rights and pregnancy-related assistance/accommodations provided by the University to ensure equitable access to University educational programs and activities.

In accordance with the University of Missouri's Collected Rules and Regulations, all faculty and staff are required to report any information concerning discrimination disclosed through communication including, but not limited to, direct conversation, email, social media, classroom papers and homework exercises to the Equity Officer/Title IX Coordinator.

For more information regarding support for those that have been impacted or to report an incident of discrimination or harassment as defined by [Chapter 600](#) of the University's Collected Rules and Regulations, visit the Office of Equity and Title IX or visit their website at [equity.mst.edu](http://equity.mst.edu).

### **Office of Equity and Title IX**

Equity Officer and Title IX Coordinator: Dr. Paul Hirtz

Phone: (573) 341-7734

Location: 900 Innovation Drive, Suite 500

E-mail: [equity@mst.edu](mailto:equity@mst.edu)

## **Changes to this syllabus**

If a revision of the syllabus becomes necessary during the semester, it will be discussed in class.

## **Statement of agreement**

Please carefully review and print for your records this syllabus. **By taking this class, you confirm that you have read and understood this document and are agreeable to the policies and provisions set forth therein.**

## Appendix A: Other resources

S&T provides resources to support your mental, physical, and social well-being. Any of us can experience challenges that make learning difficult. If you are struggling, take advantage of the following resources offered by the university.

**Student Well-Being** provides counseling services, health promotion initiatives, and prevention programs to empower the S&T community to thrive and enhance personal, academic, and professional success. Department office hours are Monday – Friday, 8 a.m. – 5:00 p.m. On the website, you can find information related to confidential individual and group counseling, wellness consultations and trainings, case management services, resources for many health and wellness topics, and help for mental health crisis situations. For the 988 Suicide and Crisis Lifeline, call or text 988, or visit [missouri988.org](https://missouri988.org). For the National Suicide Prevention Lifeline, call or text 988, or visit [missouri988.org](https://missouri988.org).

The **Health and Well-Being Canvas Course** features trainings, presentations, and other health and well-being resources for students. The course is free for all students, is non-credit, and students can enroll at any point in the semester.

**Student Support and Community Standards** is your central resource for support. During your time at S&T, you or a friend may need help navigating their student experience, facing a barrier, or experiencing a challenge. You are not alone! Student Support has a dedicated team and numerous resources such as **UCARE** and the **student emergency fund** to help you navigate the S&T experience and support your success. This includes support to address barriers related to academic, personal, emotional, medical, financial, or any other needs. All students can learn and grow from challenges or setbacks, they are stepping stones to success and we are here to help.

The **Curtis Laws Wilson Library** is the place to gather on campus, offering group meeting spaces, quiet study carrels and reservable conference rooms. The library provides students and faculty with physical and electronic books, journals, articles and databases as well as recreational reading, games and DVDs. We also have technology to check out, from laptops to chargers to calculators and everything inbetween. Librarians create library and course guides to help navigate searching for resources. Talk to us one-on-one via chat, email, phone or in person for any assistance regarding library services or finding peer-reviewed, credible research materials for study and research needs. Find out more information and connect with the library at this link: <https://library.mst.edu>.

The **Writing and Communication Center**'s mission is to assist all students in their efforts to become better writers, communicators, and critical thinkers. The Center's peer consultants and coaches provide free individualized one-on-one and small group conversations to offer meaningful feedback and guidance to students across all disciplines. More information can be found on our website, through email: [writing@mst.edu](mailto:writing@mst.edu) or stop by Curtis Laws Wilson Library 314–315.



The **Student Success Center** (SSC) offers peer tutoring and success coaching to help students succeed in their academic goals. Additionally, we work as a resource hub and can connect you to the campus resources necessary to help you dig deeper and finish the semester strong. Visit the SSC in Room 117 Innovation Lab and contact us at [ssc@mst.edu](mailto:ssc@mst.edu) or 573-341-7590. To learn more about the SSC, visit <https://ssc.mst.edu>. SSC helps in three ways:

- The **LEAD Drop-in** service provides convenient access to experienced peer learning assistants for a multitude of courses across campus. No appointments necessary. Simply check the tutoring schedule to discover when support for your specific course is available at <https://ssc.mst.edu/leaddrop-in>.
- The **LEAD Group Sessions** offer after-hours group tutoring, facilitated by dedicated peer learning assistants in partnership with faculty members. Explore the LEAD Group schedule to see if your course is featured and join LEAD at the next session: <https://ssc.mst.edu/leadgroup>.
- If your schedule clashes with our LEAD offerings, or if your course isn't covered, **Knack Tutoring** is your solution. Request a tutor for either a virtual meeting or an in-person session on campus, ensuring you get the help you need, when you need it. To sign up for your FREE Knack account, visit <https://ssc.mst.edu/knacktutoring>.

The **Student Veterans Resource Center** (SVRC) is the nexus of resources and support for student veterans at S&T. The SVRC provides student veterans with a “safe space” and a familiar atmosphere. The center’s Veteran Consuls provide one-on-one consultations to guide students to various resources on campus, while its advisor provides students with VA health and benefits resources. Visit the SVRC at Harris Hall, Suite G10, or contact the center at [svrc@mst.edu](mailto:svrc@mst.edu).

## Appendix B: Assignment schedule

	Lectures	Opens (Friday)	Due (Wednesday)
<b>Assignment 1</b>	Week 1	August 23	<b>August 28</b>
<b>Assignment 2</b>	Week 2	August 30	<b>September 4</b>
<b>Assignment 3</b>	Week 3	September 6	<b>September 11</b>
<b>Assignment 4</b>	Week 4	September 13	<b>September 18</b>
<b>Assignment 5</b>	Week 5-7	October 4	<b>October 16</b>
<b>Assignment 6</b>	Week 8-9	October 18	<b>October 23</b>
<b>Assignment 7</b>	Week 10	October 25	<b>October 30</b>
<b>Assignment 8</b>	Week 11	November 1	<b>November 6</b>
<b>Assignment 9</b>	Week 12	November 8	<b>November 13</b>
<b>Assignment 10</b>	Week 13	November 15	<b>December 4</b>

# Appendix C: tentative lecture schedule

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## Part I: Fundamentals and stellar structure (Chapters 1-10, August 19 – September 27)

<b>Week 1:</b>	<b>August 19 – 23</b>	Celestial Sphere [CH1]; Celestial Mechanics [CH2]
<b>Week 2:</b>	<b>August 26 – 30</b>	The Continuous Spectrum of Light [CH3]; The Theory of Special Relativity [CH4]
<b>Week 3:</b>	<b>September 2 – 6</b>	The Interaction of Light and Matter [CH5]; Telescopes [CH6]
<b>Week 4:</b>	<b>September 9 – 13</b>	Binary Systems and Stellar Parameters [CH7]; The Classification of Stellar Spectra [CH8]
<b>Week 5:</b>	<b>September 16 – 20</b>	Stellar Atmospheres [CH9]; The Interiors of Stars [CH10]
<b>Week 6:</b>	<b>September 23 – 27</b>	The Interiors of Stars [CH10]; Review; First Midterm exam

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## Part II: Stellar evolution (Chapters 11-18, September 30 – November 22)

<b>Week 7:</b>	<b>September 30 – October 4</b>	The Sun [CH11];
<b>Week 8:</b>	<b>October 7 – 11</b>	The Interstellar Medium and Star Formation [CH12]; Fall Break
<b>Week 9:</b>	<b>October 14 – 18</b>	Main Sequence and Post-Main-Sequence Stellar Evolution [CH13]
<b>Week 10:</b>	<b>October 21 – 25</b>	Stellar Pulsation [CH14]
<b>Week 11:</b>	<b>October 28 – November 1</b>	The Fate of Massive Stars [CH15]
<b>Week 12:</b>	<b>November 4 – 8</b>	The Degenerate Remnants of Stars [CH16];
<b>Week 13:</b>	<b>November 11 – 15</b>	General Relativity and Black Holes [CH17]
<b>Week 14:</b>	<b>November 18 – 22</b>	Close Binary Star Systems [CH18]; Review; Second Midterm exam

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## Part III: A taste of advanced astrophysics (December 2 – December 6)

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**Week 15:** December 2 – December 6 | Hot topics in today's high-energy astrophysics