DATA 275

Data in the Cosmos

TTh, Collins 318
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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 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	30%
Project	20%

Letter Grade Distribution:

>= 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+	<= 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 on weeks after finishing a unit, which will correspond to roughly every 2 weeks. Assignments will be comprised of 3-4 questions. Deliverables will entail a short computational essay for each problem, to be written in something like a Jupyter Notebook, RMarkdown, or Quarto and exported 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 assignment (you will not work with an individual more than once). Only one submission is necessary for each pairing.
- **Check-ins and Debriefs**
  - There are relatively few assignments over the course of the semester, so time management in this course can be difficult. Moreover, an important part of this course is improving teamwork skills and identifying how individuals can best contribute to a group. To that end, on weeks when no assignment is due, there will be a short check-in form that all students should complete, which gather information about what progress the students made on the assignment that week, how often they met, and what their plan is for the coming week. On weeks when an assignment is due, 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 2 days to complete each form, and scoring will be based almost entirely on whether the form is completed on 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 May 7th.**
- **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 questions about the astronomy topics that have been discussed.

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. Projects can not utilize late days, as we have a single class slot set aside for presentations.

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.

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.

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.

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.

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 to discuss a range of options to removing barriers in the course, including accommodations.

Tentative Course Outline:

The weekly coverage might change as it depends on the progress of the class. However, I highly recommend you follow along with the reading, as it makes a large difference!

Week	Date	Chapter	Description	Due
1	Thu, Jan 18		Solar System	
2	Tue, Jan 23 Thu, Jan 25		Solar System Solar System	
3	Tue, Jan 30 Thu, Feb 01 Fri, Feb 02		Solar System Stars	 HW1: SS
4	Tue, Feb 06 Thu, Feb 08		Stars Stars	
5	Tue, Feb 13 Thu, Feb 15 Fri, Feb 16		Stars Exoplanets	 Quiz 1 HW2: Stars
6	Tue, Feb 20 Thu, Feb 22		Exoplanets Exoplanets	
7	Tue, Feb 27 Thu, Feb 29 Sat, Mar 02		Exoplanets Exoplanets	 HW3: Exoplanets
8	Tue, Mar 05 Thu, Mar 07		Galaxies Galaxies	
9	Tue, Mar 12 Thu, Mar 14		Galaxies Galaxies	
10	Tue, Mar 19 Thu, Mar 21 Fri, Mar 22		Galaxies Dark Matter	 Quiz 2 HW4: Galaxies
11	Tue, Mar 26 Thu, Mar 28		*Spring Break* *Spring Break*	
12	Tue, Apr 02 Thu, Apr 04		**Jed traveling** Dark Matter	
13	Tue, Apr 09 Thu, Apr 11		Dark Matter **Jed traveling**	
14	Tue, Apr 16 Thu, Apr 18		Dark Matter Cosmology	
15	Tue, Apr 23 Thu, Apr 25 Fri, Apr 26		Cosmology Project Workday	 Quiz 3 HW5: MCMC Methods
16	Tue, Apr 30		Project Workday	
17	Tue, May 07		**Project Presentations**	