



# DATA 275 Data in the Cosmos

MW, Collins 320  
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*This syllabus is subject to change or adaptation as the semester progresses!*

**Course Description:** Within the next decade, scientific telescopes will be gathering petabytes of information every day about the observable sky and our place within the cosmos. This influx of data is forcing the established field of astronomy to collide head on with the emerging field of data science. In this course, students will explore a variety of the techniques, file-formats, and applications of data science in the modern world of astronomy. Students will work with huge datasets to investigate stellar evolution and the age of the universe, investigate signal processing techniques to tease out evidence of planets orbiting other stars, and utilize basic machine learning techniques to classify galaxy types. Communication of results through written and oral forms will be stressed.

**Prerequisite(s):** CS-151 or DATA-151

**Note:** A minimum grade of C- is required for this course to count toward university GenEd credit.

**Credits:** 4.0

**Text:** There is no official text this semester. Handouts will be distributed as necessary.

## Course Objectives:

Over the semester, students will gain working knowledge in:

1. Core topics in modern astronomy, including objects in the solar system, stars, exoplanets, galaxies, dark matter, and cosmology.
2. Implementing computing and data science problem-solving strategies within a scientific framework
3. Communication and teamwork within groups of different skills and backgrounds

This course is intended to live at the intersection between physics, astronomy, and data science. On one hand, it's goal is to give physicists and astronomers an introduction and practice to using data science ideas for scientific analysis. On the other, it strives to give data scientists introductory domain knowledge in one possible direct area of application. Above all, it seeks to foster communication and teamwork between those differing groups of individuals.

## Grade Weighting

Homework	45%
Check-ins	5%
Quizzes	25%
Project	25%

## Letter Grade Distribution:

$\geq 92.00$	A	72.00 - 77.99	C
90.00 - 91.99	A-	70.00 - 71.99	C-
88.00 - 89.99	B+	68.00 - 69.99	D+
82.00 - 87.99	B	62.00 - 67.99	D
80.00 - 81.99	B-	60.00 - 61.99	D-
78.00 - 79.99	C+	$\leq 59.99$	F

## Student Learning Objectives (SLO):

Upon completion of the course, students should be able to:

- Discuss the central ideas, concepts, and facts of modern astronomy. All good analysis is intertwined with domain knowledge, and students should feel comfortable with at least the broad strokes of the physics that props up our understanding of modern astronomy. Demonstrated through homework and quizzes.
- Visualize astronomic data and information in a way that communicates a desired outcome. Visualization is fundamental to any data analysis, and while many forms of visualization are consistent across fields, astronomy comes with some extra considerations. Demonstrated through homework and projects.
- Recognize and implement a variety of data analysis techniques, including basic statistics, regression, non-linear model fitting, time series analysis, and classification using basic machine learning techniques. While this course will apply these techniques to astronomical data, the same techniques will be transferable to other situations and data. Demonstrated through homework and projects.
- Communicate and work well with peers containing different strengths. It is immensely difficult to maintain expert-level domain knowledge, while also staying atop the latest and greatest data science techniques. More and more, specialists in both areas are finding common ground and working together to solve new and exciting problems. Students in this class come from a similar range of backgrounds, and should come out of the course understanding where their strength's lie and where they are better served asking others for assistance. Demonstrated through homework and projects.

## Course Assessment:

- **Homework**

- Homework will be due on Friday at 11:59 pm each week. Assignments will be composed of 1 question each week. Deliverables will entail a computational essay discussing the problem, to be composed in something like a Jupyter Notebook, RMarkdown, or Quarto and published to HTML. Homework materials and submissions will be handled through GitHub Classroom. Assignments will be posted on the class webpage and the provided link should be followed to download that week's assignment materials. All homework assignments will be **partner-based**, with partners pseudo-randomly assigned for each unit. Only one submission should be made for each pairing.
- *Group Dissolution Policy*: Different people are more or less skilled in working in groups, and you may come across a situation wherein your partner is struggling to be an effective group member. One of the fundamental goals of this course is to give everyone many chances to improve in this area. However, a lack of communication is the most surefire way to make any group situation infuriating, and guarantees that nobody is learning anything about working in a group. As such, I will allow one member of a group to dissolve the group should the following qualifications be met:
  - \* There is documented evidence of one group member reaching out to another in a way that clearly necessitates a response, and that group member has still not replied *at all* 48 hours later through the same medium.
  - \* This evidence is presented to me more than 48 hrs before an assignment is due.

Should both of those qualifications be met, I will dissolve the group. At that point all members will be responsible for completing and submitting their own homework assignments for the remainder of the unit. Additionally, because such a situation indicates a failing of the group, those that raised the issue will take a very modest 2.5% penalty on the unit's assignments, and those that had failed to communicate will take a harsher 7.5% penalty on the unit's assignments. The intention here is to give you incentive to strive to make even non-ideal groups work. But to give you an out should you be paired with someone who simply refuses to communicate.

- **Check-ins and Debriefs**

- An important part of this course is improving teamwork skills and identifying how individuals can best contribute to a group. To that end, after the assignment is due each week, there will be a debriefing form for students to fill out, asking them to reflect on how they contributed to their group on that assignment and how they could improve going forward. The goal of all of these check-ins is to force students to plan ahead with their partner and spend some time being introspective about how the partnership went and what steps they could take to ensure the next partnership goes equally well or better. Students will have 3 days to complete each form, and scoring will be based almost entirely on whether the form is completed or not.

- **Projects**

- There is one larger project happening at the end of the semester. The project will be group based, and is a chance to take a topic or concept covered earlier in the semester and pursue it a bit deeper or in a combined manner. Project deliverables will be an

approximately 12 minute group presentation in class during our finals time-slot. Missing the final presentation will result in a 50% deduction on the project grade. **Do not schedule a flight to leave before late on May 6th.**

- **Quizzes**

- While much of the class focus is on the data analysis applications to astronomy, developing a basic understanding of the underlying science is also important. To this end, three quizzes are spaced through the semester which will be completed in class. These quizzes will be fairly short (30 minutes) and consist of a handful of multiple choice or short answer conceptual or quantitative questions about the astronomy topics that have been discussed. Quizzes will be taken in class and allow the use of a calculator. Study guides will be distributed a week in advance of each quiz.

## Course Policies:

### **Late Work Policy**

I understand that sometimes things come up, and you are unable to get an assignment in on time, and I strive to be incredibly flexible and accepting of late work. However, there also comes a point when you get too far behind to realistically keep up with the class, and just need to turn in what you have. This is especially true as you will be working with partners on the homework, and so working on an assignment past the due date is adversely affecting your partner for the next assignment. In an effort to maintain flexibility while still have deadline penalties, my late policy allots you 3 cumulative days of late work throughout the entire semester. So you can turn 3 assignments in one day late, 6 assignments in 12 hours late, etc. without penalty. Once you have used up your 3 days (72 hours), assignments receive a 20% penalty per day late. Please note that late time counts against *all* members of the group! Projects and check-ins/debriefs can not utilize late days.

### **Incomplete Policy**

An incomplete grade will only be granted in the case of prolonged illness or family emergencies that remove the student from the campus for an extended time period during the semester. Under no situations will an incomplete be granted due to a student falling behind through lack of motivation, understanding, or time management skills. If you are concerned about your progress and how you are doing in the class, please come visit me! We can sort out where you are struggling and work out a plan to get you back on track.

### **Trans Inclusive Space**

I will gladly honor your request to address you by your affirmed name or gender pronoun. Please advise me of this at any point in the semester so that I may make appropriate changes to my records. If I accidentally use an incorrect gender pronoun when addressing you, please feel free to let me know, in whatever manner makes you comfortable, that I messed up and explain or remind me of what pronouns you use so that I can make every effort to correct that error.

## Willamette Policies:

### **Academic Honesty**

Cheating is defined as any form of intellectual dishonesty or misrepresentation of one's knowledge. Plagiarism, a form of cheating, consists of intentionally or unintentionally representing someone else's work as one's own. Integrity is of prime importance in a college setting, and thus cheating, plagiarism, theft, or assisting another to perform any of the previously listed acts is strictly prohibited. I may impose penalties for plagiarism or cheating ranging from a grade reduction on an assignment or exam to failing the course. An instructor can also involve the Office of the Dean of the College of Liberal Arts for further action. For further information, visit: [http://www.willamette.edu/cla/catalog/resources/policies/plagiarism\\_cheating.php](http://www.willamette.edu/cla/catalog/resources/policies/plagiarism_cheating.php).

*This can be particularly problematic in programming courses, so know that I will be keeping an eye out for it. Do your own work, and always indicate if you have worked with someone else.*

### **Classroom Conduct**

As an educational institution, Willamette is committed to support the ideals and standards that help create a constructive and healthy learning community. That requires, among other things, encouraging positive classroom behaviors, discouraging disruptive classroom behaviors, and setting clear standards for both of those things.

To that end, constructive classroom behaviors are those that support learners and teachers in an environment that promotes trust, respect, and collaborative learning.

Disruptive classroom behaviors are those that undermine or interfere with the abilities to learn and teach. Clear examples of disruptive behaviors include, but are not limited to:

- Interrupting others or persistently speaking out of turn
- Distracting the class from the subject-matter or discussion at hand
- Making unauthorized recordings or photos of a class meeting or discussion (except as permitted as part of an Accessible Education Services-mandated accommodation)
- Any physical threat, physical, psychological, or sexual harassment, ridicule, or abusive act towards a student, staff member, or instructor in a classroom or related setting.

### **Time Commitments**

Willamette's Credit Hour Policy holds that for every hour of class time there is an expectation of 2-3 hours work outside of class. Thus, for a class meeting three hours a week you should anticipate spending 6-9 hours outside of class engaged in course-related activities. Examples include study time, reading and homework, assignments, research projects, and group work.

### **Diversity and Disability**

Willamette University values diversity and inclusion; we are committed to a climate of mutual respect and full participation. Our goal is to create learning environments that are usable, equitable, inclusive and welcoming. If there are aspects of the instruction or design of this course that result in barriers to your inclusion or accurate assessment or achievement, please notify me as soon as possible. Students with disabilities are also encouraged to contact the Accessible Education Services office in Matthews 103 at 503-370-6737 or [accessible-info@willamette.edu](mailto:accessible-info@willamette.edu) to discuss a range of options to removing barriers in the course, including accommodations.

## Tentative Course Outline:

The weekly coverage might change a bit as it depends on the progress of the class. But this is likely to prove fairly accurate.

Week	Date	Chapter	Description	Due
1	Mon, Jan 12 Wed, Jan 14		Solar System Teamwork and Essays	
2	Mon, Jan 19 Wed, Jan 21 Fri, Jan 23		<i>MLK Day</i> Solar System	HW1: Jupiters Moons
3	Mon, Jan 26 Wed, Jan 28 Sat, Jan 31		Solar System Solar System	HW2: Asteroids
4	Mon, Feb 02 Wed, Feb 04 Fri, Feb 06		Stars Stars	HW3: Star Properties
5	Mon, Feb 09 Wed, Feb 11 Fri, Feb 13		Stars Stars	HW4: HR Diagrams
6	Mon, Feb 16 Wed, Feb 18 Fri, Feb 20		Exoplanets Exoplanets	Quiz 1 HW5: Fourier Transforms
7	Mon, Feb 23 Wed, Feb 25 Fri, Feb 27		Exoplanets Exoplanets	HW6: Transit Measurements
8	Mon, Mar 02 Wed, Mar 04 Fri, Mar 06		Exoplanets Galaxies	HW6: Exoplanet Properties
9	Mon, Mar 09 Wed, Mar 11 Fri, Mar 13		Galaxies Galaxies	HW7: Cepheid Variables
10	Mon, Mar 16 Wed, Mar 18 Fri, Mar 20		Galaxies Galaxies	HW9: Galaxy Classification
11	Mon, Mar 23 Wed, Mar 25		<i>Spring Break</i> <i>Spring Break</i>	
12	Mon, Mar 30 Wed, Apr 01 Fri, Apr 03		MCMC Methods MCMC Methods	Quiz 2 HW10: Walking a Function
13	Mon, Apr 06 Wed, Apr 08 Fri, Apr 10		MCMC Methods Dark Cosmology	HW10: Walking a Likelihood
14	Mon, Apr 13 Wed, Apr 15 Fri, Apr 17		Dark Cosmology <i>SSRD</i>	HW12: Dark Matter
15	Mon, Apr 20		Dark Cosmology	

Week	Date	Chapter	Description	Due
	Wed, Apr 22 Fri, Apr 24			HW13: Structure of Universe
16	Mon, Apr 27 Wed, Apr 29		Project Workday Project Workday	Quiz 3
17	Wed, May 06		<b>Project Presentations</b>	