Term Information

Effective Term	Autumn 2025

General Information

Course Bulletin Listing/Subject Area	Astronomy
Fiscal Unit/Academic Org	Astronomy - D0614
College/Academic Group	Arts and Sciences
Level/Career	Undergraduate
Course Number/Catalog	1100
Course Title	Astronomy IRL: An Influencer's Guide to Science
Transcript Abbreviation	Astronomy IRL
Course Description	Science shapes our lives, but with so much “scientific” info out there, how do we know what to trust? This course sharpens your ability to evaluate scientific information, using astronomy as a concrete way to develop your understanding of the methods and nature of science. To ensure you can apply this knowledge beyond astronomy, we'll put you to the test in real-world social media contexts.
Semester Credit Hours/Units	Fixed: 4

Offering Information

Length Of Course	14 Week
Flexibly Scheduled Course	Never
Does any section of this course have a distance education component?	Yes
Is any section of the course offered	100% at a distance
Grading Basis	Letter Grade
Repeatable	No
Course Components	Laboratory, Lecture
Grade Roster Component	Lecture
Credit Available by Exam	No
Admission Condition Course	No
Off Campus	Always
Campus of Offering	Columbus, Lima, Mansfield, Marion, Newark, Wooster

Prerequisites and Exclusions

Prerequisites/Corequisites	Completion of Math 1075 or higher or a Math Placement score of “N” or higher.
Exclusions	
Electronically Enforced	Yes

Cross-Listings

Cross-Listings	

Subject/CIP Code

Subject/CIP Code	40.0201
Subsidy Level	Baccalaureate Course
Intended Rank	Freshman, Sophomore, Junior, Senior

Requirement/Elective Designation

Natural Sciences

Course Details

Course goals or learning objectives/outcomes

- Course ELO 1.1 Demonstrate proficiency in fundamental scientific competencies including astronomical units and unit conversion, scientific notation, SI prefixes, interpreting graphs, common proportions, percentages and scaling relations.
- Course ELO 1.2 Comprehend the scale of the Universe and its constraints on astronomical observation and exploration.
- Course ELO 1.3 Recall and explain basic facts, principles and theories of modern astronomy.
- Course ELO 2.1 Apply and explain the scientific methods used by modern astronomy to characterize the Universe, and explain the limitations and associated uncertainties of these methods.
- Course ELO 2.2 Identify how key events in the development of modern astronomy contribute to the ongoing and changing nature of scientific knowledge and methods in the field.
- Course ELO 2.3 Demonstrate an understanding of fundamental scientific literacy concepts including uncertainty and bias in data, variable control, confounding factors, and evaluating the validity of sources of information.
- Course ELO 2.4 Describe and analyze the nature and process of scientific inquiry including the premises and boundaries of its application, and the merit and evolving nature of scientific theories.
- Course ELO 3.1 Analyze the inter-dependence and potential societal impacts of scientific and technological developments.
- Course ELO 3.2 Demonstrate an understanding of ethical practice in science and the responsible use of information from the natural sciences.
- Course ELO 4.1 Demonstrate an appreciation for the need for scientific literacy in everyday life.
- Course ELO 4.2 Interpret and critically evaluate the scientific merit of reported information both within and outside the field of astronomy.

Content Topic List

- Unit 1: Science Unlocked: How to Talk the Talk and Walk the Walk
- Unit 2: Behind the Scenes: Where Do Scientists Get Their Facts From?
- Unit 3: Guessing or Slaying? How Theories Evolve and Get Verified
- Unit 4: Game On! Tackling Tough Topics in Science Like a Boss

Sought Concurrence

No

Attachments

- Astron1100_Astronomy IRL_ASC Distance Learning Syllabus Template.docx: Syllabus

  (Syllabus. Owner: Westraadt,Lindsay)
- Astron1100_Astronomy IRL_ASC-distance-approval-cover-sheet-fillable Updated 2-1-24 APPROVED.pdf: Approved Cover Sheet

  (Cover Letter. Owner: Westraadt,Lindsay)
- Astron1100_Astronomy IRL_ASC-distance-approval-cover-sheet-fillable Updated 2-1-24.pdf: Pre-approved Cover Sheet for easier reading

  (Cover Letter. Owner: Westraadt,Lindsay)
- ge-foundations-submission.pdf: GE Submission Form

  (Other Supporting Documentation. Owner: Westraadt,Lindsay)
- Revisions Cover letter.pdf: Revisions Cover Letter

  (Cover Letter. Owner: Westraadt,Lindsay)
- Astron1100_Astronomy IRL_REVISED Syllabus.pdf: Revised Syllabus

  (Syllabus. Owner: Westraadt,Lindsay)
- Course Plan.pdf: Course Plan

  (Other Supporting Documentation. Owner: Westraadt,Lindsay)
- VLab1 Discovering the Night Sky for Yourself.pdf: Example lab 1

  (Other Supporting Documentation. Owner: Westraadt,Lindsay)
- VLab3 Standing on the Shoulders of Giants.pdf: Example lab 2

  (Other Supporting Documentation. Owner: Westraadt,Lindsay)
- Mastering Astronomy TOC.pdf: Text TOC 1

  (Other Supporting Documentation. Owner: Westraadt,Lindsay)
- An Influencer's Guide to Science IRL TOC.pdf: Text TOC 2

  (Other Supporting Documentation. Owner: Westraadt,Lindsay)

Comments

- See feedback email sent to department 12-17-2024 RLS *(by Steele,Rachel Lea on 12/17/2024 01:14 PM)*
- There is a small typo in the approved ODE cover sheet. The course number is Astronomy 1100, not Astronomy 1000. This was corrected after sending the document for approval. *(by Westraadt,Lindsay on 11/22/2024 02:54 PM)*

Workflow Information

Status	User(s)	Date/Time	Step
Submitted	Westraadt,Lindsay	11/22/2024 02:57 PM	Submitted for Approval
Approved	Thompson,Todd Alan	11/22/2024 03:03 PM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	12/02/2024 08:31 AM	College Approval
Revision Requested	Steele,Rachel Lea	12/17/2024 01:14 PM	ASCCAO Approval
Submitted	Westraadt,Lindsay	03/04/2025 09:52 AM	Submitted for Approval
Approved	Thompson,Todd Alan	03/04/2025 09:55 AM	Unit Approval
Approved	Vankeerbergen,Bernadette Chantal	03/19/2025 01:19 PM	College Approval
Pending Approval	Jenkins,Mary Ellen Bigler Hanlin,Deborah Kay Hilty,Michael Neff,Jennifer Vankeerbergen,Bernadette Chantal Steele,Rachel Lea	03/19/2025 01:19 PM	ASCCAO Approval

To the NMS Subcommittee,

Thank you for reviewing our course proposal for **Astronomy 1100: Astronomy IRL**. We appreciate your feedback, which has helped enhance the quality of the course. Please see our response to your revision requests below. For a quick overview of our vision for the course, please refer to the revised **Course description** and **General education goals and expected learning outcomes** in the updated syllabus before reviewing the detailed revisions below.

The following attachments accompany this syllabus revision:

- Revision Cover Letter (this document)
- Revised Syllabus (Astron1100_Astronomy IRL_REVISED Syllabus)
- Course Plan
- Mastering Astronomy TOC
- An Influencer's Guide to Science IRL TOC
- VLab1
- VLab3

	Subcommittee comments	Course updates	Syllabus updates
a	The Subcommittee asks that the department provide a detailed example of at least 2 of the modules so that they can assess the level and rigor of the course activities. As currently presented, it is difficult to understand how students will be meeting the Goals and ELOs of the GEN category.	See the attached **Course Plan**. The document provides a detailed description and plan for each week/module. The table of contents for the two texts referenced in the course plan are attached as **Mastering Astronomy TOC** and **An Influencer's Guide to Science IRL TOC**. Arrows have been added to the Unit 1 modules to show the interplay between Astronomy and Science IRL, and how we plan on achieving a science literacy focus using astronomy as the basis for learning. Lessons are labeled DxLx e.g. D1L2 means Day 1 Lesson 2. Even though we will not be following a 3-day a week lecture schedule, this structure was used in course planning to ensure appropriate pacing of work. There is a table at the end of the Course Plan – **Linking GE ELOs to**	**Textbook** updated. **Course Schedule** updated to reflect updated Course Plan. **How this online course works** updated to reflect updated structure of weekly activities.

<table>
<tr><td></td><td></td><td>Course Topics – that shows how GE ELOs are met in this course.</td><td></td></tr>
<tr><td>b</td><td>The Subcommittee asks that the department provide a detailed example of at least 2 of the experiential learning assignments so that they can assess the level and rigor of these activities. As currently presented, it is difficult to understand how students will meet the requirement of spending at least 3 hours/week completing the “practical tasks”. The Subcommittee also offers the friendly reminder that in addition to accounting for 25% of student time, experiential learning should also account for 25% of students’ overall grades.</td><td>See attached VLab1 and VLab3. Also see the Course Plan to see how these labs integrate into their respective weeks.</td><td>Updated How your grade is calculated to reflect 25% grade allocation to experiential learning.</td></tr>
<tr><td>c</td><td>The Subcommittee recommends that the department consider a math pre-requisite commensurate with the kinds of assessments and activities that will be a part of the course. The Subcommittee understands and appreciates that the department wants this to be an accessible course for early-career students, and they offer the friendly reminder that the pre-requisite could simply be a readiness for collegiate math (for example, completion of Math 1075 or higher or a Math Placement score of “N” or higher).</td><td>Agreed.</td><td>Prerequisites have been added.</td></tr>
<tr><td>d</td><td>The Subcommittee asks that the department amend or add to the course’s assessments so that students are completing further discussions and/or writing-focused assignments and receiving feedback from instructors. They note that many of the course ELOs include asking students to “explain”, “demonstrate” “describe” or “analyze” (syllabus, pp. 3-4); however, it will be difficult</td><td>The updated grading structure for this course is as follows:
<table><tr><th>Assignment Category</th><th>Percentage</th></tr><tr><td>Mini lesson review quizzes</td><td>20%</td></tr><tr><td>V-labs</td><td>25%</td></tr><tr><td>Astro chat</td><td>10%</td></tr><tr><td>Knowledge checks</td><td>30%</td></tr><tr><td>Unit assessments</td><td>15%</td></tr><tr><td>Total</td><td>100%</td></tr></table>
Roughly 75% of assessments are auto-graded, including mini lesson review quizzes, V-labs, knowledge checks and 2 of the 5 unit</td><td></td></tr>
</table>

	for students to demonstrate mastery of these ELOS without assessments that require more robust feedback from their instructors. At this time, it appears that the majority of the course grading will be automated via Carmen rather than graded by an instructor, and that there is a *possibility* that *all* assignments will be auto-graded (syllabus, p. 14).	assessments in the form of escape room challenges. Mini lesson review quizzes and knowledge checks are fully auto-graded MCQ quizzes. Auto-feedback will be built into review quizzes to give answer-specific feedback. V-labs are predominantly auto-graded (see **VLab1** and **VLab3**), however, V-labs will be implemented in Carmen using H5P, allowing for a range of question types and a more interactive experience. We will make use of the auto-feedback functionally in H5P to provide real-time feedback and hints on auto-graded questions, highlighting incorrect answers and guiding re-attempts, allowing students to learn as they go. In addition, manually graded reflection questions will be added to each lab to allow students to demonstrate understanding and receive feedback (see **VLab1** and **VLab3**). The main assignments dedicated to assessing and proving feedback on higher-level learning outcomes are the weekly **Astro chat** discussions and the remaining **Unit assessments**. See the attached **Course Plan** for each week's Astro chat topics as well as a description of Unit assessments provided at the start of each unit.	
e	The Subcommittee asks that the department provide additional information about how students will interact with one another and the instructor(s) during the course. Given the provided materials and the fact that students can work ahead, it seems that students will only be asked to interact with one another and the instructors once every two weeks. Additionally, those that	To increase the frequency and quality of engagement the reference to working ahead has been removed from the syllabus, and virtual discussions (Astro chat) have been introduced on a weekly basis in the form of small-group 30-minute CarmenZoom sessions facilitated by a trained TA. As is typical for large GE courses, students will likely not interact directly with the lead instructor	

	work ahead would have very little opportunity to interact with others on these discussion boards.	during Astro chat sessions. The instructor will however have a constant weekly presence in lesson recordings and will be available for consultation during office hours.	
f	The Subcommittee asks that the department provide more information about the resources that they expect to be "readily available" to students (syllabus, p. 6). They offer the friendly reminder that students may be enrolled in the course from locations all over the world, so observation of the night sky may be different for each student based up on their geographic location, the weather, the time in the semester, and whether their personal safety could be threatened by being out-of-doors at night.		See added sections under **Course materials and technologies**, namely **V-Lab Equipment** and **Accessibility Statement**
g	The Subcommittee asks that the department include in the syllabus a brief, student friendly explanation of how this course, in particular, will meet the Goals and ELOs of the GEN Foundation: Natural Sciences category. This explanation should immediately follow the listing of the GEN Goals and ELOs on p. 5 of the syllabus. This explanation should not simply refer students to the course ELOs, but rather describe how this course will meet those ELOs for the variety of students who may be enrolled in the course.		The **Course description** and **General education goals and expected learning outcomes** have been updated accordingly. **The Course goals and expected learning outcomes** have been removed from the syllabus for easier reading. The course goals and ELOs, which are well-aligned with the GE goals and ELOs, are provided in the online application for administrative purposes.
h	The Subcommittee reminds the department that any apps, software, or technologies that students will need to use to complete course requirements should be vetted by the ASC Office of Distance Education to make sure that they aligns with the university's standards for student privacy and online safety.	We are working closely with Alex Souza, an instructional designer from the ASC Office of Distance Education, to ensure that all course material is ADA compliant and meets the university's standards for student privacy and online safety. The main concerns to date were the use of AI tools and planetarium software:	An **accessibility statement** has been added under **Course materials and technologies.** The statement will also be repeated at the start of all relevant assignments.

		One aspect of the course involves exploring the use of **AI tools** to answer science questions. To stay within university AI guidelines, we will limit our activities to using Copilot through Office 365. Another potential concern is Stellarium, a free **planetarium software** that we will use in some labs. To avoid any issues relating to user accounts or software downloads, we will limit activities to their free online webpage, with no need for account creation or downloads. To avoid any issues relating to video content creation, students will be instructed to create video storyboards and recordings using Office 365 PowerPoint. Also, student videos will not be posted publicly on YouTube – except for the special instance where permission has been granted by the student to share their material on our social media platforms for recruitment and engagement purposes. Lastly, there is currently an ADA compliance concern for blind and low vision students when it comes to the use of very visual apps such as Stellarium and NASA's Eyes website. The ODE recommended that we add an **accessibility statement** to our syllabus.	Besides Office 365, no other software has been added to the syllabus, as all versions of apps used are web-based and effectively websites.
i	The Subcommittee recommends that the department use the most recent version of the Student Life Disability Services Statement (syllabus, pg. 17), which was updated in August 2024. The updated statement can be found in an easy-to-copy/paste format on the Arts and Sciences Curriculum and Assessment Services website.		Updated.
j	The Subcommittee recommends that the department use the most		Updated.

	recent version of the Diversity Statement (syllabus, pg. 16), which was updated in AU 24 with additional protected categories. The updated statement can be found in an easy-to-copy/paste format on the Arts and Sciences Curriculum and Assessment Services website.		
k	However, in addition, sufficient information needs to be added to the syllabus so that students will understand their expectations and responsibilities. The cover letter should also outline those changes.		This information is summarized under **How this online course works**.

Best regards,
Lindsay Westraadt

Syllabus

ASTRONOMY1100

Astronomy IRL: An Influencer's Guide to Science

Autumn 2025

4 Credit Hours

Online

Course overview

Instructor (TBD)

- Name
- Email Address
- Phone Number
- Course Zoom Link
- Office Hours
    - Zoom Link
    - Office hours will take place daily via zoom. Times TBD.

Note: My preferred method of contact is office hours or email communication.

Course description

Science shapes our daily lives, from the food we eat to the news we read. Yet, with so much information claiming to be "scientific," how do we know what to trust? Saying "science isn't for me" is no longer an option—we all rely on it, whether we realize it or not.

This course is designed to sharpen your ability to evaluate scientific information and apply it to real-life decisions. We focus on universal

science literacy skills, using astronomy as a concrete way to introduce and practice them. You'll explore key methods and topics in modern astronomy, using them as a lens to understand the nature and tools of science – while experiencing the wonders of our universe along the way! You'll also apply these skills in real-world scenarios, including creating your own responsible social media content.

So, why "Influencer"? Whether you create content or simply consume it, you are part of the cycle of influence. We are all shaped by online information, and at some point, we shape others. This course is for both the influenced and the influencer—helping ensure that science is used responsibly in the digital age.

Prerequisites

Completion of Math 1075 or higher or a Math Placement score of "N" or higher.

General education goals and expected learning outcomes

The goals of the *Foundations: Natural Sciences* category of the General Education curriculum are as follows:

GE Goal#1: Successful students will engage in theoretical and empirical study within the natural sciences while gaining an appreciation of the modern principles, theories, methods and modes of inquiry used generally across the natural sciences.

GE Goal#2: Successful students will discern the relationship between the theoretical and applied sciences while appreciating the implications of scientific discoveries and the potential impacts of science and technology.

As part of the *Foundations: Natural Sciences* category of the General Education curriculum, this course is designed to prepare students to be able to do the following:

GE ELO 1.1 Explain basic facts, principles, theories and methods of modern natural sciences, and describe and analyze the process of scientific inquiry.

GE ELO 1.2 Identify how key events in the development of science contribute to the ongoing and changing nature of scientific knowledge and methods.

GE ELO 1.3 Employ the processes of science through exploration, discovery and collaboration to interact directly with the natural world when feasible, using appropriate tools, models and analysis of data.

GE ELO 2.1 Analyze the inter-dependence and potential impacts of scientific and technological developments.

GE ELO 2.2 Evaluate social and ethical implications of natural scientific discoveries.

GE ELO 2.3 Critically evaluate and responsibly use information from the natural sciences.

This course achieves the outcomes of GE Goal 1 by using astronomy as a concrete way to introduce and develop an understanding of the methods and nature of science, and of universal scientific literacy skills. To promote the extension of this knowledge beyond astronomy and into everyday experiences, the outcomes of GE Goal 2 will be achieved by applying these universal skills in the context of real-life social media influences. To this end, the course has been structured into the following four units:

Unit 1: Science Unlocked: How to Talk the Talk and Walk the Walk: How do we separate science from pseudoscience? How do we separate truth from misleading claims? This unit kicks off your science IRL journey by building the skills needed to think, talk and walk like a scientist. Through the lens of astronomy, we'll trace the birth and development of science, learning what science is and how to recognize it. And we'll catch you up on the math and physics you need to go all the way in this course! Expect to have some fun along the way – we're going to put your bull$#!t

detector and logic to the test as we lay the groundwork for deeper cosmic exploration ahead.

Unit 2: Behind the Scenes: Where Do Scientists Get Their Facts From? This unit builds on the previous unit and develops trust in the scientific method by exploring how we know seemingly impossible things. You'll build domain knowledge by expanding your map of physics and exploring the astronomical methods and technologies that make discovery possible. We'll put constraints on discovery by introducing the concept of uncertainty in measurement —whether due to the vast scale of the universe, technological constraints, or inherent uncertainties in observations. You'll continue to learn how to think like a scientist as we explore what "uncertainty" means to a scientist, how they account for uncertainty and error, and that good science always reports its limitations.

Unit 3: Guessing or Slaying? How Theories Evolve and Get Verified: Now that we've covered the basics of how science works, we're letting you loose in the world of modern astronomy! This unit builds trust in the scientific method by showing how scientific theories are born, tested, and refined. We'll dive into four hot topics in astronomy, exploring key concepts, theory development, and open questions. You'll also learn about current and upcoming surveys tackling these mysteries. Plus, it's your time to shine as a responsible influencer—get ready to create media content on a trending astronomy topic!

Unit 4: Game On! Tackling Tough Topics in Science Like a Boss: Now that you've got a solid grip on the scientific process, it's time to put those skills to work IRL! This unit is all about using science literacy in decision-making—spotting and debunking false claims, evaluating source trustworthiness, understanding the significance of claims, and asking whether it matters IRL! With the rise of AI tools that can answer just about anything, the real challenge isn't finding information—it's knowing the right questions to ask and how to validate the answers. Plus, get ready to level up on your influencer game! Be prepared to tackle more complex topics and up your appeal!

How this online course works

Mode of delivery

This course is 96% online. There is only one 30-minute session a week where you are required to be logged in to CarmenZoom at a scheduled time.

Pace of online activities

This course is divided into 14 modules. Each module is designed to be completed in a week. An estimated 12 hours is required per week for this course.

Credit hours and work expectations

This is a **4-credit-hour course** with a practical component. According to Ohio State policy (go.osu.edu/credithours), students should expect around 12 hours of engagement with the class each week to receive a grade of (C) average. Actual hours spent will vary by student learning habits and the assignments each week.

Weekly tasks include roughly 7 **mini lessons** with review quizzes, a **V-lab**, an **Astro chat** virtual discussion and a **knowledge check** quiz. Except for virtual discussions – which require scheduled attendance, weekly tasks are divided into a number of shorter tasks that can be completed throughout the week at your own time. Unless otherwise specified, all weekly tasks are due by the end of the week in which they are scheduled (see **Course Schedule**). See **Late assignments** for more information on late or missed tasks and assignments.

In addition to weekly tasks, students will complete a **unit assessment** at the end of, or during, each unit that will test the astronomy-related concepts and science literacy skills developed over the 3–4 week period. The dates and/or deadlines for all unit assessments can be found under **Course Schedule**. Unit assessments will take on different forms, including escape room challenges, activities and student-created content. See **Description of major course assignments** for a description of unit assessment assignments. It is anticipated that students will spend

roughly 2 hours completing and/or preparing for unit assessments each week.

An overview of the weekly tasks and the estimated hours required is given in the table below.

Activity	Description	No. per week	Hrs. per week
Mini lessons	Mini lessons are designed for knowledge building and skills development and comprise of readings, instructional videos, and/or interactive activities. Each mini lesson is roughly 30 minutes long, followed by a 10-minute review quiz. **Mode of delivery and assessment:** Carmen assignment	7	~4.5
V-lab	Virtual labs are aimed at hands-on exploration of the week's topic/s and are designed to be completed within 3 hours. **Mode of delivery and assessment:** Carmen assignment	1	3
Astro chat	Virtual discussions will center on the week's key theme and offer students a space to engage with peers and deepen their understanding. Each small-group discussion will take place at a fixed 30-minute time slot in CarmenZoon each	1	1.5

	week, with an expected 1 hour of preparation required. **Mode of delivery and assessment:** CarmenZoom session, facilitated and graded by TA.		
Knowledge check	At the end of each week, students will take a knowledge check quiz. Students can expect to spend 1 hour on knowledge checks – 30 minutes to prepare and 30 minutes to compete the quiz. **Mode of delivery and assessment:** Carmen quiz	1	1
Unit assessments	In addition to weekly tasks, students will complete a unit assessment for each unit. It is anticipated that students will spend roughly 2 hours completing and/or preparing for unit assessments each week. **Mode of delivery and assessment:** Variable. See **Description of major course assignments** for details.		2
TOTAL			12

Participation requirements

Participating in online activities

You are only required to participate in one 30-minute virtual **Astro chat** discussion on CarmenZoom per week. All other weekly tasks can be completed throughout the week at your own time. See **Credit hours and work expectations** for task details and clarity on due dates.

Office hours and live sessions

The attendance of office hours and any ad hoc live sessions is optional. Recordings of live sessions (excluding office hours) will be made available for asynchronous access.

Course communication guidelines

Writing style

All formal written communication in this course, including emails, discussion posts, and assignments, should adhere to standard grammar and punctuation. Use complete sentences and clear language, avoiding overly casual language or abbreviations. Please proofread communications to ensure clarity and accuracy.

Tone and civility

This course is designed to foster a respectful and supportive learning environment. All interactions, whether with peers or instructors, should be conducted with courtesy and thoughtfulness. Approach discussions and communications with an open mind, especially in cases of differing perspectives. In situations of disagreement, focus on constructive dialogue. Any disruptive or disrespectful behavior may be addressed formally according to The Ohio State University's student conduct policies. As your instructor, I am committed to responding to inquiries thoughtfully and encouraging an inclusive and respectful space for all students.

Citing your sources

Proper citation is essential in this course to maintain academic integrity and respect intellectual property. When referencing material in assignments or discussions, provide comprehensive citations. For example, include the following information where applicable: author(s), title, publisher, publication date, page numbers (if applicable), and a link for online sources. Use a consistent citation style (e.g., APA, MLA) throughout.

Protecting and saving your work

To safeguard your work, please compose assignments in a word processing tool before submitting them on Carmen. Saving your work offline provides a backup in case of internet connectivity issues, browser timeouts, or failed submissions. Ensure you regularly save your progress to avoid data loss and keep copies of submitted assignments until you receive a grade confirmation.

Course materials and technologies

Required Textbook

Bennett, J., Donahue, M., Schneider, N., & Voit, M. (2023). The Cosmic Perspective (10th ed.). Pearson. The online textbook is included in your course fees and accessible via Carmen.

Supplementary reference material, including An Influencer's Guide to Science IRL, will be made available for download on Carmen.

Course technology

Technology support

For help with your password, university email, Carmen, or any other technology issues, questions, or requests, contact the Ohio State IT Service Desk. Standard support hours are available at it.osu.edu/help, and support for urgent issues is available 24/7.

- Self-Service and Chat support: it.osu.edu/help
- Phone: 614-688-4357(HELP)
- Email: 8help@osu.edu
- TDD: 614-688-8743

Technology skills needed for this course

- Basic computer and web-browsing skills
- Navigating Carmen (go.osu.edu/canvasstudent)
- CarmenZoom virtual meetings (go.osu.edu/zoom-meetings)

Required Equipment

- Computer: current Mac (MacOs) or PC (Windows 10) with high-speed internet connection
- Webcam: built-in or external webcam, fully installed and tested
- Microphone: built-in laptop or tablet mic or external microphone
- Other: a mobile device (smartphone or tablet) to use for BuckeyePass authentication

Required software

- Microsoft Office 365: All Ohio State students are now eligible for free Microsoft Office 365. Full instructions for downloading and installation can be found at go.osu.edu/office365help.

Carmen Access

You will need to use BuckeyePass (buckeyepass.osu.edu) multi-factor authentication to access your courses in Carmen. To ensure that you are able to connect to Carmen at all times, it is recommended that you take the following steps:

- Register multiple devices in case something happens to your primary device. Visit the BuckeyePass
- Request passcodes to keep as a backup authentication option. When you see the Duo login screen on your computer, click **Enter**

a Passcode and then click the **Text me new codes** button that appears. This will text you ten passcodes good for 365 days that can each be used once.
- Download the Duo Mobile application to all of your registered devices for the ability to generate one-time codes in the event that you lose cell, data, or Wi-Fi service

If none of these options will meet the needs of your situation, you can contact the IT Service Desk at 614-688-4357(HELP) and IT support staff will work out a solution with you.

Hypothes.is

This course requires the use of a digital social annotation tool called Hypothes.is. Hypothes.is allows students to engage with course readings and online content by highlighting text and adding comments directly on web pages or PDFs. This tool will be used to foster collaborative learning and facilitate discussions about the course material. Students will be able to annotate readings, share insights, ask questions, and respond to peers, creating a dynamic learning environment. The instructor may also monitor and participate in the annotations, providing feedback, guiding discussions, and answering questions to enhance the learning experience.

If you encounter an issue with access to this tool, please contact your instructor at their name.#@osu.edu and ascode@osu.edu. Accommodation and assistance will be arranged for you to complete any work required with this tool free of penalty.

V-Lab Equipment

The following equipment will be required for V-labs:

- Calculator
- Ruler
- Phone camera
- Craft materials to model our solar system at home, including Styrofoam base and balls, skewers and a lamp. Any replacement

items serving the same function can be used. For example, a phone torch can be used instead of a lamp, and clay balls can be used instead of Styrofoam balls.
- Diffraction grating glasses. These will be available for collection from the Astronomy Department. Students unable to collect glasses, can create their own diffraction grating at home using an old CD.

Details of equipment requirements will be provided at the start of each lab. Please reach out with any equipment-related concerns.

Accessibility Statement

This course utilizes web-based planetarium tools such as Stellarium and NASA's Eyes, which are highly visual applications. If you have difficulty accessing this content due to a visual impairment or other accessibility concerns, equivalent alternative assignments will be provided as needed. Please reach out if you require accommodations.

At times, this course may require outdoor explorations such as moon observations and walking the Solar System to Scale on North Campus. If you are unable to participate in outdoor explorations due to safety or accessibility concerns, or being out of town, equivalent alternative assignments will be provided as needed. Please reach out for assistance.

Grading and instructor response

How your grade is calculated

Assignment Category	Percentage
Mini lesson review quizzes	20%
V-labs	25%

Assignment Category	Percentage
Astro chat	10%
Knowledge checks	30%
Unit assessments	15%
Total	**100%**

Description of major course assignments

Assignment categories

See **Credit hours and work expectations** for an overview of the assignment categories listed above.

Below are the details of the unit assessments. See **Course Schedule** for due dates.

Unit 1 assessments

Escape Room: Smoke and Mirrors

This escape room will be based on the mini lessons from Weeks 1-3. See the learning outcomes listed at the start of each lesson to guide your preparation.

Duration: 1 hour

Format and grading: Auto-graded Carmen assignment

Ongoing Activity 1: You Be the Scientist!

In this ongoing activity you will craft your own physical model of the Earth-Moon-Sun system, use your model to make predictions about when you should see each phase of the moon, test your predictions by watching the sky, and then refining your model if needed.

An alternative version of this assignment is available on request for students with accessibility concerns.

Duration: 6 weeks

Format and grading: Scientific report, completed according to template. See rubric for grading guidelines.

Unit 2 assessment

Escape Room: The Mystery of the Dead Star

This escape room will be based on the mini lessons from Weeks 4-7. See the learning outcomes listed at the start of each lesson to guide your preparation.

Duration: 1 hour

Format and grading: Auto-graded Carmen assignment

Unit 3 assessment

Ongoing Activity 2: You Be the Influencer!

This ongoing activity will be issued at the start of Unit 3. Using the science communication tips in your user guide, you'll create responsible content explaining one of the astronomy topics from the provided list. If you want to choose a different topic, check with us first to ensure it meets the assignment's learning goals. Your content should be engaging for your target audience and meet all the requirements outlined in the grading rubric.

Format of submission: Your content can take the form of a popular science article or a YouTube video. For YouTube videos, you can submit either a voice-overed storyboard or go ahead and create the final video—your choice!

Due date and grading: Your final product will be due in the first week of the next unit. You'll present it to your discussion group, where your TA and peers will grade it based on the grading rubric.

Unit 4 assessment

Ongoing Activity 3: You Be the Influencer – Boss Level!

In the previous unit, you gained hands-on experience creating science content and received feedback on your work. Now, it's time to level up! We'll tackle more complex topics and be even more selective when it comes to judging the appeal of your content.

This ongoing activity will be issued at the start of Unit 4. Using the science communication tips in your user guide, create a responsible YouTube video on one of the astronomy topics from our list of hot topics. Your video should be engaging for your target audience and cover all the hallmarks of responsible reporting, as outlined in the grading rubric.

Format of submission: You can submit either a storyboard with an accompanying script or go ahead and create the final video—your choice!

Due date and grading: Your video (or voice-overed storyboard) will be due in the last week of term. You'll present it to your discussion group, where your TA and peers will grade it based on the grading rubric.

Academic integrity and collaboration guidelines

The completion of all mini lesson review quizzes and knowledge check quizzes are strictly closed-internet with no collaboration. Students may however reference course notes when completing quizzes. Unless otherwise stated, the same rules apply to unit assessment escape rooms.

V-labs, Astro chat preparation and content creation assignments are typically open-internet, open-notes and collaboration is permitted. However, unless otherwise stated, students are expected to submit their own work for grading.

Late assignments

Late submissions will incur a 10% grade deduction for each day past the deadline.

Missed assignments will automatically receive a grade of zero.

All activities need to be submitted for grading by the last day of class.

Exceptions to the above rules can be made for cogent reasons on request. The responsibility is on the student to request an extension as soon as possible. **Extension requests received more than one week after the original deadline may be denied if no valid reason for the delay is provided.**

Grading Scale

- 93-100: A
- 90-92: A–
- 87-89: B+
- 83-86: B
- 80-82: B–
- 77-79: C+
- 73-76: C
- 70-72: C–
- 67-69: D+
- 60-66: D
- Under 60: E

Instructor feedback and response time

Grading and feedback

Mini lesson review quizzes, knowledge check quizzes, and unit assessment escape rooms will be auto-graded by Carmen, and students will receive their results automatically once the assessment has closed.

V-labs require manual grading for some questions. Grades for each lab will typically be made available within a week after the due date.

Astro chat discussions and the presentation of unit assessment content creation assignments will be graded by your TA and peers in your small-group discussion sessions and grades will be made available shortly after the end of the session.

Preferred contact method

Students can ask questions, voice concerns or query grades during office hours or via email. The typical response time for email enquiries is 1-2 business days.

Academic policies

Academic integrity policy

See **Descriptions of major course assignments**, above, for my specific guidelines about collaboration and academic integrity in the context of this online class. Suspected infringements of these requirements will be reported to the Committee on Academic Misconduct for further investigation.

It is the responsibility of the Committee on Academic Misconduct to investigate or establish procedures for the investigation of all reported cases of student academic misconduct. The term “academic misconduct” includes all forms of student academic misconduct wherever committed; illustrated by, but not limited to, cases of plagiarism and dishonest practices in connection with examinations. Instructors shall report all

instances of alleged academic misconduct to the committee (Faculty Rule 3335-5-487). For additional information, see the Code of Student Conduct: http://studentlife.osu.edu/csc/.

If I suspect that a student has committed academic misconduct in this course, I am obligated by university rules to report my suspicions to the Committee on Academic Misconduct. If COAM determines that you have violated the university's Code of Student Conduct (i.e., committed academic misconduct), the sanctions for the misconduct could include a failing grade in this course and suspension or dismissal from the university.

If you have any questions about the above policy or what constitutes academic misconduct in this course, please contact me.

Other sources of information on academic misconduct (integrity) to which you can refer include:

- Committee on Academic Misconduct web page (go.osu.edu/coam)
- Ten Suggestions for Preserving Academic Integrity (go.osu.edu/ten-suggestions)

Copyright for instructional materials

The materials used in connection with this course may be subject to copyright protection and are only for the use of students officially enrolled in the course for the educational purposes associated with the course. Copyright law must be considered before copying, retaining, or disseminating materials outside of the course.

Statement on title IX

Title IX makes it clear that violence and harassment based on sex and gender are Civil Rights offenses subject to the same kinds of accountability and the same kinds of support applied to offenses against other protected categories (e.g., race). If you or someone you know has been sexually harassed or assaulted, you may find the appropriate resources at http://titleix.osu.edu or by contacting the Ohio State Title IX Coordinator at titleix@osu.edu.

Commitment to a diverse and inclusive learning environment

The Ohio State University affirms the importance and value of diversity of people and ideas. We believe in creating equitable research opportunities for all students and to providing programs and curricula that allow our students to understand critical societal challenges from diverse perspectives and aspire to use research to promote sustainable solutions for all. We are committed to maintaining an inclusive community that recognizes and values the inherent worth and dignity of every person; fosters sensitivity, understanding, and mutual respect among all members; and encourages each individual to strive to reach their own potential. The Ohio State University does not discriminate on the basis of age, ancestry, color, disability, gender identity or expression, genetic information, HIV/AIDS status, military status, national origin, race, religion, sex, gender, sexual orientation, pregnancy, protected veteran status, or any other bases under the law, in its activities, academic programs, admission, and employment. (To learn more about diversity, equity, and inclusion and for opportunities to get involved, please visit: https://odi.osu.edu/ or https://cbsc.osu.edu)

Land acknowledgement

We would like to acknowledge the land that The Ohio State University occupies is the ancestral and contemporary territory of the Shawnee, Potawatomi, Delaware, Miami, Peoria, Seneca, Wyandotte, Ojibwe and Cherokee peoples. Specifically, the university resides on land ceded in the 1795 Treaty of Greeneville and the forced removal of tribes through the Indian Removal Act of 1830. I/We want to honor the resiliency of these tribal nations and recognize the historical contexts that has and continues to affect the Indigenous peoples of this land.

More information on OSU's land acknowledgement can be found here: https://mcc.osu.edu/about-us/land-acknowledgement

Your mental health

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance or reduce a student's ability to participate in daily activities. The Ohio State University offers services to assist you with addressing these and other concerns you may be experiencing. If you or someone you know are suffering from any of the aforementioned conditions, you can learn more about the broad range of confidential mental health services available on campus via the Office of Student Life's Counseling and Consultation Service (CCS) by visiting ccs.osu.edu or calling 614-292-5766. CCS is located on the 4th Floor of the Younkin Success Center and 10th Floor of Lincoln Tower. You can reach an on-call counselor when CCS is closed at 614-292-5766 and 24 hour emergency help is also available 24/7 by dialing 988 to reach the Suicide and Crisis Lifeline.

Accessibility accommodations for students with disabilities

Requesting accommodations

The university strives to maintain a healthy and accessible environment to support student learning in and out of the classroom. If you anticipate or experience academic barriers based on your disability (including mental health, chronic, or temporary medical conditions), please let me know immediately so that we can privately discuss options. To establish reasonable accommodations, I may request that you register with Student Life Disability Services. After registration, make arrangements with me as soon as possible to discuss your accommodations so that they may be implemented in a timely fashion.

If you are ill and need to miss class, including if you are staying home and away from others while experiencing symptoms of a viral infection or fever, please let me know immediately. In cases where illness interacts with an underlying medical condition, please consult with Student Life Disability Services to request reasonable accommodations. You can connect with them at slds@osu.edu; 614-292-3307; or slds.osu.edu.

Religious accommodations

Ohio State has had a longstanding practice of making reasonable academic accommodations for students' religious beliefs and practices in accordance with applicable law. In 2023, Ohio State updated its practice to align with new state legislation. Under this new provision, students must be in early communication with their instructors regarding any known accommodation requests for religious beliefs and practices, providing notice of specific dates for which they request alternative accommodations within 14 days after the first instructional day of the course. Instructors in turn shall not question the sincerity of a student's religious or spiritual belief system in reviewing such requests and shall keep requests for accommodations confidential.

With sufficient notice, instructors will provide students with reasonable alternative accommodations with regard to examinations and other academic requirements with respect to students' sincerely held religious beliefs and practices by allowing up to three absences each semester for the student to attend or participate in religious activities. Examples of religious accommodations can include, but are not limited to, rescheduling an exam, altering the time of a student's presentation, allowing make-up assignments to substitute for missed class work, or flexibility in due dates or research responsibilities. If concerns arise about a requested accommodation, instructors are to consult their tenure initiating unit head for assistance.

A student's request for time off shall be provided if the student's sincerely held religious belief or practice severely affects the student's ability to take an exam or meet an academic requirement and the student has notified their instructor, in writing during the first 14 days after the course begins,

of the date of each absence. Although students are required to provide notice within the first 14 days after a course begins, instructors are strongly encouraged to work with the student to provide a reasonable accommodation if a request is made outside the notice period. A student may not be penalized for an absence approved under this policy.

If students have questions or disputes related to academic accommodations, they should contact their course instructor, and then their department or college office. For questions or to report discrimination or harassment based on religion, individuals should contact the Office of Institutional Equity.

Policy: Religious Holidays, Holy Days and Observances

Course Schedule

Refer to our Carmen course page for up-to-date assignment due dates. Unless otherwise specified, all tasks need to be completed by the end of the week in which they appear. See **Late assignments** for more information on late or missed tasks and assignments.

Week	Topics and Tasks	Assessments Due
Unit 1: Science Unlocked: How to Talk the Talk and Walk the Walk		
1	**Is it Science?** Astronomy mini lessons topics: Patterns in the Night Sky; The Science of Astronomy Science IRL mini lessons topic: Is it Science? V-lab: Discovering the Night Sky for Yourself	Mini lessons review quizzes Knowledge check

Week	Topics and Tasks	Assessments Due
	Astro chat: How good is your bull$#!t detector? Is it even science? Ongoing Activity 1: You Be the Scientist!	
2	**How to Speak and Think Like a Scientist** Astronomy mini lessons topic: A Modern View of the Universe Science IRL mini lessons topic: How to Speak and Think Like a Scientist V-lab: The Power of Math: Scaling Relations Astro chat: How good is your bull$#!t detector? Data and logic edition Ongoing Activity 1: You Be the Scientist!	Mini lessons review quizzes Knowledge check
3	**A Map of Physics** Astronomy mini lessons topic: Orbital Mechanics Science IRL mini lessons topic: A Map of Physics V-lab: Standing on the Shoulders of Giants Astro chat: When common-sense fails you! Ongoing Activity 1: You Be the Scientist!	Mini lessons review quizzes Knowledge check

Week	Topics and Tasks	Assessments Due
Unit 2: Behind the Scenes: Where Do Scientists Get Their Facts From?		
4	**How far can and have we gone?** Astronomy mini lessons topics: Our Planetary System; Solar System Exploration Science IRL mini lessons topic: A Map of Physics V-lab: Exploring the Scale of our Solar System Astro chat: Our evolving definition of a planet Ongoing Activity 1: You Be the Scientist!	Mini lessons review quizzes Knowledge check **Unit 1 Assessment: Escape Room**
5	**If we can't *go* there, how do we know so much?** Astronomy mini lessons topics: How we use light; Surveying the Stars Science IRL mini lessons topic: A Map of Physics V-lab: Properties of Stars Astro chat: The hidden world of light Ongoing Activity 1: You Be the Scientist!	Mini lessons review quizzes Knowledge check

Week	Topics and Tasks	Assessments Due
6	**Are there limits to our observations?** Astronomy mini lessons topics: How we use light; Exoplanets Science IRL mini lessons topics: A Map of Physics; Sources of Error V-lab: Transiting Exoplanets Astro chat: Do aliens know we exist? Ongoing Activity 1: You Be the Scientist!	Mini lessons review quizzes Knowledge check **Ongoing Activity 1 due**
7	**If only we had a cosmic measuring tape!** Astronomy mini lessons topics: Counting galaxies; Measuring galactic distances; Lookback time Science IRL mini lessons topics: A Map of Physics; Sources of Error V-lab: Parallax Astro chat: Each crayon of light tells a story	Mini lessons review quizzes Knowledge check
Unit 3: Guessing or Slaying? How Theories Evolve and Get Verified		
8	**Stellar evolution** Astronomy mini lessons topic: Stellar Evolution	Mini lessons review quizzes Knowledge check

Week	Topics and Tasks	Assessments Due
	Science IRL mini lessons topic: - V-lab: Scaling Relations and Stellar Evolution Astro chat: We are made of star stuff! Ongoing Activity 2: You Be the Influencer!	**Unit 2 Assessment: Escape Room**
9	**Dark matter** Astronomy mini lessons topic: Dark Matter Science IRL mini lessons topic: A Map of Physics V-lab: Galaxy Rotation Curves Astro chat: Newtonian Gravity vs. General Relativity Ongoing Activity 2: You Be the Influencer!	Mini lessons review quizzes Knowledge check
10	**Cosmic expansion and dark energy** Astronomy mini lessons topics: Cosmic expansion; Dark energy Science IRL mini lessons topic: - V-lab: The Expanding Universe Astro chat: What's at the edge of the universe? Ongoing Activity 2: You Be the Influencer!	Mini lessons review quizzes Knowledge check

Week	Topics and Tasks	Assessments Due
11	**The early universe** Astronomy mini lessons topic: The Birth of the Universe Science IRL mini lessons topic: A Map of Physics V-lab: Rewinding the Universe Astro chat: Inflation – faster than the speed of light?! Ongoing Activity 2: You Be the Influencer!	Mini lessons review quizzes Knowledge check
Unit 4: Game On! Tackling Tough Topics in Science Like a Boss		
12	**Is it reliable science?** Astronomy mini lessons topic: Life in the Universe Science IRL mini lessons topics: A Basic Guide to Science IRL: Checkpoint 1 and 2 V-lab: Finding and evaluating scientific sources: Life in the Universe Astro chat: Extraordinary claims: Aliens are visiting Earth Ongoing Activity 3: You Be the Influencer – Boss Level!	Mini lessons review quizzes Knowledge check **Ongoing Activity 2 due**

Week	Topics and Tasks	Assessments Due
13	**Does it warrant action?** Astronomy mini lessons topic: Planetary Atmospheres Science IRL mini lessons topic: A Basic Guide to Science IRL: Checkpoint 3 V-lab: Finding and evaluating scientific sources: Climate change Astro chat: Is this politics or the real deal? Ongoing Activity 3: You Be the Influencer – Boss Level!	Mini lessons review quizzes Knowledge check
14	**Does it matter IRL?** Astronomy mini lessons topic: Black holes Science IRL mini lessons topic: A Basic Guide to Science IRL: Checkpoint 4 V-lab: Evaluating the technological and socio-economic impact black hole of research Astro chat: Is taxpayer funding for blue sky research justified? Ongoing Activity 3: You Be the Influencer – Boss Level!	Mini lessons review quizzes Knowledge check
15		**Ongoing Activity 3 due**

Week	Topics and Tasks	Assessments Due
Finals		This course has no final exam.

Unit 1: Science Unlocked: How to Talk the Talk and Walk the Walk

What makes something *real* science? How do we separate science from pseudoscience? How do we separate truth from misleading claims? This unit kicks off your science IRL journey by building the skills needed to think, talk and walk like a scientist. Through the lens of astronomy, we'll trace the birth and development of science, learning what science is and how to recognize it. And we'll catch you up on the math and physics you need to go all the way in this course! Expect to have some fun along the way – we're going to put your bull$#!t detector and logic to the test as we lay the groundwork for deeper cosmic exploration ahead.

Unit assessments: There are two unit assessments for Unit 1:

Escape Room: Smoke and Mirrors
This escape room will be based on the mini lessons from Weeks 1-3. See the learning outcomes listed at the start of each lesson to guide your preparation.

Ongoing Activity 1: You Be the Scientist!
In this ongoing activity you will craft your own physical model of the Earth-Moon-Sun system, use your model to make predictions about when you should see each phase of the moon, test your predictions by watching the sky, and then refining your model if needed.
An alternative version of this assignment is available on request for students with accessibility concerns.

Week 1: Is it Science? (Week 1)

Ever wonder if that YouTube video was legit science or total bull$#!t? This week, we sharpen our pseudoscience detectors! We'll trace the birth of modern astronomy—where science began—exploring the scientific process and technology's early impact. After outlining the hallmarks of science, it's your turn: experience science in action with night sky observations and put your skills to the test in "Is it even science? YouTube edition."

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Is it even science?**		Textbook chapters: 2. Discovering the Universe for Yourself 3. The Science of Astronomy	Influencer's Guide sections: 2. Is it Science? Opening Comments: Present students with a mix of science and pseudoscience YouTube videos related to Astronomy. Ask students to classify each video as science or pseudoscience. We will revisit these videos at the end of the week.
Mini Lessons: **What is science?**	D1L1	2.1. Patterns in the Night Sky	
	D1L2	2.2. The Reason for the Seasons	
	D2L1	2.4 The Ancient Mystery of the Planets	
	D2L2	3.1. The Ancient Roots of Science 3.2. Ancient Greek Science	
	D3L1	3.3. The Copernican Revolution	
	D3L2	3.4. The Nature of Science	2.1. The scientific process: What is science? 2.2. The hallmarks and scope of science
V-Lab		**Discovering the Night Sky for Yourself:** • Recreate the Curiosity of Early Astronomers • Test and Refine Your Understanding • Experience the Scientific Cycle in Action	
Astro Chat		**How good is your bull$#!t detector? Is it even science?** Use hallmarks introduced in Section 2.2. to classify the videos from the opening comments as science or pseudoscience.	
Knowledge Check		MCQ quiz covering this week's lessons.	

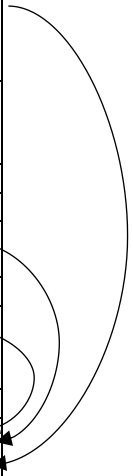
Week2: How to Speak and Think Like a Scientist (Week 2)

Confused by scientific gibberish? This week, we start breaking it down! First, we'll explore the universe's vast scales—from subatomic particles to the cosmic horizon—while decoding astronomers' units of measurement. Then, we'll lay the math and graphing foundations you will need to succeed in this course.

Let's be real—you can't escape math in science! But don't worry, we're keeping it light—just the essentials. More importantly, we'll show you why scientists love it (Einstein called it "the poetry of logical ideas"). In V-Lab, you'll see how math elegantly describes the relationship between variables and opens a whole new world of understanding!

And, of course, we'll have some fun along the way—spotting misleading visuals, dodging logical traps, and putting your skills to the test in " How good is your bull$#!t detector? Data and logic edition."

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **What did they say?**		Textbook chapters: 1. A Modern View of the Universe 3. The Science of Astronomy	Influencer's Guide sections: 3. How to Speak and Think Like a Scientist Opening Comments: Present students with information from the media that contains data misrepresentation and/or logical fallacies and briefly assess their ability to identify inconsistencies. We will revisit this information at the end of the week.
Mini Lessons: **How to Speak and Think Like a Scientist**	D1L1	1.1 The Scale of the Universe Appendix C: A Few Mathematical Skills	3.1.1. Working with big and small numbers
	D1L2		3.1.2. Units and unit conversion
	D2L1		3.1.2. Units and unit conversion
	D2L2		3.3.1. Graphs 3.3.2. Data misrepresentation
	D3L1		3.4. The power of math: Scaling relations
	D3L2	3.4 The Nature of Science: Logic and Science	3.6.1. Types of logic 3.6.2. Valid vs. sound arguments 3.6.3. Common logical fallacies
V-Lab		**The Power of Math: Scaling Relations**	
Astro Chat		**How good is your bull$#!t detector? Data and logic edition** Use the knowledge gained in this module, particularly relating to graphs, data misrepresentation and logical fallacies to critically evaluate claims.	
Knowledge Check		MCQ quiz covering this week's lessons.	



Week 3: A Map of Physics (Week 3)

Ever feel like your mind is leaving your body when a scientist rambles on about something that defies common sense? If you can't rely on common sense, how do you evaluate scientific claims? Do you just trust the expert? **No—you need domain knowledge.** Science thrives on skepticism, testing assumptions, and building on centuries of discoveries. There's no shortcut to this knowledge, but this course will get you in the ballpark of knowing what you need to know and what questions to ask!

This week, you'll prove firsthand how easily common sense can fail you and develop an understanding of why domain knowledge is key. We'll start building your map of physics by jumping into the basics of orbital and classical mechanics. In V-Lab, you'll get hands-on, experiencing the cumulative nature of scientific knowledge and exploring the power of physics by measuring Jupiter's mass all the way from Earth!

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **The importance of domain knowledge**		Textbook chapters: 4. Making Sense of the Universe: Understanding Motion, Energy, and Gravity	Influencer's Guide sections: 4. A Map of Physics Opening Comments: Present students with a YouTube video discussing an astronomy topic addressing conceptually challenging physics such as relativity or string theory, illustrating the ineffectiveness of common sense in understanding these topics.
Mini Lessons: **A map of physics**	D1L1		4.1. The importance of domain knowledge 4.2. A map of physics (overview of the main fields of physics introduced in this course)
	D1L2	3.3 The Copernican Revolution: Kepler's three laws of planetary motion	
	D2L1	4.2 Newton's Laws of Motion	
	D2L2	4.3 Conservation Laws in Astronomy	
	D3L1	4.4 The Universal Law of Gravitation	4.2.1. Classical mechanics
	D3L2	4.5 Orbits	4.2.2. Orbital mechanics
V-Lab		**Standing on the Shoulders of Giants:** • Illustrate the Cumulative Nature of Scientific Knowledge • Illustrate the Power of Mathematical Models • Experience the Scientific Cycle in Action	
Astro Chat		**When common-sense fails you!** Discuss pre-selected examples illustrating how common-sense can fail you. For each example, allow students to predict outcomes and then reveal and discuss outcomes as a group. E.g. what will happen if you spin an open bucket filled with water over your head? Will the water fall out? No!	
Knowledge Check		MCQ quiz covering this week's lessons.	

Unit 2: Behind the Scenes: Where Do Scientists Get Their Facts From?

This unit builds on the previous unit and develops trust in the scientific method by exploring how we know seemingly impossible things. You'll build domain knowledge by expanding your map of physics and exploring the astronomical methods and technologies that make discovery possible. We'll put constraints on discovery by introducing the concept of uncertainty in measurement —whether due to the vast scale of the universe, technological constraints, or inherent uncertainties in observations. You'll continue to learn how to think like a scientist as we explore what "uncertainty" means to a scientist, how they account for uncertainty and error, and that good science always reports its limitations.

Unit assessment: Escape Room: The Mystery of the Dead Star
This escape room will be based on the mini lessons from Weeks 4-7. See the learning outcomes listed at the start of each lesson to guide your preparation.

Week 1: How far can and have we gone? (Week 4)

Ever wonder about space travel? How far have humans actually gone, and will we ever be zipping through the universe in spaceships like in Star Wars? This week, we'll explore what we know about our solar system and the past and present missions that got us here. In V-Lab, you'll experience the challenges of direct observation firsthand by physically mapping out the scale of our solar system (bundle up—you're heading outside!). You'll also tackle the question, "What's the fastest we could ever travel?" Get ready for a crash course in special relativity—complete with real-world technological proof and major bragging rights! Finally, in discussion, you'll explore how our understanding of the universe evolves as our observational tools improve.

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **How far can and have we gone?**		Textbook chapters: 7. Our Planetary System S2. Space and Time	Influencer's Guide sections: 4. A Map of Physics Opening Comments: Thematic YouTube video
Mini Lessons: **Exploring our Solar System**	D1L1	7.1. Studying the Solar System	
	D1L2	7.2. Patterns in the Solar System	
	D2L1	7.3. Spacecraft Exploration of the Solar System	
	D2L2	7.3. Spacecraft Exploration of the Solar System	
	D3L1	Special Relativity	4.2.5. Special Relativity
	D3L2	Special Relativity	
V-Lab		**Exploring the Scale of our Solar System**	
Astro Chat		**Our evolving definition of a planet**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 2: If we can't *go* there, how do we know so much? (Week 5)

Light! Astronomy is all about observing light, and this week, we're diving into the electromagnetic spectrum and spectroscopy to uncover what light can tell us about stars. You'll learn how we determine key properties like the luminosity, temperature, size, mass and composition of stars by combining observation with validated models—science building on science! In V-Lab, you'll create your own HR diagram, setting the stage for studying stellar evolution in the next unit. And in discussion, you'll actively explore the hidden world of light by building your own diffraction grating!

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **If we can't go there, how do we know so much?**		Textbook chapters: 5. Light and Matter: Reading Messages from the Cosmos 15. Surveying the Stars	Influencer's Guide sections: 4. A Map of Physics Opening Comments: Thematic YouTube video
Mini Lessons: **What we learn from light**	D1L1	5.2. Properties of Light 5.3. Properties of Matter	
	D1L2	5.4. Learning from Light: Composition	4.2.3. Spectroscopy
	D2L1	5.4. Learning from Light: Temperature	
	D2L2	15.1. Properties of Stars	
	D3L1	15.2. Patterns Among Stars	
	D3L2	15.3 Star Clusters	
V-Lab		**Properties of Stars**	
Astro Chat		**The hidden world of light**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 3: Are there limits to our observations? (Week 6)

This week, we continue exploring how combining observation with validated theories can deepen our understanding of the universe. We'll focus on exoplanets, their properties, and the surveys and methods used to detect them. A key concept we'll introduce is Doppler shift, which will be crucial for later discussions. We'll also address the limits of observation by examining sources of error in measurement. In V-Lab, you'll gain hands-on experience by analyzing transit data and learning about the effects of noise and bias in measurements. In discussion, we'll further explore the concept of observational bias in exoplanet detection by pondering whether hypothetical aliens can know we exist!

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Are there limits to our observations?**		Textbook chapters: 5. Light and Matter: Reading Messages from the Cosmos 13. Exoplanets: The New Science of Distant Worlds	Influencer's Guide sections: 3. How to Speak and Think Like a Scientist 4. A Map of Physics Opening Comments: Thematic YouTube video
Mini Lessons: **Exoplanet discovery**	D1L1	5.4. Learning from Light: Doppler Effect	4.2.3. Doppler shift
	D1L2	13.1. Detecting Planets Around Other Stars	
	D2L1	13.1. Detecting Planets Around Other Stars	
	D2L2	13.2. The Nature of Planets Around Other Stars	
	D3L1	13.3. The Formation of Other Solar Systems	
	D3L2		3.2.1. Scientific vs. everyday meaning of uncertainty 3.2.4. Sources of error
V-Lab		**Transiting Exoplanets**	
Astro Chat		**Do aliens know we exist?**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 4: If only we had a cosmic measuring tape! (Week 7)

This week is all about quantifying the night sky. How many stars and galaxies are out there? How far away are they? And how do we even measure that? We'll explore how astronomers estimate cosmic numbers using sampling and dive into the cosmic distance ladder—our tool for measuring distances in space. In V-Lab, you'll experiment with parallax, the second rung of the ladder. We'll also continue our discussion on uncertainty, breaking down how each rung introduces new challenges. Plus, did you know astronomers time travel? The further we look, the younger the universe appears—welcome to lookback time! Since distant objects are redshifted, we'll discuss why astronomers use different wavelengths of light to uncover different cosmic stories in our weekly discussion: "Each crayon of light tells a story."

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **If only we had a cosmic measuring tape!**		Textbook chapters: 20. Galaxies and the Foundation of Modern Cosmology	Influencer's Guide sections: 3. How to Speak and Think Like a Scientist 4. A Map of Physics Opening Comments: Thematic YouTube video
Mini Lessons: **Measuring the universe**	D1L1	20.1 Islands of Stars	
	D1L2	Counting galaxies	3.2.2. Sample vs. population
	D2L1	20.2. Measuring Galactic Distances	3.2.4. Sources of error
	D2L2	20.2. Measuring Galactic Distances	
	D3L1	Lookback time	
	D3L2		4.2.3. Each crayon of light tells a story
V-Lab		**Parallax**	
Astro Chat		**Each crayon of light tells a story**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Unit 3: Guessing or Slaying? How Theories Evolve and Get Verified

Now that we've covered the basics of how science works, we're letting you loose in the world of modern astronomy! This unit builds trust in the scientific method by showing how scientific theories are born, tested, and refined. We'll dive into four hot topics in astronomy, exploring key concepts, theory development, and open questions. You'll also learn about current and upcoming surveys tackling these mysteries. Plus, it's your time to shine as a responsible influencer—get ready to create media content on a trending astronomy topic!

Unit assessment: Ongoing Activity 2: You Be the Influencer!

This ongoing activity will be issued at the start of Unit 3. Using the science communication tips in your user guide, you'll create responsible content explaining one of the astronomy topics from the provided list. If you want to choose a different topic, check with us first to ensure it meets the assignment's learning goals. Your content should be engaging for your target audience and meet all the requirements outlined in the grading rubric.

Format of submission: Your content can take the form of a popular science article or a YouTube video. For YouTube videos, you can submit either a voice-overed storyboard or go ahead and create the final video—your choice!

Due date and grading: Your final product will be due in the first week of the next unit. You'll present it to your discussion group, where your TA and peers will grade it based on the grading rubric.

Week 1: Stellar evolution (Week 8)

This week, we look at the basics of stellar evolution, the age of stars, take a walk through the stellar graveyard, and give you a crash course in current research in the field. In V-Lab we will apply this knowledge to learn more about the stars in our night sky and we'll return to scaling relations for a better understanding of the lifetime of stars. In discussion, we unpack Carl Sagan's famous quote, "We are made of star stuff".

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **We are made of star stuff!**		Textbook chapters: 16. Star Birth 17. Star Stuff	Influencer's Guide sections: - Opening Comments: Thematic YouTube video
Mini Lessons: **Stellar Evolution**	D1L1	16.1. Stellar Nurseries	
	D1L2	16.2. Stages of Star Birth 16.3. Masses of Newborn Stars	
	D2L1	17.1. Lives in the Balance	
	D2L2	17.2. Life as a Low-Mass Star	
	D3L1	17.3. Life as a High-Mass Star	
	D3L2	17.4. The Roles of Mass and Mass Exchange Open questions and surveys	
V-Lab		**Scaling Relations and Stellar Evolution**	
Astro Chat		**We are made of star stuff!**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 2: Dark matter (Week 9)

This week is all about dark matter—how it was discovered and where research stands today. We'll dive into General Relativity (with real-world validation included!) and compare it to Newtonian gravity in discussion. In V-Lab, you'll explore the observational evidence for dark matter firsthand!

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Unseen Influences P1**		Textbook chapters: S3. Spacetime and Gravity 23. Dark Matter, Dark Energy, and the Fate of the Universe	Influencer's Guide sections: 4. A Map of Physics Opening Comments: Thematic YouTube video
Mini Lessons: **Dark Matter**	D1L1	General Relativity	4.2.6. General Relativity
	D1L2	General Relativity	
	D2L1	23.2 Evidence for Dark Matter	
	D2L2	23.2 Evidence for Dark Matter	
	D3L1	23.3 Structure Formation	
	D3L2	Open questions and surveys	
V-Lab		**Galaxy Rotation Curves**	
Astro Chat		**Newtonian Gravity vs. General Relativity**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 3: Cosmic expansion and dark energy (Week 10)

This week, we delve into cosmic expansion and dark energy research. We'll help you get your head around the tough concept of cosmological redshift, and in V-Lab, you'll explore Hubble's observational evidence that led to the conceptualization of the Big Bang Theory. In discussion, we'll contemplate what is at the edge of the universe.

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Unseen Influences P2**		Textbook chapters: 20. Galaxies and the Foundation of Modern Cosmology 23. Dark Matter, Dark Energy, and the Fate of the Universe	Influencer's Guide sections: - Opening Comments: Thematic YouTube video
Mini Lessons: **Cosmic expansion**	D1L1	Hubble's Observations	
	D1L2	20.3 The Age of the Universe	
	D2L1	20.3 The Age of the Universe	
	D2L2	23.4 Dark Energy and the Fate of the Universe	
	D3L1	23.4 Dark Energy and the Fate of the Universe	
	D3L2	Open questions and surveys	
V-Lab		**The Expanding Universe**	
Astro Chat		**What's at the edge of the universe?**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 4: The early universe (Week 11)

Ready to time travel?! This week we travel back in time, rewinding the universe to learn what happened in the first few minutes! We'll pick up some particle physics along the way, and in discussion, we'll try wrapping our heads around the concept of inflation – did the early universe travel faster than the speed of light?!

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Rewinding the Universe**		Textbook chapters: S4. Building Blocks of the Universe 22. The Birth of the Universe	Influencer's Guide sections: 4. A Map of Physics Opening Comments: Thematic YouTube video
Mini Lessons: **The BBT**	D1L1	S4.2 Fundamental Particles and Forces	4.2.4. Particle Physics
	D1L2	22.1 The Big Bang Theory	
	D2L1	22.2 Evidence for the Big Bang	
	D2L2	22.2 Evidence for the Big Bang	
	D3L1	22.3 The Big Bang and Inflation	
	D3L2	Open questions and surveys	
V-Lab		**Rewinding the Universe**	
Astro Chat		**Inflation – faster than the speed of light?!**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Unit 4: Game On! Tackling Tough Topics in Science Like a Boss

Now that you've got a solid grip on the scientific process, it's time to put those skills to work IRL! This unit is all about using science literacy in decision-making—spotting and debunking false claims, evaluating source trustworthiness, understanding the significance of claims, and asking whether it matters IRL! With the rise of AI tools that can answer just about anything, the real challenge isn't finding information—it's knowing the right questions to ask and how to validate the answers. Plus, get ready to level up on your influencer game! Be prepared to tackle more complex topics and up your appeal!

Unit assessment: Ongoing Activity 3: You Be the Influencer – Boss Level!

In the previous unit, you gained hands-on experience creating science content and received feedback on your work. Now, it's time to level up! We'll tackle more complex topics and be even more selective when it comes to judging the appeal of your content.

This ongoing activity will be issued at the start of Unit 4. Using the science communication tips in your user guide, create a responsible YouTube video on one of the astronomy topics from our list of hot topics. Your video should be engaging for your target audience and cover all the hallmarks of responsible reporting, as outlined in the grading rubric.

Format of submission: You can submit either a storyboard with an accompanying script or go ahead and create the final video—your choice!

Due date and grading: Your video (or voice-overed storyboard) will be due in the last week of term. You'll present it to your discussion group, where your TA and peers will grade it based on the grading rubric.

Week 1: Is it reliable science? (Week 12)

You've spent nearly this entire course learning what science is, and by now, your bull$#!t detector should be on point. This week, we're stepping it up by looking at what makes a scientific source trustworthy. And what better topic to dive into than aliens and UFOs?! We'll explore the scientific study of life in the universe—what we know, open questions, and surveys. In V-Lab, you'll find and evaluate the trustworthiness of scientific sources studying life beyond Earth. We'll wrap up by using your understanding of the hallmarks of science and trustworthy sources to evaluate the juicy claim that aliens are visiting Earth!

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Can I trust it?**		Textbook chapters: 24. Life in the Universe	Influencer's Guide sections: 5. A Basic Guide to Science IRL Opening Comments: Thematic YouTube video
Mini Lessons: **Aliens**	D1L1	24.1 Life on Earth	
	D1L2	24.2 Life in the Solar System	
	D2L1	24.3 Life Around Other Stars	
	D2L2	24.4 The Search for Extraterrestrial Intelligence	
	D3L1	24.5 Interstellar Travel and Its Implications for Civilization Open questions and surveys	
	D3L2		Checkpoint 1: Is it science? Checkpoint 2: Can I trust this information?
V-Lab		**Finding and evaluating scientific sources: Life in the Universe**	
Astro Chat		**Extraordinary claims: Aliens are visiting Earth**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 2: Does it warrant action? (Week 13)

Throughout this course, you've been developing your understanding of science, how it works, and key points to consider when evaluating information. You're now going to consolidate this information into a framework that can help you decide if a result is truly significant – and you'll put your framework to the test in the context of climate change. We'll explore the basics of planetary atmospheres, and in V-Lab, you'll find and evaluate the significance of climate change research. We'll wrap up with a debate: "Is it politics, or the real deal?!" What information do you need to choose a side and where will you source this information?

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Is it significant?**		Textbook chapters: 10. Planetary Atmospheres: Earth and the Other Terrestrial Worlds	Influencer's Guide sections: 5. A Basic Guide to Science IRL Opening Comments: Thematic YouTube video
Mini Lessons: **Climate Change**	D1L1	10.1 Atmospheric Basics	
	D1L2	10.2 Weather and Climate	
	D2L1	10.3 Atmospheres of the Moon and Mercury	
	D2L2	10.4 The Atmospheric History of Mars	
	D3L1	10.5 The Atmospheric History of Venus	
	D3L2	10.6 Earth's Unique Atmosphere	Checkpoint 3: How significant are these findings?
V-Lab		**Finding and evaluating scientific sources: Climate change**	
Astro Chat		**Is this politics or the real deal?**	
Knowledge Check		MCQ quiz covering this week's lessons.	

Week 3: Does it matter IRL? (Week 14)

This section goes deeper into science and decision-making, exploring the technological and socio-economic impact of scientific research. The debate can go in many directions—like the consequences of not acting on climate change—but here, we'll focus on funding research. When budgets are tight, how do we justify spending on something as abstract as studying black holes? This week, we'll catch you up on black holes—what we know, open questions, and upcoming surveys. You'll dive into the technological and socio-economic impacts of black hole research and have the chance to voice your opinion on using taxpayer funds for blue-sky research.

		Topics and Activities	
		Mastering Astronomy	Influencer's Guide to Science IRL
The Big Idea: **Does it matter IRL?**		Textbook chapters: 18. The Bizarre Stellar Graveyard	Influencer's Guide sections: 5. A Basic Guide to Science IRL Opening Comments: Thematic YouTube video
Mini Lessons: **Black Holes**	D1L1	18.3. Black Holes What is a black hole?	
	D1L2	What would it be like to visit a black hole?	
	D2L1	Do black holes really exist?	
	D2L2	Open questions	
	D3L1	Planned surveys	
	D3L2		Checkpoint 4: Does it matter IRL?
V-Lab		**Evaluating the technological and socio-economic impact black hole of research**	
Astro Chat		**Is taxpayer funding for blue sky research justified?**	
Knowledge Check		MCQ quiz covering this week's lessons.	

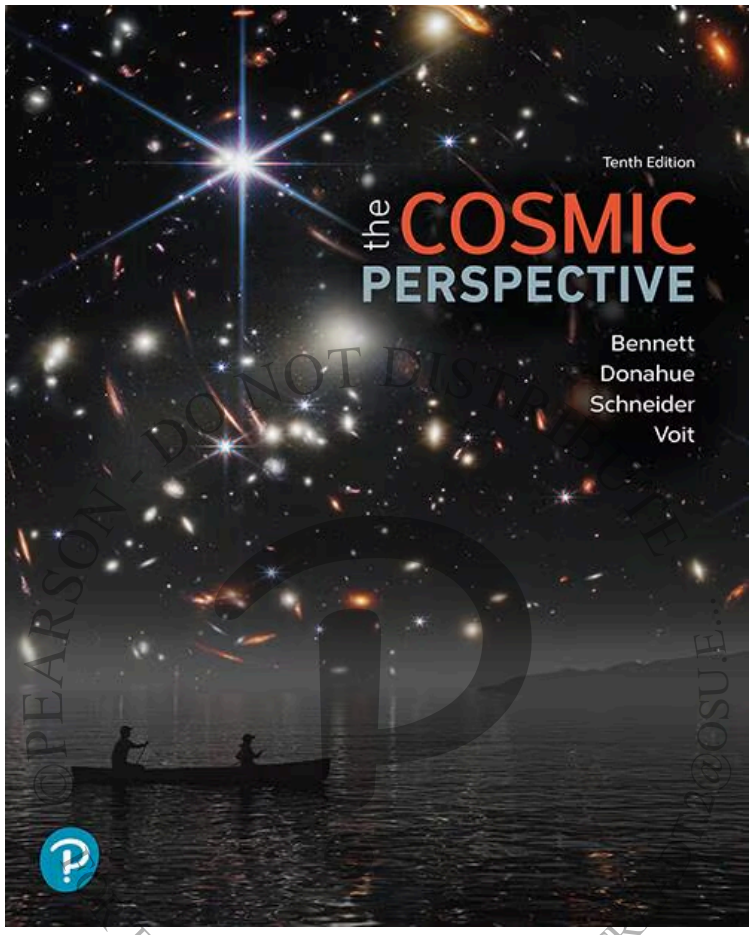
Linking GE ELOs to Course Topics

GE ELO	Topics for Each Unit			
	Unit 1: Science Unlocked	**Unit 2: Behind the Scenes**	**Unit 3: Guessing or Slaying?**	**Unit 4: Game On!**
1.1. Explain basic facts, principles, theories and methods of modern natural sciences, and describe and analyze the process of scientific inquiry. **1.2.** Identify how key events in the development of science contribute to the ongoing and changing nature of scientific knowledge and methods.	**Science IRL:** **W1:** Is it Science? How to Speak and Think Like a Scientist: **W2:** Measuring our Universe **W2:** Data analysis and visualization **W2:** Logic **W3:** A Map of Physics **Astronomy:** Astronomy Facts: **W1:** Key observations and events that led to the birth of modern science. **W2:** Scales of our Universe and astronomical units A Map of Physics: **W3:** Orbital mechanics and classical mechanics	**Science IRL:** How to Speak and Think Like a Scientist: **W3-4:** Dealing with uncertainty in measurement **Astronomy:** Astronomy Facts: **W1:** Our solar system **W2:** Properties and composition of stars **W3:** Exoplanets and their properties **W4:** Cosmic scales: objects, quantities, distances, and time A Map of Physics: **W1:** Special Relativity **W2:** Spectroscopy **W3:** Doppler shift **W4:** Each crayon of light tells a story Astronomy Methods: **W1:** Solar system exploration: Current	**Science IRL:** **W1-4:** A Framework for Understanding Science **W2-4:** Notes on Science Communication **Astronomy:** Key concepts, theory development and open questions: **W1:** Stellar evolution **W2:** Dark matter **W3:** Cosmic expansion and dark energy **W4:** The early universe A Map of Physics: **W2:** General Relativity **W4:** Particle Physics	**Science IRL:** A Basic Guide to Science IRL: **W1:** Checkpoint 1: Is it science? **W1:** Checkpoint 2: Can I trust this information? **W2:** Checkpoint 3: How significant are these findings? **W3:** Checkpoint 4: Does it matter IRL? **W1-3:** Notes on Science Communication **W1-3:** AI Tools **Astronomy:** **W1:** Life in the Universe: What we know, open questions and planned surveys **W2:** Planetary atmospheres: The basics

		missions and limitations of direct observation **W2:** Beyond our solar system: What we learn from light **W3:** Methods of exoplanet discovery **W4:** Estimating and measuring the universe, including quantities of astronomical objects, distances (Cosmic Distance Ladder) and time (lookback time)		**W3:** Black holes: What we know, open questions and planned surveys
1.3. Employ the processes of science through exploration, discovery and collaboration to interact directly with the natural world when feasible, using appropriate tools, models and analysis of data.	**V-Lab:** **W1:** Discovering the Night Sky for Yourself **W2:** The Power of Math: Scaling Relations **W3:** Standing on the Shoulders of Giants **Ongoing Activity 1:** You Be the Scientist!	**V-Lab:** **W1:** Exploring the Scale of our Solar System **W2:** Properties of Stars **W3:** Transiting Exoplanets **W4:** Parallax **Ongoing Activity 1:** You Be the Scientist!	**V-Lab:** **W1:** Scaling Relations and Stellar Evolution **W2:** Galaxy Rotation Curves **W3:** The Expanding Universe **W4:** Rewinding the Universe	**V-Lab:** **W1:** Finding and evaluating scientific sources: Life in the Universe **W2:** Finding and evaluating scientific sources: Climate change **W3:** Evaluating the technological and socio-economic impact of research
2.1. Analyze the inter-dependence and potential impacts of scientific and technological developments. **2.2.** Evaluate social and ethical implications of	**W3:** Technological and socio-economic impact of the telescope. **W3:** Technological validation of classical mechanics IRL	**W1:** Technological and socio-economic impact of missions to mars. **W3:** Technological validation of SR IRL	**W1-4:** Current and planned surveys **W2:** Technological validation of GR IRL	**W1, 3:** Current and planned surveys **W3:** Technological and socio-economic impact of black hole research.

natural scientific discoveries.				
2.3. Critically evaluate and responsibly use information from the natural sciences.	**Critically evaluate (Astro Chat):** **W1:** How good is your bull$#!t detector? Is it even science? **W2:** How good is your bull$#!t detector? Data and logic edition **W3:** When common-sense fails you!	**Critically evaluate (Astro Chat):** **W1:** Our evolving definition of a planet **W2:** The hidden world of light **W3:** Do aliens know we exist? **W4:** Each crayon of light tells a story	**Critically evaluate (Astro Chat):** **W1:** We are made of star stuff! **W2:** Newtonian Gravity vs. General Relativity **W3:** The history of the Big Bang Theory **W4:** Inflation – faster than the speed of light?! **Responsibly use information:** **Ongoing Activity 2:** You Be the Influencer!	**Critically evaluate (Astro Chat):** **W1:** Extraordinary claims: Aliens are visiting Earth **W2:** Is this politics or the real deal? **W3:** Is taxpayer funding for blue sky research justified? **Responsibly use information:** **Ongoing Activity 3:** You Be the Influencer – Boss Level!

The Cosmic Perspective



TENTH EDITION

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20 GALAXIES AND THE FOUNDATION OF MODERN COSMOLOGY

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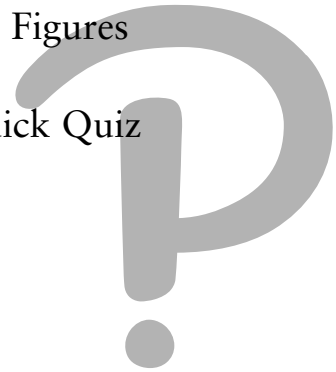


An Influencer's Guide to Science IRL

Contents

1. About this User's Guide

Science shapes our daily lives, from the food we eat to the news we read. Yet, with so much information claiming to be "scientific," how do we know what to trust? Saying "science isn't for me" is no longer an option—we all rely on it, whether we realize it or not.

This guide is designed to sharpen your ability to evaluate scientific information and apply it to real-life decisions. In today's world, powerful AI tools can help answer science-related questions—if you know what to ask. This guide will show you which questions matter and how to use AI effectively to find reliable answers.

So, why "Influencer"? Whether you create content or simply consume it, you are part of the cycle of influence. We are all shaped by online information, and at some point, we shape others. This guide is for both the **influenced** and the **influencer**—helping ensure that science is used responsibly in the digital age.

1.1. How this guide will be used in this course

This guide summarizes the science literacy tools we aim to introduce and develop in this course. While these tools are universal, we will strengthen your science literacy skills by applying them specifically to astronomy, providing a concrete way to learn and practice these concepts.

In **Module 1: Science Unlocked**, we will cover **Sections 2 to 4** of this guide, laying the foundation for deeper exploration of the scientific method in later modules. We will:

- Define what science is—and what it is not (**Section 2: Is it Science?**), enabling you to assess the scientific validity of incoming information.
- Teach fundamental number handling, graphing, and logic skills (**Section 3: How to Speak and Think Like a Scientist**), helping you navigate the sometimes complex language of scientific data.
- Introduce the core principles of physics (**Section 4: A Map of Physics**), which form the basis of all astronomical inferences.

In **Module 2: Behind the Scenes** and **Module 3: Guessing or Slaying?**, we will further develop the concepts introduced in Module 1. These modules will illustrate science in action—showing how astronomers make measurements and observations, and how they develop rigorous theories about the universe. Along the way, you will expand your Map of Physics and continue learning How to Speak and Think Like a Scientist.

Finally, in **Module 4: Game On!**, we will cover **Section 5: A Basic Guide to Science IRL** and **Section 7: AI Tools**. This module will integrate all the skills developed in the course, offering a step-by-step approach to using scientific information in real life—from assessing scientific validity to evaluating the relevance and significance of information in everyday contexts.

Lastly, from Module 2 onwards, you will start developing your own responsible social media content! Using the tips form **Section 6: Notes on Science Communication**, you will create astronomy-related YouTube content that responsibly wows your audience!

V-Lab 1: Discovering the Night Sky for Yourself

Design notes: Design notes are in red and provide information on how this lab will be implemented online. Labs will be incorporated into Carmen Canvas using H5P and will use a variety of auto graded (AG) as well as manually graded (MG) response options. Response fields are indicated in square brackets e.g. [MCQ-AG] indicates an auto graded multiple choice response field.

Aims of This V-Lab

- **Recreate the Curiosity of Early Astronomers**
  Practically explore and reproduce **naked-eye observations** that would have intrigued early scientists and sparked the birth of modern science.
- **Test and Refine Your Understanding**
  Put modern models of the **celestial sphere and solar system** to the test! Just like in the scientific process, you'll compare your own mental model against real-world observations. If predictions don't match reality, you'll refine your model—just as scientists do.
- **Experience the Scientific Cycle in Action**
  Engage in the full **scientific cycle**—from **observations to model development, predictions, testing, and refinement, then back again**. This process will be repeated throughout the course, reinforcing the **hallmarks of science** as we go. This V-Lab serves as your **first hands-on introduction** to this ongoing cycle of discovery.

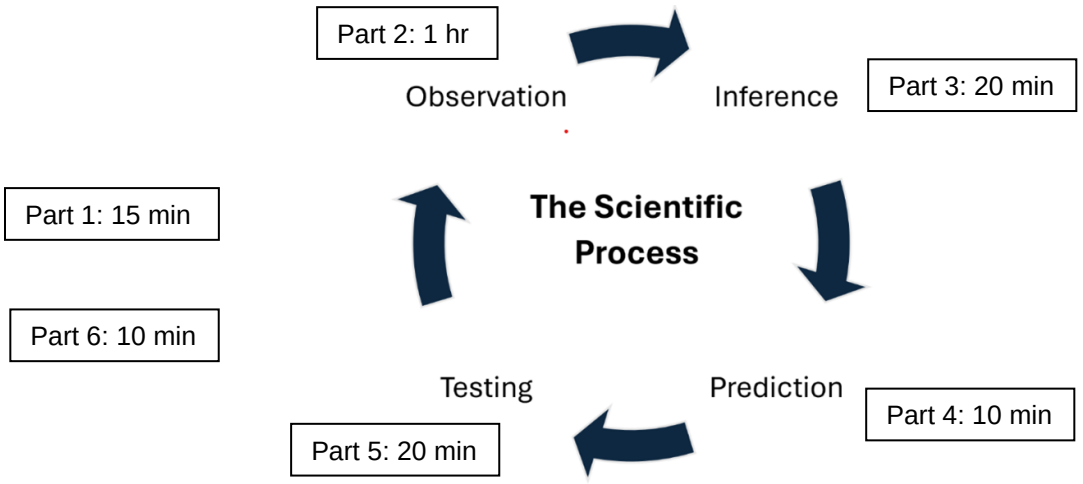
Equipment

- Stellarium planetarium software
  http://stellarium-web.org/

Navigation

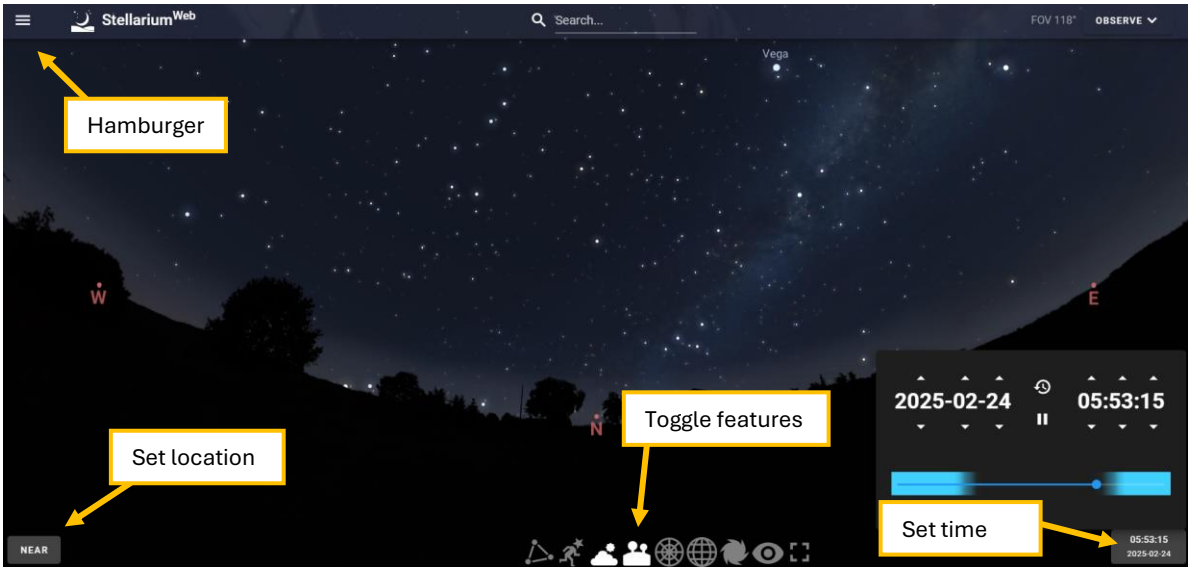
Design note: To emphasize the cyclical nature of scientific discovery, students will navigate this V-Lab through embedded links on this landing page.

Let's get started! Click on Part 1 to start this week's V-Lab.



Part 1: Access Stellarium

1. Go to http://stellarium-web.org/, which is the web interface for the software.
2. Once Stellarium loads, click the hamburger in the top left corner (three lines) to close the left panel. Your screen will look something like the one below. If you are accessing the webpage in the day, you will see a daytime scene. For now, you won't see the expanded time settings in the bottom right corner.



3. Spend a few minutes learning how to navigate the page. At the bottom middle, you can toggle features on and off. Click on each option and see what they do. For now, start with the features selected above.
4. You can pinch zoom in and out of the sky using your fingers on a track pad or phone. Try it out.
5. You can change the time in the lower right corner. We've shown you the expanded time settings in the above picture. Spend a few minutes learning what these different settings do. See what happens when you move the slide bar. Press pause and see what happens when you flip through different months or days.
6. You can change your location in the lower left corner. Keep the default setting with autolocation on.

Side note: Stellarium is also a free desktop app if you find you want to explore more or find it better to install it. **You do not have to pay for an app**. The mobile version of this app is also really useful for stargazing: simply point your phone at the sky and you'll find out in seconds whether that strange bright object in the West is really Jupiter, or maybe just a star, or a satellite!

Part 2: Observe
From within Stellarium, let's explore and reproduce some of the naked-eye observations that intrigued early scientists and sparked the birth of modern science!

Motion of stars:

7. Look North and find Polaris. You can see the name and details of a star by clicking on it – Stellarium provides a wealth of information, some of which we will unpack throughout this course. Click on Polaris and observe how its position changes over time by adjusting the time settings. Try different times, days and even years.
   What do you observe about the motion of Polaris?
   [MCQ-AG]

8. Still looking North, observe the motion of other stars. Pick three stars of your choice, the first one close to Polaris, the next a little further away, and the next close to the horizon. Now observe the motion of each of your stars as you did for Polaris.
   What do you observe about the motion of stars other than Polaris?
   [MCQ-AG]

9. What is a circumpolar star?
   [MCQ-AG]

10. How does the visibility of seasonal stars change throughout the year?
    [MCQ-AG]

11. Does the South Pole have a South Star?
    [MCQ-AG]

Motion of constellations:

12. Let's set things up so that you can view the constellations. Using the feature bar at the bottom of the page, turn on Constellations and Constellations Art. Face North and click on Polaris. Observe how the constellations move throughout a 24-hour period by adjusting the time settings one hour at a time.
    What do you observe about the motion of the constellations through the sky?
    [MCQ-AG]

13. Turn around and face South. Click on the hamburger in the top left corner and select Ecliptic Line under View Settings. Click the hamburger again to hide the left panel. You will now see the ecliptic line in red. This is the path that the Sun appears to follow in the sky. Go to your time settings. Click pause to make navigation easier. Set the date to January 25. Any year is fine. Drag the slide bar to just before sunrise. You are now ready to explore the zodiac constellations! For each month, starting in January, slide the slide bar a little to the right to see which constellation the Sun is "travelling through" that month.
    Use your observations to sort the list of zodiac constellations below in order of appearance.
    [Ordered list-AG]

Motion of the Sun:

14. Still facing South, remove the constellations from your viewing window and deselect the Ecliptic Line under View Settings. Choose any day and observe the Sun as it moves across the sky.
    What do you observe about the Sun's motion through the sky?
    [MCQ-AG]

Motion of planets:

15. Face South with the Ecliptic Line selected. With the time settings on pause, set the time to 22:00 on any given day. Run through time one day at a time by holding down the day up-arrow for a couple of years. Observe Mars closely.
    What do you notice about the motion Mars over a period of months? How does its behavior differ from the stars, the Sun and the moon?
    [MCQ-AG]

16. What is this type of motion called?
    [MCQ-AG]

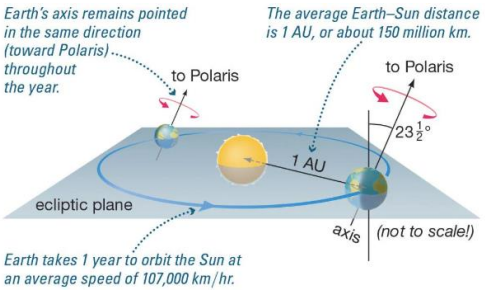
Side note: Looking to experience stargazing IRL? Check out **Stargazers' Hub** under **Astro Central** on Carmen for **stargazing tips, star party dates, and astro student orgs**! There are plenty of ways to get involved—come join the fun!

Part 3: Model

In this section, we will give you time to pause and briefly review the modern scientific models used to explain the patterns in our night sky, including the observations you made in Part 2. These models were introduced in this week's lessons. Take some time understanding these models. We will ask you to make predictions based on your understanding in the next section!

The key models used to explain the patterns in our night sky include:

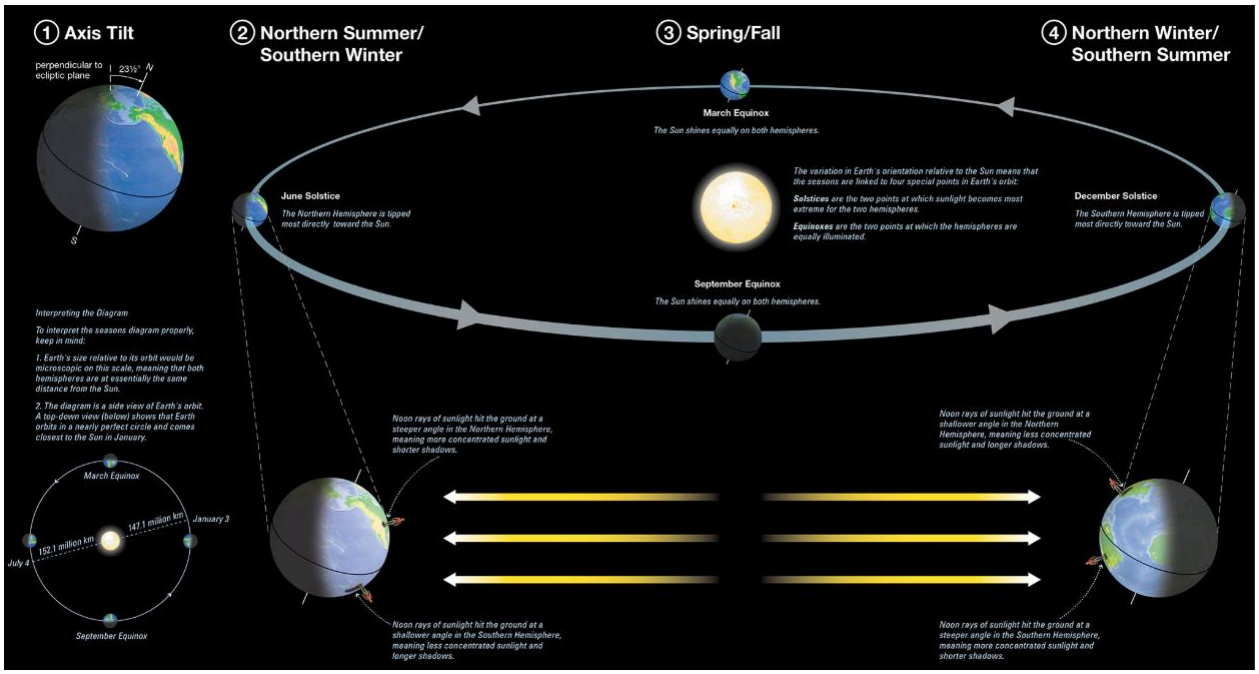
The model of Earth's daily rotation and yearly orbit around the Sun: both of which are counterclockwise as viewed from above the North Pole. The Earth, together with the other planets, rotate around the Sun, confined close to the ecliptic plane.



Source: Mastering Astronomy

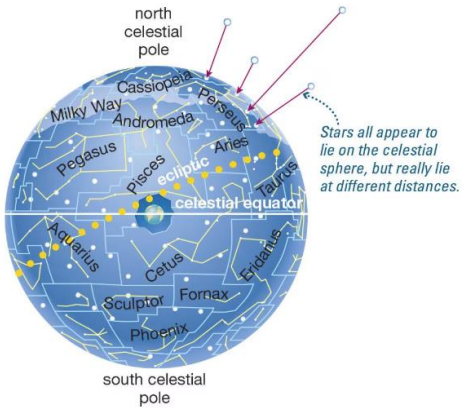
17. Consider the diagram above. In Part 2, why do you think we looked South when we wanted to view the Sun or the planets?
[MCQ-AG]

The model explaining the reason for the seasons:



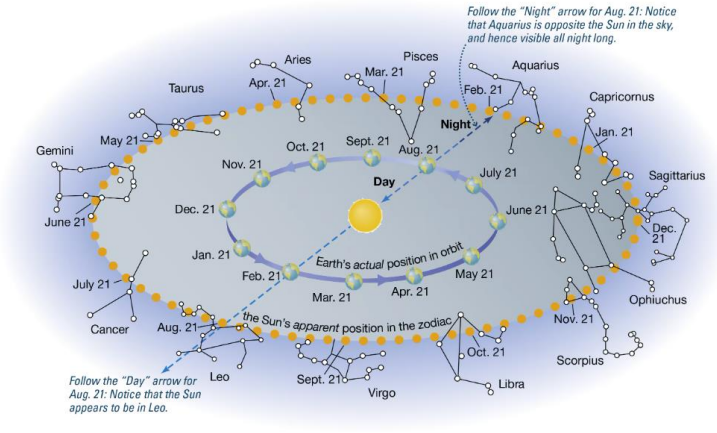
Source: Mastering Astronomy

The Celestial Sphere: The stars and constellations appear to lie on a celestial sphere that surrounds Earth. This is shown in the diagram to the right. This is an illusion created by our lack of depth perception in space, but it is useful for mapping the sky. The celestial sphere is a representation of how the entire sky looks as seen from Earth. Imagine you were sitting on a stationary beach ball in space. If you look in any direction, you will always see the same stars. It's the same on Earth. Since the Earth is spinning, you take a full 360° view of the sky every day, but you still see the same stars in each direction every day. That is, you would, if the Sun didn't block out half the sky during the day!



Source: Mastering Astronomy

As you orbit around the Sun, the Sun determines which half of the sky you can see by blocking out the half of the sky behind it. The Sun appears to move steadily eastward along the ecliptic as Earth orbits the Sun, so we see the Sun against the background of different zodiac constellations at different times of year. For example, on August 21 the Sun appears to be in Leo, because it is between us and the much more distant stars that make up Leo. The zodiac constellations are made up of stars on the celestial sphere that happen to lie along the ecliptic.



Source: Mastering Astronomy

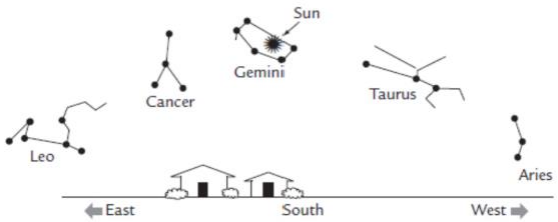
For a model simulation explaining the **retrograde motion of planets**, click here to watch a short video.

Part 4: Predict

Now you will put your understanding of the models described in Part 3 to the test by making predictions that you will test in Part 5.

Answer the following questions. Give your honest answers. These questions will be graded on participation, not correctness, and are design to give you feedback on how well you understand current models of our solar system.

18. **Prediction 1:** Since the Earth's axis is always tilted towards Polaris, which of the following viewing directions will result in seeing mostly the same stars night after night? Select all that apply.
    a. N in the Northern Hemisphere
    b. S in the Southern Hemisphere
    c. S in the Northern Hemisphere
    d. N in the Southern Hemisphere
    e. W or E in the Northern Hemisphere
    f. E or W in the Southern Hemisphere
    [Multi-select MCQ-AG]



19. **Prediction 2:** If you could see stars during the day, the drawing above shows what the sky looks like at noon on a given day. The Sun is at the highest point it will reach on this day and is near the stars of the constellation Gemini. What is the name of the constellation that will be closest to the Sun at sunset on this day?
    a. Leo
    b. Gemini
    c. Cancer
    d. Taurus
    e. Aries

    [MCQ-AG]

20. **Prediction 3:** The picture above shows the position of the stars at noon on a certain day. How long would you have to wait to see Gemini at this same position in the sky at midnight?
    a. 1 year
    b. 6 months
    c. 12 hours
    d. Gemini is never seen at this position at midnight
    e. 24 hours

    [MCQ-AG]

21. **Prediction 4:** Which of the following statements is true about the Sun's motion across the sky?
    a. The Sun rises due West every day and sets due East.
    b. The Sun rises roughly East every day and sets roughly West.
    c. The Sun's highest point in the sky is directly above your head on most days.
    d. The Sun rises due East every day and sets due West.
    e. The Sun rises roughly West every day and sets roughly East.

    [MCQ-AG]

Part 5: Test and Refine Model

Just like scientific models of the Universe are refined through prediction and observational feedback, in this section, you will develop your understanding of the above models by making predictions and testing your interpretation through observational feedback. This is what we call hypothetical-deductive reasoning, and it is the basis of science! And a great way to learn.

Ready? Let's put your predictions to the test! Using Stellarium, check your answers to the questions in Part 4 and then answer them again with your updated knowledge. This time we will grade on correctness!

Prediction 1

22. **Test:** Go ahead and test your initial prediction for this question. How did you use Stellarium to test your prediction?
    [Text-MG]

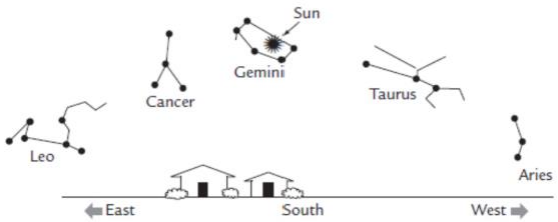
23. **Update your model:** Since the Earth's axis is always tilted towards Polaris, which of the following viewing directions will result in seeing mostly the same stars night after night? Select all that apply.
    a. N in the Northern Hemisphere
    b. S in the Southern Hemisphere
    c. S in the Northern Hemisphere
    d. N in the Southern Hemisphere
    e. W or E in the Northern Hemisphere
    f. E or W in the Southern Hemisphere
    [Multi-select MCQ-AG]

24. **Reflect:** How did testing your initial answer with observational evidence grow your understanding? There is no right or wrong answer to this question.
    a. It didn't, I understood this concept the first time.
    b. It didn't, I still don't understand what is going on.
    c. My understanding grew! I now know enough to answer the question, but there's still some things I need to understand. Maybe some more time making and testing predictions will develop my understanding further.
    d. My understanding grew! I now understand this concept fully!

    [MCQ-AG]

Prediction 2

25. **Test:** Go ahead and test your initial prediction for this question. How did you use Stellarium to test your prediction?
    [Text-MG]



26. **Update your model:** If you could see stars during the day, the drawing above shows what **the** sky looks like at noon on a given day. The Sun is at the highest point it will reach on this day and is near the stars of the constellation Gemini. What is the name of the constellation that will be closest to the Sun at sunset on this day?
    a. Leo
    b. Gemini
    c. Cancer
    d. Taurus
    e. Aries

    [MCQ-AG]

27. **Reflect:** How did testing your initial answer with observational evidence grow your understanding? There is no right or wrong answer to this question.
    e. It didn't, I understood this concept the first time.
    f. It didn't, I still don't understand what is going on.
    g. My understanding grew! I now know enough to answer the question, but there's still some things I need to understand. Maybe some more time making and testing predictions will develop my understanding further.
    h. My understanding grew! I now understand this concept fully!

    [MCQ-AG]

Prediction 3

28. **Test:** Go ahead and test your initial prediction for this question. How did you use Stellarium to test your prediction?
    [Text-MG]

29. **Update your model:** The picture above shows the position of the stars at noon on a certain day. How long would you have to wait to see Gemini at this same position in the sky at midnight?
    a. 1 year
    b. 6 months
    c. 12 hours
    d. Gemini is never seen at this position at midnight
    e. 24 hours

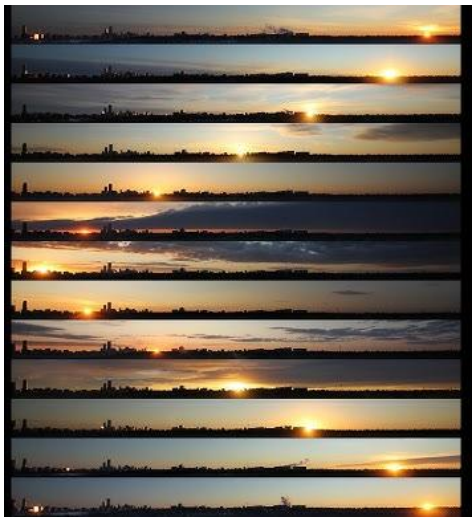
    [MCQ-AG]

30. **Reflect:** How did testing your initial answer with observational evidence grow your understanding? There is no right or wrong answer to this question.
    i. It didn't, I understood this concept the first time.
    j. It didn't, I still don't understand what is going on.
    k. My understanding grew! I now know enough to answer the question, but there's still some things I need to understand. Maybe some more time making and testing predictions will develop my understanding further.
    l. My understanding grew! I now understand this concept fully!

    [MCQ-AG]

Prediction 4

31. **Test:** To test your answer to this question, you are going to observe sunrise and sunset every month for a year! Go to your time settings. Click pause to make navigation easier. Set the date to January. Any day and year are fine. For each month, starting in January, use the slide bar to view sunrise, follow the Sun's path through the sky, and view sunset. Note the position of sunrise and sunset each month.
    Using your observations, sort the screenshots below in order of appearance, starting with what you observed in January.
    [Ordered list-AG]



1. **Update your model:** Which of the following statements is true about the Sun's motion across the sky?
    a. The Sun rises due West every day and sets due East.
    b. The Sun rises roughly East every day and sets roughly West.
    c. The Sun's highest point in the sky is directly above your head on most days.
    d. The Sun rises due East every day and sets due West.
    e. The Sun rises roughly West every day and sets roughly East.

    [MCQ-AG]

32. **Reflect:** How did testing your initial answer with observational evidence grow your understanding? There is no right or wrong answer to this question.
    a. It didn't, I understood this concept the first time.
    b. It didn't, I still don't understand what is going on.
    c. My understanding grew! I now know enough to answer the question, but there's still some things I need to understand. Maybe some more time making and testing predictions will develop my understanding further.
    d. My understanding grew! I now understand this concept fully!

    [MCQ-AG]

Part 6: Final Reflections

33. Comment on your experience in this V-Lab. Did you enjoy using Stellarium? What did you learn? How did you experience the hypothetical-deductive approach to learning? What was new for you? Did you find the lab valuable? What would you have liked to see more of? Write a paragraph on any ONE of these or another related topic.
    [Text-MG]

Lab 3: Standing on the Shoulders of Giants

Design notes: Design notes are in red and provide information on how this lab will be implemented online. Labs will be incorporated into Carmen Canvas using H5P and will use a variety of auto graded (AG) as well as manually graded (MG) response options. Response fields are indicated in square brackets e.g. [MCQ-AG] indicates an auto graded multiple choice response field.

Aims of This V-Lab

- **Illustrate the Cumulative Nature of Scientific Knowledge**
  Explore how scientific understanding evolves over time, with each discovery building upon previous work as new technology emerges.
- **Illustrate the Power of Mathematical Models**
  See how mathematics allows us to study distant and unseen worlds, revealing hidden aspects of the universe.
- **Experience the Scientific Cycle in Action**
  In this V-Lab, you will step into the role of a scientist, experiencing firsthand the challenges and excitement of discovery. You'll navigate the unknown with limited information, confront technological constraints, and feel the thrill of uncovering new insights—all while practicing the extreme patience that real scientific progress demands.

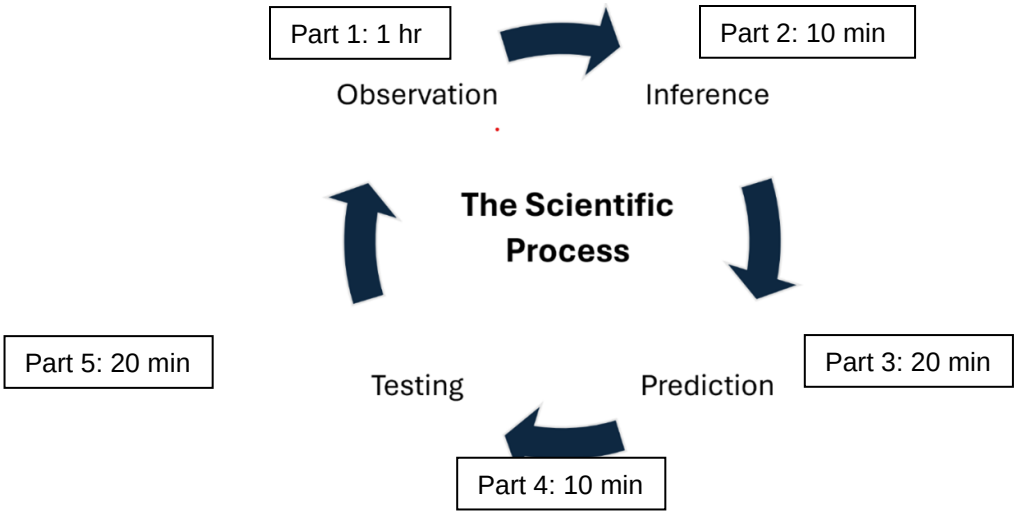
Equipment

- Calculator

Navigation

Design note: To emphasize the cyclical nature of scientific discovery, students will navigate this V-Lab through embedded links on this landing page.

Let's get started! Click on Part 1 to start this week's V-Lab.



Part 1: Observe

Galileo and the Moons of Jupiter:

Let's go back in time to 1609. You are the not-yet famous Galileo Galilei, and you've recently perfected your version of the new-fangled "spy-glasses" that you saw at a traveling show. You are excited to use this device to explore the night sky! You spot 4 very intriguing points of light very close to Jupiter, all in a line. They look something like the image below:

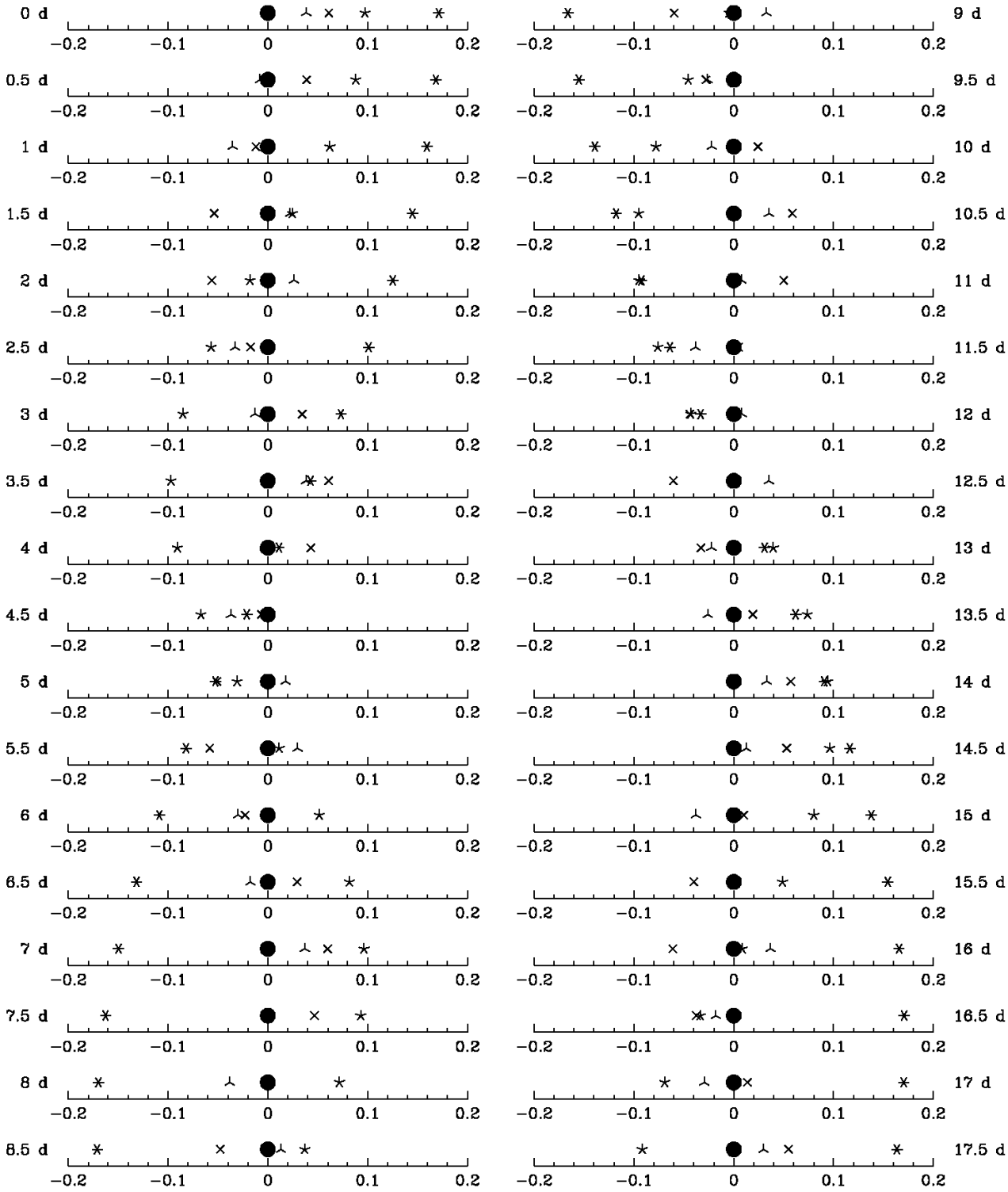
Design note: Reproduce the image for copyright purposes.

You have no idea what these objects are. You think maybe they are stars. You observe that the positions of these objects change – both from night to night, and during an individual night. But even as these objects move, they always stay close to Jupiter. Watching them dance around Jupiter for a while, you conclude that they must be *orbiting* around Jupiter – just like our own Moon orbits around Earth! Remarkable!

You originally referred to these points of light as the Medicean Stars (after the Medici family) and individually numbered them as I, II, III, and IV. The names we use today – Io, Europa, Ganymede, and Callisto – were later given by Simon Marius, a German astronomer who claimed to have discovered them around the same time. His names, inspired by mythological lovers of Zeus, eventually became the standard. But don't worry, we still refer to them as Jupiter's "Galilean" moons – because you discovered them and because we now know that they are moons, not stars as you originally had assumed!

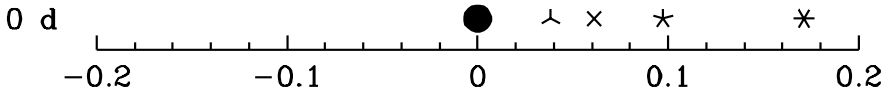
Since you have a keen eye for detail, you carefully record the positions of these objects over time. For an example of your original drawings, see here. Below is a clearer version of what you would have recorded.

Moons of Jupiter



Let's take a moment to make sense of what you drew:

Angular scale: In each instance, the black circle marks the position of Jupiter, and the asterisks mark the positions of the moons. The angular scale is marked in degrees, as shown below:



See your lesson notes for a reminder of how we measure angular distance in degrees in Astronomy, and how we convert an angular separation between two objects on the celestial sphere into a linear distance. In this picture, the third moon is separated from Jupiter by an angle of about 0.1 degrees.

Time in days: Each entry in your diagram shows an observation at a different time, separated by intervals of 0.5 days, with the time of the observation marked to the left or right (e.g., "5.5d" means that the observation was taken 5.5 days since the beginning of the observing campaign).

Symbols: The picture above (*the first observation*, which we will say occurs at "0 days") shows a time when each moon is at its maximum angular separation from Jupiter. Each moon is marked with a different symbol, which stays the same through the whole observing campaign. From inner to outer, the moons are: Io, Europa, Ganymede, and Callisto.

Let's practice taking some readings before we get started with calculations:

1. What is the angular position of Io on day 10?
   [Value-AG]

2. What is the angular position of Ganymede on day 16.5?
   [Value-AG]

Great, you're ready to get started!

Science as we know it today has not yet been developed, but you can make some inferences about these objects with what you know already. Just by observing the moons, you can determine how far away they are from Jupiter and how long it takes each one of them to complete their respective orbits.

Measuring orbital radii:

3. Read off the scale and record the angular distances (θ) of the four moons from Jupiter, in degrees, at time "0 days"?
   Io: [Dropdown List-AG]
   Europa: [Dropdown List-AG]
   Ganymede: [Dropdown List-AG]
   Callisto: [Dropdown List-AG]

4. Remember, at time “0 days”, all the moons are at their maximum distance from Jupiter. This means that if they are orbiting Jupiter on a circular path, the angular distances you just recorded are equal to their orbital radii. This is great!
   You would like to have these radii in kms and not angular units. Recall from lessons that the equation to convert angular distance (θ) to a linear distance (D) is **D = d x (θ / 57.3 degrees)**. All you need is d – the distance of Jupiter from Earth.
   You are in luck! Copernicus, with the use of some clever geometry, has already estimated the distance from Earth to Jupiter to be about 6.3×10^8 km.
   Use this information to compute the orbital radii (R) of the moons’ orbits around Jupiter in kilometers.
   Io: [Value-AG]
   Europa: [Value-AG]
   Ganymede: [Value-AG]
   Callisto: [Value-AG]

Measuring orbital periods:

5. From your diagram, determine the orbital periods of each of the four moons. The orbital period is the length of time the moon takes to go around Jupiter once. It is measured in days. Try to measure the orbital period to at least a precision of 0.5 days (e.g., 10.5 days or 16.0 days), or to a finer degree (e.g., 0.1 days) if you can (e.g., 6.7 days or 8.8 days).
   Hint: Start with the outer moon Callisto and work inwards towards the innermost moon, Io.
   Io: [Dropdown List-AG]
   Europa: [Dropdown List-AG]
   Ganymede: [Dropdown List-AG]
   Callisto: [Dropdown List-AG]

6. Convert the orbital period (P) that you measured for each moon from units of days to units of seconds. There are 60 x 60 x 24 = 86,400 seconds in a day.
   Io: [Value-AG]
   Europa: [Value-AG]
   Ganymede: [Value-AG]
   Callisto: [Value-AG]

Simple but powerful:

7. How did Galileo’s early telescopic observations support the work of Copernicus and Kepler that proposed that the Earth goes around the Sun?

   [Text-MG]

8. We’ve been focusing on the four Galilean moons. How many moons does Jupiter actually have that we know of?
   [MCQ-AG]

Side note: Want to see the Galilean moons for yourself? Check out **Stargazers' Hub** under **Astro Central** on Carmen for **stargazing tips, star party dates, and astro student orgs**! There are plenty of ways to get a hands-on stargazing experience—come join the fun!

Part 2: Model

Along came Newton:

Amazingly enough, Galileo's observations contain enough information to determine the mass of Jupiter! The method is straight forward and is still widely used by astronomers today. However, we just didn't have the knowledge to do this until Newton discovered the Law of Universal Gravitation in the late 1660s, roughly half a century after Galileo's original observations!

In last week's lab, you learned all about scaling relations (how we turn observations into math), and we used Newton's Law of Universal Gravitation as an example. Recall $F = G\frac{mM}{R^2}$. We also made some big claims that in this lab you'll see just how useful and amazing math is. Well, it's time, get ready to be amazed! We're going to show you two jaw-dropping instances of the power of math – how it allows us to learn about unreachable places and how it even allows us to discover hidden worlds!

The rest of this V-Lab will refer to Newton's mathematical models of the world. That is, Newton's Law of Universal Gravitation and his laws of motion.

Fun fact: Newton was born the year Galileo died!

Part 3: Infer/Predict

In this section, we're going to show you how we can use math to predict the mass of Jupiter! In this week's lessons, you would have seen that **orbits are a main way that we estimate the masses of astronomical objects**. One excellent application of this comes in a case like this, where a smaller object is on a circular orbit around a much more massive object. In this case, Jupiter's moons have much lower mass than the planet itself.

To the right, we show how the equation for the mass of the central object is derived from Newton's Law of Universal Gravitation and a version of Newton's Second Law of Motion for circular orbits. You absolutely do not need to understand this or

1. **Gravitational Force** acting on a moon orbiting Jupiter:

$$F = \frac{GMm}{R^2}$$

where:

- G = gravitational constant
- M = mass of Jupiter
- m = mass of the moon
- R = orbital radius of the moon

2. **Centripetal Force** keeping the moon in orbit:

$$F = \frac{mV^2}{R}$$

where V is the moon's orbital velocity.

3. **Equating the two forces** ($F_{\text{gravity}} = F_{\text{centripetal}}$):

$$\frac{GMm}{R^2} = \frac{mV^2}{R}$$

4. **Cancel m (since it appears on both sides):**

$$\frac{GM}{R^2} = \frac{V^2}{R}$$

5. **Solve for M:**

$$M = \frac{RV^2}{G}$$

remember it. Just have the visual in your head of how we can go from two equations to a third with mathematical logic!

Ok, let's use this equation to take Galileo's observations and calculate the mass of Jupiter. In this case, the mass of Jupiter, M, is given by **$M = (RV^2) / G$**. In this equation, G is the Newtonian Gravitational *Constant*. As one of the fundamental physical constants, it doesn't change – it's just a number. The value of G is **$G = 6.67 \times 10^{-20}$ $km^3kg^{-1}s^{-2}$** with units using *kilometers*.
Important: the given value of G contains units of kilometers (km), your orbital radii, R, should be in km, and your orbital speeds should be km/sec. The mass formula in bold above will give you an estimate of the mass of Jupiter when you plug in your numbers! Remember to use parentheses and square your speed when calculating.

9. Assume that the moons are on circular orbits (this is not a bad assumption!). The formula for speed = distance/time. For a circular orbit with radius R and a period P, the **orbital speed $V = (2\pi R)/P$**. Use this equation to compute the orbital speeds of the four moons in units of km/sec.
   Io: [Dropdown List-AG]
   Europa: [Dropdown List-AG]
   Ganymede: [Dropdown List-AG]
   Callisto: [Dropdown List-AG]

10. Use the mass formula to estimate the mass of Jupiter from the orbital speed and orbital radius of Callisto.
    [Value-AG]

11. How does your calculated mass of Jupiter compare with 1.89813×10^{27} kg, the current best estimate of the mass of Jupiter?
    [MCQ-AG]

12. What are potential sources of error in your calculation of the mass of Jupiter? Hint: Look at the two main parameters used to calculate M. What sources of error are there in Galileo's measurements of these values?
    [Text-MG]

Part 4: Predict and Test
Now, let's see how math can lead us to discover hidden worlds!

Le Verrier and Adams:
Let's fast forward to 1846. You are the French mathematician, Urbain Le Verrier!

Design note: Short video, recounting the steps of Neptune's discovery from Le Verrier's point of view.

Example content from ChatGPT:

> As I sit at my desk in the quiet of my study, the rhythmic ticking of the clock is a fitting companion to my thoughts. The task at hand has consumed me for some time

now—there is a strange anomaly in the orbit of Uranus. For years, astronomers have been puzzled by slight deviations in its predicted path. These discrepancies have led me to a bold conclusion: something unseen must be exerting a gravitational influence on Uranus, causing its orbit to shift in ways that Newtonian mechanics cannot fully explain.

I trust in Newton's laws; they have served us well, providing the foundation upon which our understanding of the cosmos rests. And if Newton's laws are correct, then there must be another planet, hidden from our view, tugging on Uranus and altering its orbit. The question is: where?

I have spent weeks painstakingly calculating, applying the principles of gravitation, and refining my observations. The force required to explain the discrepancies in Uranus' orbit must come from an object farther out, beyond the reach of our telescopes—until now. After countless equations, adjustments, and revisions, I am confident I have pinpointed the position of this invisible planet. It should lie at a particular location, not far from Uranus, precisely where the gravity from this unseen body would best account for the motion of the distant planet.

It is now time for the next step. I can only trust that my work is sound and wait for confirmation from those with the tools to verify my hypothesis. I reach out to my colleague and friend, the astronomer **Johann Galle** at the **Berlin Observatory**. With a mixture of excitement and anticipation, I send him my calculations, urging him to direct his telescope to the precise coordinates I've calculated. I tell him: if my calculations are correct, this new planet should be visible to the naked eye.

The waiting is agonizing. Days pass, and I cannot help but imagine the moment when the telescope will reveal the object that has eluded us for so long. The thought of finally proving my theory—and unveiling a new world to humanity—drives me to distraction.

Then, the news comes: **September 23, 1846**. Galle has found the planet. **Neptune**. Just where I had predicted it would be.

The sensation of triumph is indescribable. My calculations, grounded in the trust I place in Newton's laws, have brought us to the discovery of a new planet. This is the power of mathematics—an invisible world, hidden from the eyes of astronomers, revealed through careful reasoning and observation. It is a moment of profound vindication, knowing that the universe itself adheres to the predictable, elegant laws of motion that Newton laid down.

Yet, I am not alone in this discovery. **John Couch Adams**, an English mathematician, had also been working on the same problem. His predictions, though similar to mine, had not gained the same attention. The race for this discovery had, in a way, been a quiet competition between our two countries, though it was my name that would be most closely associated with the moment of Neptune's discovery.

Nonetheless, I know the importance of this moment transcends individual recognition. What we have witnessed is the power of reason, the unyielding pursuit of knowledge, and the confirmation that the universe is governed by laws we can understand. In the end, it is not the credit or fame that matters, but the deeper

understanding we now have of the cosmos. The discovery of Neptune—just as predicted—reminds us that there is still much to learn, and the universe is vast beyond our imagining.

13. Briefly describe the sequence of events that led to the discovery of Neptune. Share your thoughts on this. One to two paragraphs are enough.
    [Text-MG]

And the story doesn't end here! While Newton's mechanics worked well for most of the solar system, the orbit of Mercury showed small deviations that Newtonian mechanics couldn't fully explain – a subtle sign of greater things to come, albeit centuries later!

14. For centuries, Newtonian mechanics accurately predicted planetary orbits, motions of celestial bodies, and phenomena like tides, making it an extraordinarily successful theory for its time. We still use it daily for numerous engineering applications! However, in the early 20th century, a new theory came along to supplement Newtonian mechanics for extreme conditions. Can you guess the name of this theory?
    [MCQ-AG]

Part 5: Final Reflections

15. Refer to the Hallmarks of Science in your User's Guide. Which hallmarks of science are illustrated in this V-Lab?
    [Multi-select MCQ-AG]

16. In this section, you analyzed data that were the first ever recordings of celestial objects done with the help of a TELESCOPE. Explain how technology influenced science in this instance. Bearing in mind that Galileo did not invent the telescope. He learned about the idea at a traveling market.
    [Text-MG]

GE Foundation Courses

Overview

Courses that are accepted into the General Education (GE) Foundations provide introductory or foundational coverage of the subject of that category. Additionally, each course must meet a set of Expected Learning Outcomes (ELO). Courses may be accepted into more than one Foundation, but ELOs for each Foundation must be met. It may be helpful to consult your Director of Undergraduate Studies or appropriate support staff person as you develop and submit your course.

This form contains sections outlining the ELOs of each Foundation category. You can navigate between them using the Bookmarks function in Acrobat. Please enter text in the boxes to describe how your class meets the ELOs of the Foundation(s) to which it applies. Because this document will be used in the course review and approval process, you should use language that is clear and concise and that colleagues outside of your discipline will be able to follow. Please be as specific as possible, listing concrete activities, specific theories, names of scholars, titles of textbooks etc. Your answers will be evaluated in conjunction with the syllabus submitted for the course.

Accessibility

If you have a disability and have trouble accessing this document or need to receive the document in another format, please reach out to Meg Daly at daly.66@osu.edu or call 614-247-8412.

GE Rationale: Foundations: Race, Ethnicity, and Gender Diversity (3 credits)

Requesting a GE category for a course implies that the course fulfills **all** the expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Race, Ethnicity, and Gender Diversity, please answer the following questions for each ELO.

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational for the study of Race, Ethnicity and Gender Diversity.

Course Subject & Number: Astronomy 1100

B. Specific Goals of Race, Ethnicity, and Gender Diversity

GOAL 1: Successful students will engage in a systematic assessment of how historically and socially constructed categories of race, ethnicity, and gender, and possibly others, shape perceptions, individual outcomes, and broader societal, political, economic, and cultural systems.

Expected Learning Outcome 1.1: Successful students are able to describe and evaluate the social positions and representations of categories including race, gender, and ethnicity, and possibly others. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.2: Successful students are able to explain how categories including race, gender, and ethnicity continue to function within complex systems of power to impact individual lived experiences and broader societal issues. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.3: Successful students are able to analyze how the intersection of categories including race, gender, and ethnicity combine to shape lived experiences. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.4: Successful students are able to evaluate social and ethical implications of studying race, gender, and ethnicity. Please link this ELO to the course goals and topics and indicate *specific* activities/ assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

GOAL 2: Successful students will recognize and compare a range of lived experiences of race, gender, and ethnicity.

Expected Learning Outcome 2.1: Successful students are able to demonstrate critical self- reflection and critique of their social positions and identities. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 2.2: Successful students are able to recognize how perceptions of difference shape one's own attitudes, beliefs, or behaviors. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 2.3: Successful students are able to describe how the categories of race, gender, and ethnicity influence the lived experiences of others. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

GE Rationale: Foundations: Social and Behavioral Sciences (3 credits)

Requesting a GE category for a course implies that the course **all** expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Social and Behavioral Sciences, please answer the following questions for each ELO.

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational in the study of Social and Behavioral Sciences.

Course Subject & Number: Astronomy 1100

B. Specific Goals of Social and Behavioral Sciences

GOAL 1: Successful students will critically analyze and apply theoretical and empirical approaches within the social and behavioral sciences, including modern principles, theories, methods, and modes of inquiry.

Expected Learning Outcome 1.1: Successful students are able to explain basic facts, principles, theories and methods of social and behavioral science. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.2: Successful students are able to explain and evaluate differences, similarities, and disparities among institutions, organizations, cultures, societies, and/or individuals using social and behavioral science. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

GOAL 2: Successful students will recognize the implications of social and behavioral scientific findings and their potential impacts.

Expected Learning Outcome 2.1: Successful students are able to analyze how political, economic, individual, or social factors and values impact social structures, policies, and/or decisions. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 2.2: Successful students are able to evaluate social and ethical implications of social scientific and behavioral research. Please link this ELO to the course goals and topics and indicate *specific* activities/ assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 2.3: Successful students are able to critically evaluate and responsibly use information from the social and behavioral sciences. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

GE Rationale: Foundations: Historical or Cultural Studies (3 credits)

Requesting a GE category for a course implies that the course fulfills the expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Historical and Cultural Studies, please answer the following questions for each ELO. Note that for this Foundation, a course need satisfy **either** the ELOs for Historical Studies **or** the ELOs for Cultural Studies.

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational in the study of History **or** Cultures.

Course Subject & Number: Astronomy 1100

B. Specific Goals of Historical *or* Cultural Studies

Historical Studies (A) Goal: Successful students will critically investigate and analyze historical ideas, events, persons, material culture and artifacts to understand how they shape society and people.

Expected Learning Outcome 1.1A: Successful students are able to identify, differentiate, and analyze primary and secondary sources related to historical events, periods, or ideas. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.2A: Successful students are able to use methods and theories of historical inquiry to describe and analyze the origin of at least one selected contemporary issue. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.3A: Successful students are able to use historical sources and methods to construct an integrated perspective on at least one historical period, event or idea that influences human perceptions, beliefs, and behaviors. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.4A: Successful students are able to evaluate social and ethical implications in historical studies. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Cultural Studies (B) Goal: Successful students will evaluate significant cultural phenomena and ideas to develop capacities for aesthetic and cultural response, judgment, interpretation, and evaluation.

Expected Learning Outcome 1.1B: Successful students are able to analyze and interpret selected major forms of human thought, culture, ideas or expression. Please link this ELO to the course goals and topics and identify the *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.2B: Successful students are able to describe and analyze selected cultural phenomena and ideas across time using a diverse range of primary and secondary sources and an explicit focus on different theories and methodologies. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.3B: Successful students are able to use appropriate sources and methods to construct an integrated and comparative perspective of cultural periods, events or ideas that influence human perceptions, beliefs, and behaviors. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.4B: Successful students are able to evaluate social and ethical implications in cultural studies. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met.

GE Rationale: Foundations: Writing and Information Literacy (3 credits)

Requesting a GE category for a course implies that the course fulfills **all** expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Writing and Information Literacy, please answer the following questions for each ELO.

Course Subject & Number: Astronomy 1100

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational in the study of Writing and Information Literacy.

B. Specific Goals of Writing and Information Literacy

GOAL 1: Successful students will demonstrate skills in effective reading, and writing, as well as oral, digital, and/or visual communication for a range of purposes, audiences, and context.

Expected Learning Outcome 1.1: Successful students are able to compose and interpret across a wide range of purposes and audiences using writing, as well as oral, visual, digital and/or other methods appropriate to the context. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. Explain how the course includes opportunities for feedback on writing and revision. Furthermore, please describe how you plan to insure sufficiently low instructor-student ratio to provide efficient instruction and feedback. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.2: Successful students are able to use textual conventions, including proper attribution of ideas and/or source, as appropriate to the communication situation. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. Is an appropriate text, writing manual, or other resource about the pedagogy of effective communication being used in the course? *(50-700 words)*

Expected Learning Outcome 1.3: Successful students are able to generate ideas and informed responses incorporating diverse perspectives and information from a range of sources, as appropriate to the communication situation. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: _____

Expected Learning Outcome 1.4: Successful students are able to evaluate social and ethical implications in writing and information literacy practices. Please link this ELO to the course goals and topics and indicate *specific* activities/ assignments through which it will be met. *(50-700 words)*

GOAL 2: Successful students will develop the knowledge, skills, and habits of mind needed for information literacy.

Expected Learning Outcome 2.1: Successful students are able to demonstrate responsible, civil, and ethical practices when accessing, using, sharing, or creating information. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 2.2: Successful students are able to locate, identify and use information through context appropriate search strategies. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 2.3: Successful students are able to employ reflective and critical strategies to evaluate and select credible and relevant information sources. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

GE Rationale: Foundations: Literary, Visual, or Performing Arts (3 credits)

Requesting a GE category for a course implies that the course fulfills **all** expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Literary, Visual, and Performing Arts, please answer the following questions for each ELO.

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational in the study of Literary, Visual, or Performing Arts.

B. Specific Goals

Goal 1: Successful students will analyze, interpret, and evaluate major forms of human thought, cultures, and expression; and demonstrate capacities for aesthetic and culturally informed understanding.

Expected Learning Outcome 1.1: Successful students are able to analyze and interpret significant works of design or visual, spatial, literary or performing arts. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.2: Successful students are able to describe and explain how cultures identify, evaluate, shape, and value works of literature, visual and performing art, and design. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.3: Successful students are able to evaluate how artistic ideas influence and shape human beliefs and the interactions between the arts and human perceptions and behavior. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.4: Successful students are able to evaluate social and ethical implications in literature, visual and performing arts, and design. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Goal 2: Successful students will experience the arts and reflect on that experience critically and creatively.

Expected Learning Outcome 2.1: Successful students are able to engage in informed observation and/or active participation within the visual, spatial, literary, or performing arts and design. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 2.2: Successful students are able to critically reflect on and share their own experience of observing or engaging in the visual, spatial, literary, or performing arts and design.
Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

GE Rationale: Foundations: Natural Science (4 credits)

Requesting a GE category for a course implies that the course fulfills **all** expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Natural Sciences, please answer the following questions for each ELO.

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational in the study of Natural Science.

This course is both introductory and foundational in the study of Natural Science. It serves as an introduction by offering students a broad overview of the core topics, principles, and methodologies of modern astronomy in a manner that is accessible to those with no prior knowledge of the subject. By exploring concepts such as the nature and scale of the universe, the types and properties of celestial bodies, the processes that drive astronomical phenomena, and how we obtained this knowledge, the course provides a comprehensive entry point into the Natural Sciences. The course is also foundational because it explicitly focuses on developing essential science literacy skills. Through the application of scientific methods and the examination of the evolution of science within the field of astronomy, students gain essential data analysis skills as well as a deeper understanding of how scientific knowledge is constructed, validated, and communicated. This knowledge is fundamental for interpreting and critically evaluating scientific information, both within astronomy and across other scientific disciplines. Moreover, the course bridges theoretical understanding and practical application by emphasizing the real-world relevance of science literacy. The course trains students to evaluate scientific claims using a range of science literacy skills thereby laying a strong foundation for students to engage with scientific inquiry meaningfully and responsibly. As part of a General Education curriculum, the course connects the foundational principles of Natural Sciences with broader societal contexts. By examining how scientific inquiry drives technology (and vice versa) and the responsible use of scientific information, students come to appreciate the interdependence between science and society. This integrative approach equips students with the skills and perspectives needed to navigate a science-driven world.

NOTE: Having the Course Schedule provided in the course syllabus at hand when reviewing the achievement of the GE and course ELOs below will be useful as the schedule provides a clear picture of the course organization.

Course Subject & Number: Astronomy 1100

B. Specific Goals for Natural Sciences

GOAL 1: Successful students will engage in theoretical and empirical study within the natural sciences, gaining an appreciation of the modern principles, theories, methods, and modes of inquiry used generally across the natural sciences.

Expected Learning Outcome 1.1: Successful students are able to explain basic facts, principles, theories and methods of modern natural sciences; describe and analyze the process of scientific inquiry. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Relevant course ELOs:
Course ELO 1.3 Recall and explain basic facts, principles and theories of modern astronomy.
Course ELO 2.1 Apply and explain the scientific methods used by modern astronomy to characterize the Universe, and explain the limitations and associated uncertainties of these methods.
Course ELO 2.4 Describe and analyze the nature and process of scientific inquiry including the premises and boundaries of its application, and the merit and evolving nature of scientific theories.

Specific activities through which these ELOs will be met:
Course ELO 1.3 will be met through weekly mini lessons, covering a wide range of astronomy-related topics that change from week to week. Mini lessons are designed for knowledge building and skills development and comprise of instructional readings, videos, and/or interactive activities, followed by a short review quiz.
Course ELO 2.1 will be met through mini lessons and weekly practical tasks, predominantly in Units 1 (Science Unlocked: How to Talk the Talk and Walk the Walk) and 2 (Behind the Scenes: Where Do Scientists Get Their Facts From?). Practical tasks will take on a variety of forms and will allow students to engage with scientific methods of observation, modeling and data analysis directly. Examples of practical tasks include modeling the Sun-Earth-Moon system, physically demonstrating the conservation of angular momentum, night sky observations, and inferring astronomical phenomena from real-world data.
Course ELO 2.4 will be developed through both reflective mini lessons and practical tasks. In particular, the mini lessons and practical tasks associated with Unit 3 (Guessing or Slaying? How Theories Evolve and Get Verified) will go beyond data analysis and will emphasize the full process of scientific inquiry, including how theories are developed and validated.

Expected Learning Outcome 1.2: Successful students are able to identify how key events in the development of science contribute to the ongoing and changing nature of scientific knowledge and methods. Please link this ELO to the course goals and topics and indicate specific activities/assignments through which it will be met. *(50-700 words)*

Relevant course ELOs:
Course ELO 2.2 Identify how key events in the development of modern astronomy contribute to the ongoing and changing nature of scientific knowledge and methods in the field.

Specific activities through which this ELO will be met:
This ELO will be addressed through the mini lessons and practical tasks in Unit 3 (Guessing or Slaying? How Theories Evolve and Get Verified). Students will engage with topics such as dark matter and cosmic expansion that illustrate the development and validation of scientific theories within the field of astronomy. These ideas will be further explored through virtual discussions that highlight the historical evolution of key astronomical theories, open questions in the field, and the technological advancements driving current discoveries.

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.3: Successful students are able to employ the processes of science through exploration, discovery, and collaboration to interact directly with the natural world when feasible, using appropriate tools, models, and analysis of data. Please explain the 1-credit hour equivalent experiential component included in the course: e.g., traditional lab, course-based research experiences, directed observations, or simulations. Please note that students are expected to analyze data and report on outcomes as part of this experiential component. *(50-1000 words)*

Relevant course ELOs:
Course ELO 1.1 Demonstrate proficiency in fundamental scientific competencies including astronomical units and unit conversion, scientific notation, SI prefixes, interpreting graphs, common proportions, percentages and scaling relations.
Course ELO 2.1 Apply and explain the scientific methods used by modern astronomy to characterize the Universe, and explain the limitations and associated uncertainties of these methods.

Specific activities through which these ELOs will be met:
Course ELO 1.1 will be met through weekly mini lessons in Unit 1 (Science Unlocked: How to Talk the Talk and Walk the Walk). Mini lessons are designed for knowledge building and skills development and comprise of instructional readings, videos, and/or interactive activities, followed by a short review quiz. The purpose of Course ELO 1.1 in this context is to provide students with the skills necessary to partake in Course ELO 2.1.
Course ELO 2.1 will be met through mini lessons and weekly practical tasks, predominantly in Units 1 (Science Unlocked: How to Talk the Talk and Walk the Walk) and 2 (Behind the Scenes: Where Do Scientists Get Their Facts From?). Practical tasks will take on a variety of forms and will allow students to engage with scientific methods of observation, modeling and data analysis directly. Examples of practical tasks include modeling the Sun-Earth-Moon system, physically demonstrating the conservation of angular momentum, night sky observations, and inferring astronomical phenomena from real-world data.

Course Subject & Number: Astronomy 1100

GOAL 2: Successful students will discern the relationship between the theoretical and applied sciences, while appreciating the implications of scientific discoveries and the potential impacts of science and technology.

Expected Learning Outcome 2.1: Successful students are able to analyze the inter-dependence and potential impacts of scientific and technological developments. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Relevant course ELOs:
Course ELO 3.1 Analyze the inter-dependence and potential societal impacts of scientific and technological developments.

Specific activities through which this ELO will be met:
The technologies used for space exploration and astronomical observations will be explored in the mini lessons, practical tasks, and virtual discussions in Unit 2 (Behind the Scenes: Where Do Scientists Get Their Facts From?). For example, students will interact with tools like the NASA's Eyes website, showcasing the impressive suite of missions that have revolutionized our ability to observe and understand the cosmos. This exploration will culminate in a virtual discussion, where students will reflect on the ways these technologies enable groundbreaking discoveries and provide insights into phenomena previously thought to be beyond human reach. Additionally, activities will highlight the broader implications of these advancements. Students will evaluate how technologies designed for astronomy have practical applications in other fields, such as medical imaging, communication systems, and environmental monitoring.
The interdependence between science and technology will be further examined in Unit 3 (Guessing or Slaying? How Theories Evolve and Get Verified). Mini lessons and virtual discussions will emphasize the role of technological advancements in driving scientific discovery by highlighting their role in the development and validation of key astronomical theories.

Expected Learning Outcome 2.2: Successful students are able to evaluate social and ethical implications of natural scientific discoveries. Please link this ELO to the course goals and topics and indicate *specific* activities/ assignments through which it will be met. *(50-700 words)*

Relevant course ELOs:
Course ELO 3.1 Analyze the inter-dependence and potential societal impacts of scientific and technological developments.
Course ELO 3.2 Demonstrate an understanding of ethical practice in science and the responsible use of information from the natural sciences.
Course ELO 4.1 Demonstrate an appreciation for the need for scientific literacy in everyday life.

Specific activities through which these ELOs will be met:
Course ELO 3.1 will be developed as part of the mini lessons and practical tasks in Unit 2 (Behind the Scenes: Where Do Scientists Get Their Facts From?), where students will be given an opportunity to explore how technologies designed for astronomy have practical applications in other fields, such as medical imaging, communication systems, and environmental monitoring.
In terms of ELOs 3.2 and 4.1, the focus will be on science misinformation in the media. Unit 4 (Game On! Tackling Tough Topics in Science Like a Boss) will emphasize the importance of science literacy in recognizing and addressing the manipulation or misrepresentation of scientific findings. Students will explore, by way of example, how inaccurate or misleading information can shape public perception, policies, and decision-making, and will be given guidelines on the responsible use of information in the natural sciences and on how to identify credible sources.

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 2.3: Successful students are able to critically evaluate and responsibly use information from the natural sciences. Please link this ELO to the course goals and topics and indicate *specific* activities/ assignments through which it will be met. *(50-700 words)*

Relevant course ELOs:
Course ELO 1.1 Demonstrate proficiency in fundamental scientific competencies including astronomical units and unit conversion, scientific notation, SI prefixes, interpreting graphs, common proportions, percentages and scaling relations.
Course ELO 2.3 Demonstrate an understanding of fundamental scientific literacy concepts including uncertainty and bias in data, variable control, confounding factors, and evaluating the validity of sources of information.
Course ELO 2.4 Describe and analyze the nature and process of scientific inquiry including the premises and boundaries of its application, and the merit and evolving nature of scientific theories.
Course ELO 3.2 Demonstrate an understanding of ethical practice in science and the responsible use of information from the natural sciences.
Course ELO 4.2 Interpret and critically evaluate the scientific merit of reported information both within and outside the field of astronomy.

Specific activities through which these ELOs will be met:
As described in the preceding sections, the science literacy skills outlined in Course ELOs 1.1, 2.3, and 2.4 will be systematically developed throughout the course in Units 1 (Science Unlocked: How to Talk the Talk and Walk the Walk), 2 (Behind the Scenes: Where Do Scientists Get Their Facts From?), and 3 (Guessing or Slaying? How Theories Evolve and Get Verified). These units focus on equipping students with the ability to interpret data, recognizing biases and uncertainties, and understand the nature and bounds of scientific inquiry and knowledge.
In Unit 4 (Game On! Tackling Tough Topics in Science Like a Boss), students will apply these foundational skills to real-world challenges, addressing Course ELO 4.2. Before tackling real-world challenges, the mini lessons in Unit 4 will complete the science literacy toolkit by providing guidelines on the responsible use of information in the natural sciences and on how to identify credible sources (Course ELO 3.2). These guidelines ensure that students are well-equipped to navigate the often misinformation-rich landscape of social media science communication.
Once their scientific literacy toolkits are complete, students will be given an opportunity to practice and refine what they have learned through practical tasks and virtual discussions that engage students in scientific myth-busting, deconstructing hard-to-understand concepts, and making informed decisions on science-related issues. By progressively building and then applying skills, the course ensures students develop a robust science literacy framework, empowering them to engage with scientific issues in both academic and everyday contexts responsibly, with confidence and critical awareness.

Course Subject & Number: Astronomy 1100

GE Rationale: Foundations: Mathematical and Quantitative Reasoning (or Data Analysis) (3 credits)

Requesting a GE category for a course implies that the course fulfills **all** expected learning outcomes (ELOs) of that GE category. To help the reviewing panel evaluate the appropriateness of your course for the Foundations: Mathematical and Quantitative Reasoning (or Data Analysis), please answer the following questions for each ELO.

A. Foundations

Please explain in 50-500 words why or how this course is introductory or foundational in the study of Mathematical & Quantitative Reasoning (or Data Analysis).

B. Specific Goals for Mathematical & Quantitative Reasoning/Data Analysis

Goal: Successful students will be able to apply quantitative or logical reasoning and/or mathematical/statistical analysis methodologies to understand and solve problems and to communicate results.

Expected Learning Outcome 1.1: Successful students are able to use logical, mathematical and/or statistical concepts and methods to represent real-world situations. Please link this ELO to the course goals and topics and indicate *specific* activities/ assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.2: Successful students are able to use diverse logical, mathematical and/or statistical approaches, technologies, and tools to communicate about data symbolically, visually, numerically, and verbally. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.3: Successful students are able to draw appropriate inferences from data based on quantitative analysis and/or logical reasoning. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Course Subject & Number: Astronomy 1100

Expected Learning Outcome 1.4: Successful students are able to make and evaluate important assumptions in estimation, modeling, logical argumentation, and/or data analysis. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Expected Learning Outcome 1.5: Successful students are able to evaluate social and ethical implications in mathematical and quantitative reasoning. Please link this ELO to the course goals and topics and indicate *specific* activities/assignments through which it will be met. *(50-700 words)*

Distance Approval Cover Sheet

For Permanent DL/DH Approval | College of Arts and Sciences (Updated 2-1-24)

Course Number and Title: ASTRON1000: Astronomy IRL

Carmen Use

When building your course, we recommend using the ASC Distance Learning Course Template for CarmenCanvas. For more on use of Carmen: Common Sense Best Practices.

[X] A Carmen site will be created for the course, including a syllabus and gradebook at minimum.

If no, why not?

Syllabus

[X] Proposed syllabus uses the ASC distance learning syllabus template, includes boilerplate language where required, as well as a clear description of the technical and academic support services offered, and how learners can obtain them.

[X] Syllabus is consistent and is easy to understand from the student perspective.

[X] Syllabus includes a schedule with dates and/or a description of what constitutes the beginning and end of a week or module.

[ ] If there are required synchronous sessions, the syllabus clearly states when they will happen and how to access them.

Additional comments (optional).

Instructor Presence

For more on instructor presence: About Online Instructor Presence.
For more on Regular and Substantive Interaction: Regular Substantive Interaction (RSI) Guidance

Students should have opportunities for regular and substantive academic interactions with the course instructor. Some ways to achieve this objective:

[X] Instructor monitors and engages with student learning experiences on a regular and substantive cadence.

Explain your plan for understanding student experiences of the course and how the instructor will be responsive to those experiences (required).

- Task completion and performance will be monitored using the Carmen grade book on a weekly basis. Students with missed assignments and/or low grades will be approached via email and offered assistance.
- Weekly FAQ discussion forums will be used to monitor and respond to frequently asked questions related to a particular week's tasks.
- Students' textbook annotations will be monitored by the instructor and TAs using the Hypothesis tool and commented on where relevant.
- At the end of each week, students will have the option to reflect on their course experience. The instructor will review student reflections and respond to issues in a timely manner.

[X] Regular instructor communications with the class via announcements or weekly check-ins.

[X] Instructional content, such as video, audio, or interactive lessons, that is visibly created or mediated by the instructor.

[X] Regular participation in class discussion, such as in Carmen discussions or synchronous sessions.

[X] Regular opportunities for students to receive personal instructor feedback on assignments.

Please comment on this dimension of the proposed course (or select/explain methods above).

- At the start of the course, the instructor will introduce themselves and the TA and IA team during a live virtual discussion which will be recorded for asynchronous viewing.
- Instructional content for this course will be created by a team. As such, not all material will be visibly created by the instructor. However, instructor presence will be created via weekly video overviews at the start of each week whereby the instructor will introduce the week's topics and tasks and remind students of where they are in the course and other relevant administrative information.
- The instructor will facilitate biweekly virtual discussions as described in the syllabus.
- The instructor will facilitate TA feedback on all assignments, and the instructor will be available every weekday during office hours on Zoom to assist students.

Delivery Well-Suited to DL/DH Environment

Technology questions adapted from the Quality Matters rubric. For information about Ohio State learning technologies: Toolsets.

- [X] The tools used in the course support the learning outcomes and competencies.
- [X] Course tools promote learner engagement and active learning.
- [X] Technologies required in the course have been vetted for accessibility, security, privacy and legality by the appropriate offices and are readily and reasonably obtainable.
- [X] Links are provided to privacy policies for all external tools required in the course.

Additional technology comments:

We are developing this course with the assistance of an instructional designer from the ASC Office of Distance Education to ensure that all the above conditions are met.

Which components of this course are planned for synchronous delivery and which for asynchronous delivery? (For DH, address what is planned for in-person meetings as well)

This course is fully asynchronous. In some instances, students will be given the opportunity to attend live virtual discussions. However, attendance of live discussions will not be compulsory, and live events will be recorded for asynchronous viewing.

If you believe further explanation would be helpful, please comment on how course activities have been adjusted for distance learning:

Workload Estimation

For more information about calculating online instruction time: ODEE Credit Hour Estimation.

[X] Course credit hours align with estimated average weekly time to complete the course successfully.

[X] Course includes regular substantive interaction well-suited to the learning environment at a frequency and engagement level appropriate to the course.

Provide a brief outline of a typical course week, categorizing course activities and estimating the approximate time to complete them or participate (required):

See Credit hours and work expectations in the syllabus.

[ ] In the case of course delivery change requests, the course demonstrates comparable rigor in meeting course learning outcomes.

Accessibility

For more information or a further conversation, contact the accessibility coordinator for the College of Arts and Sciences. For tools and training on accessibility: Digital Accessibility Services.

[X] Instructor(s) teaching the course will have taken Digital Accessibility training (starting in 2022) and will ensure all course materials and activities meet requirements for diverse learners, including alternate means of accessing course materials when appropriate.

[X] Information is provided about the accessibility of all technologies required in the course. All third-party tools (tools without campus-wide license agreements) have their accessibility statements included.

Description of any anticipated accommodation requests and how they have been/will be addressed.

Additional comments (optional):

We are developing this course with the assistance of an instructional designer from the ASC Office of Distance Education to ensure that all the above conditions are met.

Academic Integrity

For more information: Academic Integrity.

[X] The course syllabus includes online-specific policies about academic integrity, including specific parameters for each major assignment:

[X] Assignments are designed to deter cheating and plagiarism and/or course technologies such as online proctoring or plagiarism check or other strategies are in place to deter cheating.

Additional comments (optional):

Frequent, Varied Assignments/Assessments

For more information: *Designing Assessments for Students*.

Student success in online courses is maximized when there are frequent, varied learning activities. Possible approaches:

[X] Opportunities for students to receive course information through a variety of different sources, including indirect sources, such as textbooks and lectures, and direct sources, such as scholarly resources and field observation.

[X] Variety of assignment formats to provide students with multiple means of demonstrating learning.

[X] Opportunities for students to apply course knowledge and skills to authentic, real-world tasks in assignments.

Comment briefly on the frequency and variety of assignment types and assessment approaches used in this course or select methods above:

Every week, students will experience the week's topic through a variety of assignment formats including instructional readings and videos, virtual colloquia and discussion forums, and simulated and real-world explorations. Unit challenges will also take on a variety of formats, including escape room challenges and student-created social media content. See Credit hours and work expectations in the Syllabus for more details.

Community Building

For more information: Student Interaction Online.

Students engage more fully in courses when they have an opportunity to interact with their peers and feel they are part of a community of learners. Possible approaches:

[X] Opportunities for students to interact academically with classmates through regular class discussion or group assignments.

[X] Opportunities for students to interact socially with classmates, such as through video conference sessions or a course Q&A forum.

[ ] Attention is paid to other ways to minimize transactional distance (psychological and communicative gaps between students and their peers, instructor, course content, and institution).

Please comment on this dimension of the proposed course (required)

- Community building will take place via virtual discussions aimed at collectively exploring key course topics. Discussions will take place once every two weeks. Preliminary topics and timing of discussions are indicated in the Course Schedule provided in the syllabus.
- Weekly FAQ discussion forums as described under Instructor Prescence above will also contribute to community buidling as students navigate the course and Practical Tasks together.
- Students will be able to view and comment on each other's textbook annotations using the Hypothesis tool.
- Students will be encouraged to share photos of themselves completing the weekly Practical Tasks. Throughout the course students will carry out a variety of practical tasks

Transparency and Metacognitive Explanations

For more information: *Supporting Student Learning*.

Students have successful, meaningful experiences when they understand how the components of a course connect together, when they have guidance on how to study, and when they are encouraged to take ownership of their learning. Possible approaches:

[X] Instructor explanations about the learning goals and overall design or organization of the course.

[X] Context or rationale to explain the purpose and relevance of major tasks and assignments.

- [X] Guidance or resources for ancillary skills necessary to complete assignments, such as conducting library research or using technology tools.
- [X] Opportunities for students to take ownership or leadership in their learning, such as by choosing topics of interest for an assignment or leading a group discussion or meeting.
- [ ] Opportunities for students to reflect on their learning process, including their goals, study strategies, and progress.
- [X] Opportunities for students to provide feedback on the course.

Please comment on this dimension of the proposed course (or select methods above):

Additional Considerations

Comment on any other aspects of the online delivery not addressed above (optional):

Syllabus and cover sheet reviewed by Bob Mick on 11/22/24

Reviewer Comments:

I have reviewed the syllabus and cover sheet and have one recommendation.

1. This cover sheet states that Hypothes.is will be used. The use of this technology should be included in the syllabus under Course Technology. A short explanation should be included for the students to understand how it will be used. When using Hypthes.is an additional specific statement should be included in the syllabus:

"This course requires the use of a digital social annotation tool called Hypothes.is. If you encounter an issue with access to this tool, please contact your instructor at their name.#@osu.edu and ascode@osu.edu. Accommodation and assistance will be arranged for you to complete any work required with this tool free of penalty."

https://ascode.osu.edu/tools/tech-tools-course-syllabus-statements

The ASC Office of Distance Education strives to be a valuable resource to instructors and departments in the College of Arts and Sciences. In addition to managing the DL course review process, hosting ASC Teaching Forums, and developing an ever-expanding catalog of instructor support resources, we also provide one-on-one instructional design consultation to ASC instructors interested in redesigning any aspect of their online course. If your department or any of your individual instructors wish to meet with one of our instructional designers to discuss how we can provide advice, assistance, and support, please do let me know.

Additional resources and examples can be found on ASC's Office of Distance Education website.