Introduction to Astronomy
PHY 101/105
Fall 2020

What is our place in the universe? This course provides an introduction to the sciences of astronomy and cosmology. We will study a wide range of texts written by ancient thinkers such as Aristotle and Ptolemy, reformation-era thinkers such as Copernicus and Kepler, and modern thinkers such as Hubble, Einstein and Lemaitre.

Instructor information and class times

Kerry Kuehn, Ph.D.
Professor, Dept. of Physics
Office Hrs. (S133): TBA
WLC Office Tel: (414) 443-8850
www.kerrykkuehn.com
kerry.kuehn@wlc.edu

Lecture room (PHY 101): S105 (Generac Hall)
Lecture time: MWF 9:00 - 9:45 a.m.
Lab room (PHY 105): S115 (Generac Hall)
Lab time: M or R 7:00 - 9:45 p.m.

Grade components

Homework Assignments	15%	Comprehensive final exam	20%
Weekly quizzes	65%	Astronomy observation notebook	(for PHY 105)

Grading scale

A	100-93%	C	74-67%
AB	92-88%	CD	66-62%
B	87-80%	D	61-54%
BC	79-75%	F	53-0%

What are we learning in this course? This course will be divided into four units:

Unit 1: Observing the sky (about 2 weeks) In this unit, we will be familiarizing ourselves with the motion of the sun, the moon, the stars and the planets from day to day throughout the year. Our approach will be purely observational and inductive; this means that we will simply try to get a grasp of how the sky appears *to us.* In other words, we will not focus on the implications of various scientific models (such as heliocentrism or geocentrism).

Unit 2: The Geocentric world view (about 4 weeks) In this unit, we will begin to explore the *geocentric* model of the world (that is: the universe), which was predominant until the 17th century. We begin by studying the ancient Greek scientist Aristotle's famous book *On the Heavens.* In this book, he defends geocentrism against those who had argued that the Earth is one of the planets. We then move on to Ptolemy's *Almagest* and Bede's *The Reckoning of Time*. Our approach will be deductive; this means that we will be exploring the logical implications of assuming a geocentric world-view.

Unit 3: The Heliocentric world-view (about 5 weeks) In this unit, we will turn to the *heliocentric* model of the world, which was forcefully advocated by Copernicus in the 16th century. We will also read selections from Galileo's *Starry Messenger* and Kepler's *Epitome of Copernican Astronomy.* This will take us up to about the 19th century

Unit 4: Modern cosmology (about 6 weeks) With the advent of powerful new telescopes, astronomers learned how to measure the distances to nearby stars. This allowed scientists to re-address questions such as "how big is the universe?" more precisely than ever before. What kinds of new models did they come up with? In our final unit, we will read the works of Leavitt, Slipher, Hubble, and Lemaitre.

How will course material be delivered? The material that I expect you to learn is being delivered in two formats: (1) assigned readings, and (2) lectures.

(1) The assigned readings will be from my book *A Student's Guide through the Great Physics Texts, Volume 1: The Heavens and the Earth*. You will need to obtain a copy of this book.

(2) In order to provide flexibility for students enrolled in *Introduction to Astronomy*, *all of my lectures are being made available online*. To this end, I have set up a YouTube Channel that contains weekly lectures. You must watch all of these.

Introduction to Astronomy
PHY 101/105
Fall 2020

Each week on my personal website (www.kerrykkuehn.com), I will identify (i) which chapter(s) you must read, (2) which youtube lecture(s) you must watch, and (3) what homework problem(s) you must complete.

What, then, will we do during our classroom time? On Mondays and Wednesdays during class time, we will discuss the reading assignment and the youtube lectures. We will also work through practice problems together. The classroom time is designed to deepen your understanding of Astronomy and to prepare you for the quiz on Friday.

Weekly quizzes Every Friday, we will have a quiz during the first half of the class period. During the second half of the class period, we will review the answers and score the quiz. The quizzes are designed to ensure that you are keeping up with the course material.

Weekly homework assignments Every week, I will assign a few homework problems. These may be numerical, conceptual, or essay-style problems. You must complete the homework problems and upload your solution *via* MyWLC before class on Friday. I will check that you have uploaded your homework and assign a simple pass/fail grade. The homework problems are designed to encourage you to engage with the material and to prepare you for the weekly quizzes.

Comprehensive Final Exam There will be a comprehensive final examination given during the finals week.

General Education Requirement Fulfillment By enrolling in both the classroom component (PHY 101) and the laboratory/observational component (PHY105) of this course, students are able to satisfy the *Laboratory Science* requirement for the General Education Curriculum of Wisconsin Lutheran College. In addition, students enrolled in PHY 105 will be asked to upload one of the exercises from their *Astronomy Observation Notebook* to their General Education Portfolio using *Taskstream;* this will support the *Inquiry and Analysis Essential Learning Outcome* (ELO).

General Course objectives There are a number of general objectives that I use to shape this course. I would like you to:

- understand nature—(specifically the sciences of astronomy and cosmology)
- improve your reading comprehension and vocabulary—(through the reading and discussion of great texts)
- distinguish between truth from error—(by analyzing and comparing the best ideas which have been written)
- better articulate scientific ideas—(both verbally and in written form)
- solve problems—(conceptual, mathematical, and experimental)
- obtain a suitable foundation for advanced coursework in physics (come talk to me about how to earn a major or minor in physics!)

From the perspective of the General Education Curriculum, this course is concerned with the *Inquiry and Analysis* Essential Learning Objective (ELO).

Specific Course objectives There are also a number of specific course objectives. For example, I would like you to learn how to

- identify the astronomical significance of key dates marking the seasons (*e.g.* vernal equinox, summer solstice)
- calculate the altitude of the sun at its zenith on key dates
- identify constellations and predict the motion of the sun through the zodiac
- predict the position of the moon within the zodiac based on its phase and the position of the sun
- learn how astronomical instruments are used to measure the locations and sizes of celestial bodies
- maintain a clear and well-organized astronomy observation notebook
- describe the motion of the four visible planets using both a geocentric and a heliocentric world-view
- evaluate Copernicus' rationale for a heliocentric world-view, as well as counter-arguments
- explain Kepler's three laws of planetary motion and the Newtonian theory of gravity
- critically analyze ancient, modern and contemporary cosmological theories
- recognize and evaluate both theistic and atheistic arguments rooted in astronomy and cosmology Reading and discussing the great texts

Teaching Philosophy In this course, we will read and discuss some of the classic scientific texts dealing with astronomy and cosmology. The scientific texts we will read are considered classics because they address timeless questions in a particularly honest and convincing manner. This does not mean that everything they say is true. In fact many classic scientific texts contradict one another. But it is by the careful analysis of the most reputable observations and opinions that one may begin to discern truth from error.

You will not understand everything you read; nobody does. The texts are challenging. Like great literature, these texts must be ``grown into", so to speak. (Remember: nobody understands all of Shakespeare or all of the Bible the first time they read it, either!) So think of this course as a ``first dip" into the deep end of the pool. These texts are classics because—like fine wine—both the beginner and the advanced scholar can profit by studying them.

Much of the time that we spend in the classroom will be devoted to discussing the reading selections. As the discussion leader, I will typically ask questions regarding specific ideas which are found in the texts. For instance, I may ask, "How far away is the plane Venus?" or "Has it always been at that distance?" And if so, "How do you know?" The task will then be to try, as a group, to answer these questions.

It is critical that participants carefully read the assigned selections before engaging in classroom discussion. This will help participants to make relevant comments and to cite textual evidence to support or contradict assertions made during the course of the discussion. In this way, many assertions will be revealed as problematic, in which case they must then be refined or rejected altogether. This is precisely the method used by scientists themselves in order to discover and evaluate competing ideas or theories.

During our discussion, you may speak with complete freedom. There is only one rule: *any comment or question you make must be made publicly so that all others can hear and respond*. Most students are initially apprehensive about engaging in public discussion. This is natural. If you find yourself to be one of these it is important to realize that you do not need to make an elaborate point in order to engage in classroom discussion. Often, a short question can provide a simple avenue. For example, ``I am unclear what the author means by the term *celestial*. Can someone please clarify?" Write down questions like these in the margins while reading the text. Start like this. Pretty soon, you may find yourself joining gamely in classroom discussion.

Astronomy Observational notebook (PHY 105) Students enrolled in PHY 105 must keep a dedicated astronomy notebook containing his or her laboratory exercises and observations for this course. Each exercise should begin on a new page. You should reserve the first few pages in your notebook for a table of contents, and the notebook pages should be numbered. Notebook grades will be determined based on how clear, neat, correct, and convincing your writing and thinking are.

Observations which are recorded in your notebook should contain:

- Your name and the names of all others present during the observation
- The location, date and time of arrival and departure on site
- The viewing conditions, such as sky transparency, weather, and local lighting environment (if outdoors)
- For each object viewed: date and time of observation, the designation, name and type of object, the constellation, and the make and model of telescope or other viewing aid used.
- Any additional thoughts or analysis that seems appropriate (or required by the instructor)

Final thoughts I want to encourage you to come to me with any concerns you may have during the course of the semester, whether they be physics questions or difficulties with reading or discussion. This course is designed to challenge you, but not to "break" you. Reading the classics in any field is challenging, but very rewarding. I would very much like to help you succeed and to enjoy this class! My contact information is listed at the beginning of this syllabus, so please feel free to contact me!

Required textbook:

- Kerry K. Kuehn, Physics: A Student's Guide through the Great Texts, Volume I: The Heavens and the Earth. Springer (2015). ISBN-978-1-4939-1360-2

Suggested books:

- Roger Sinnott, Sky & Telescope's Pocket Sky Atlas. Sky Publishing (2006). ISBN-10 1931559317.

Introduction to Astronomy
PHY 101/105
Fall 2020

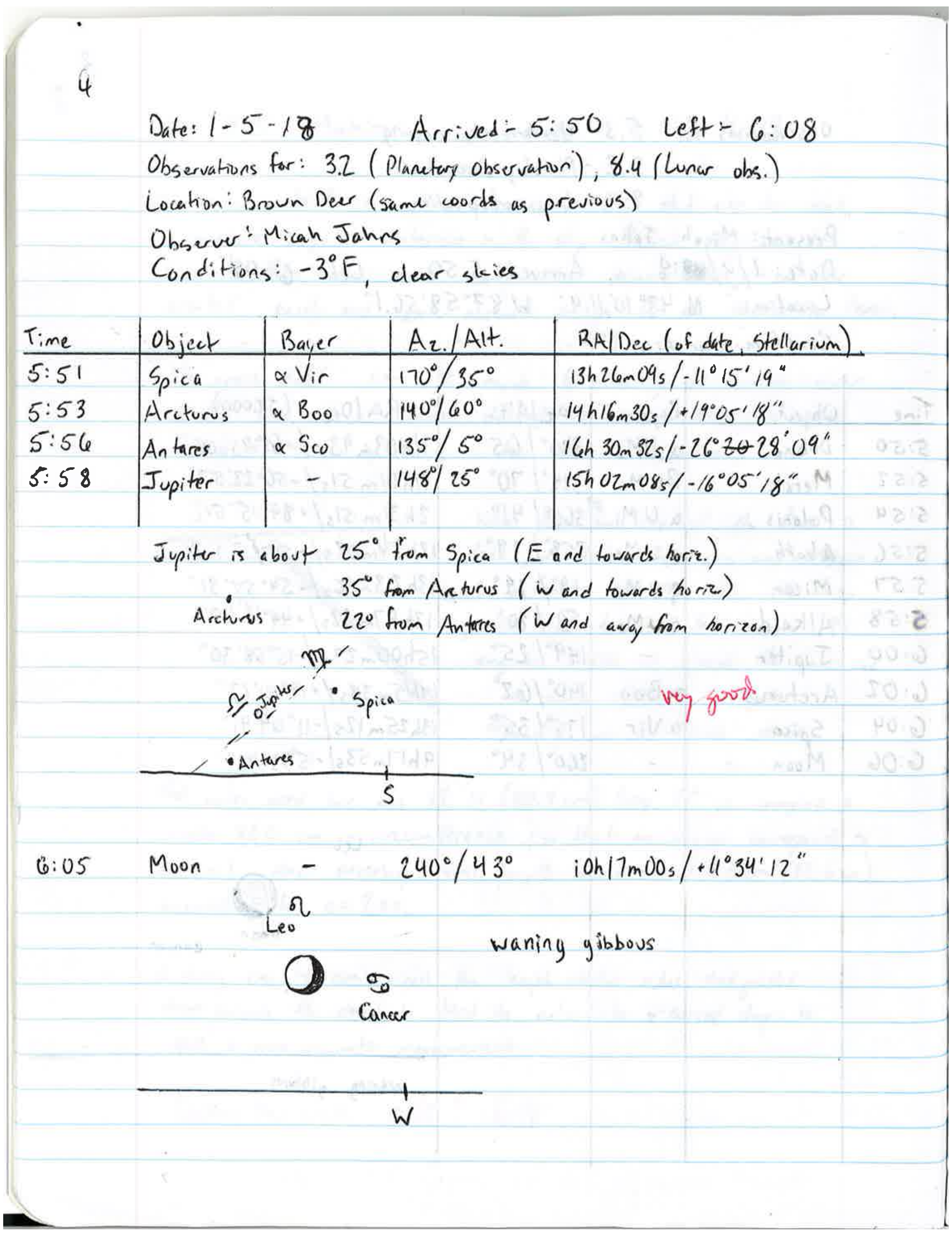
- Observer's Handbook 106 edition. Royal Astronomical Society of Canada (2013). ISBN-10 1927879000.
- Tom VanDamme and David Harriman, Astronomy Book 3: Seasons and the Celestial Sphere. Falling Apple Science Institute (2012).

Required software/apps (free download)

- Stellarium. Desktop planetarium software by Matthew Gates and Barry Gerdes.

Suggested software/apps

- Luminos. Tablet stargazing software by Wobbleworks LLC.



4

Date: 1-5-18 Arrived - 5:50 Left - 6:08
Observations for: 3.2 (Planetary observation), 8.4 (Lunar obs.)
Location: Brown Deer (same coords as previous)
Observer: Micah Jahns
Conditions: -3°F, clear skies

Time	Object	Bayer	Az./Alt.	RA/Dec (of date, Stellarium)
5:51	Spica	α Vir	170°/35°	13h26m09s/-11°15'19"
5:53	Arcturus	α Boo	140°/60°	14h16m30s/+19°05'18"
5:56	Antares	α Sco	135°/5°	16h 30m 32s/-26° ~~20~~ 28'09"
5:58	Jupiter	-	148°/25°	15h 02m 08s/-16°05'18"

Jupiter is about 25° from Spica (E and towards horiz.)
35° from Arcturus (W and towards horiz.)
22° from Antares (W and away from horizon)

6:05	Moon	-	240°/43°	10h17m00s/+11°34'12"

Introduction to Astronomy
PHY 101/105
Fall 2020

Student health, safety and well-being Wisconsin Lutheran College is devoted to the personal welfare of each student by creating and nurturing a Christian community in which all members can grow intellectually, socially, emotionally, and spiritually.

A student's experiences at Wisconsin Lutheran College can be among the most enjoyable and rewarding of their lives. We know that college life also come with challenges. It is natural and acceptable for people to want to talk with someone about personal and/or other challenges, including but not limited to the following: boundaries, relationship difficulties, stress, anxiety, depression, substance use, eating concerns, or self-esteem issues.
And, WLC is blessed to have many people working to help take care of you. Regarding matters such as the ones noted above, the following individuals are available to help you – it's what they love to do – and please know you are encouraged to reach out and connect with one or more of them whenever you need to and, moreover, to learn about other resources that were created with you in mind:

If you, or someone you know, is having a mental health crisis, call the Crisis Line, available 24/7, at 800.438.1772, option #1. You may also bring a student to the Student Health Center during building hours.

- Christian Family Solutions: Text "WLChelp" to 484848 for an appointment
- Director of Health Services: Jackie Kacmarynski, Jackie.kacmarynski@wlc.edu or 414.443.8549
- Campus Pastors: Pastor Greg Lyon - gregory.lyon@wlc.edu or 414.443.8551 and/or Pastor Wayne Shevey - wayne.shevey@wlc.edu or 414.443.8723
- Director of Student Support Services: Karen Sitz, karen.sitz@wlc.edu or 414.443.8797
- Your respective RA and/or RC
- Public Safety: 414.443.8500

Approximate course outline

Week 1 (Aug. 31, Sep. 2, 4):		
		Goal: familiarize yourself with the night sky using *Stellarium* and the *Guideposts*.
		Laboratory: How to keep a laboratory/observation notebook. Assemble Horizon Globe. Do exercises with Horizon Globe beginning with "Day and Night" through "Using the Moon and Planet Calendar" (the grey and yellow sections in Tom VanDamme's *Basic Astronomy* manual.)
Week 2 (Sep. 7, 9, 11):		
		Goal: Learn the *Four Stories* and the *Zodiac*.
		Laboratory: Do exercises with Horizon Globe beginning with "Constellations" and ending with "What's Next" (the red, green and purple sections in *Basic Astronomy* by Tom VanDamme).
Week 3 (Sep. 14, 16, 18)		
		Goal: Study Aristotle's *On the Heavens* (Ch 1-4). Why does Aristotle believe in geocentrism? Do you?
		Laboratory: Finish Horizon Globe exercises.
Week 4 (Sep. 21, 23, 25)		
		Goal: Study of Ptolemy's *Almagest.* How does Ptolemy defend geocentrism?
		Laboratory: *Building a cross-staff* (Ex. 7.5). Your cross-staff will be used during the month of October, when you will do *Lunar Observations* (Ex. 8.4).
Week 5 (Sep. 28, 30, Oct. 2)		
		Goal: Study Bede's *The Reckoning of Time.* What is the relationship between Astronomy and Calendar Construction.

		Laboratory: Finish up Horizon Globe exercises. Do *Spherical Astrolabe* (Ex. 7.3).
Week 6 (Oct. 5, 7, 9)		
		Goal: Study Waldseemuller's *Cosmography.* What is the relationship between astronomy and map-making.
		Laboratory: *Latitude and longitude observations* (Ex. 9.3). This involves one evening observation and one noon-time observations. These can be done anytime during this week and the next. Just plan ahead so you don't run into cloudy weather on the last day of the week!
Week 7 (Oct. 12, 14, 16)		
		Goal: Study Copernicus' *On the Revolutions of the Heavenly Spheres.* How does Copernicus defend heliocentrism?
		Laboratory: Begin *Lunar observations* (Ex. 8.4). This involves going out at the same time every evening between 8:30 and 10:30 to record your observations of the moon.
Week 8 (Oct. 19, 21, 23)		
		Goal: Continue our study of Copernicus' heliocentrism. Begin to study Kepler.
		Laboratory:
Week 9 (Oct. 26, 28, 30)		
		Goal: Continue our study of Kepler.
		Laboratory: Learning about (and how to set up) a Schmidt-Cassegrain telescope. Prepare for *Jupiter Observation* (Ex. 19.2).
Week 10 (Nov. 2, 4, 6)		
		Goal: Study Galileo's *Starry Messenger.*
		Laboratory: Each group must sign up for a time during which they demonstrate that they know how to set up and polar align the telescope.
Week 11 (Nov. 9, 11, 13)		
		Goal: introduce astronomical distance measurement and the work of Henrietta Leavitt.
		Laboratory: Each group must sign up for a time during which they demonstrate that they know how to set up and polar align the telescope.
Week 12 (Nov. 16, 18, 20)		
		Goal: Study Slipher's *Nebulae* and Shapley's *Galaxies*.
		Laboratory: *Spectroscopy Lab* (Ex. 22.2).
Week 13 (Nov. 23, 25, 27)		
		Goal: Study Hubble's *The Realm of the Nebulae*
		Laboratory: Early astronomical measurement
Week 14 (Nov. 30, Dec. 2, 4) **Online instruction**		
		Goal: Introduction to Einstein's General Theory of Relativity
		Laboratory: Early astronomical measurement.

Week 15 (Dec. 7, 9, 10) **Online instruction**		
		Goal: Lemaitre's *The Primeval Atom*
		Laboratory: Independent observation.
Week 16 (Dec. 14-18): Final exams		