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# A One Credit Hour Eclipse Course for 2024: Description and Offer to the Community

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## ABSTRACT

The April 8, 2024 total solar eclipse will provide a wonderful opportunity not only for public outreach but also for university and school education in North America. To that end, I have created a one credit hour course which covers the physics of eclipses and also a survey of their impact on society through the windows of history, art, literature and motion pictures. It ends with lectures on transits and exoplanets. I describe the course as given face-to-face in autumn 2023, plans for a massive online spring course and how to obtain course materials for interested instructors in universities and schools. There are $>$ 400 PowerPoint slides with hyperlinks on GitHub. They can adapted, subject to an attribution, non-commercial, share-alike license from Creative Commons. I also can provide 70 multiple choice questions, with answers, and 14 videos in mp4 format. The goal is to offer a turn-key course which can be taught with minimal effort in the spring of 2024. The course is survey/non-major level, not meant to be complete or exhaustive, and is offered "as it is", with a best effort to give accurate content and attributions.

*Keywords:* Astronomy education(2165) — Eclipses(442) — History of astronomy(1868) — Interdisciplinary astronomy(804)

## 1. INTRODUCTION

Eclipses offer a rare, unique and powerful way for the people to experience a multi-sensory connection with the cosmos, and also still provide some unique scientific opportunities. The US experienced a new type of eclipse on Aug. 21, 2017: coast-to-coast, with much coverage by the mass media and communication via the Internet and social media. The result was a surge in people viewing the eclipse, both on and off the totality path – and a surge in interest in astronomy.

The Apr. 8, 2024 eclipse should be a bigger event, since the 2017 event is fresh in people's minds. Both through teaching general education astronomy at the university level and via informal communications, I have noted that many misconceptions still exist about eclipses. These include but are not limited to:
1) a partial eclipse shows most of the same phenomena as a total eclipse,
2) eclipses are common, based on the seven year gap between 2017 and 2024, and
3) one always needs eclipse glasses, even during totality.
These types of misconceptions diminish the incentive to make an effort to learn about or make a point to observe an eclipse, even if totality is close (within a 1–2 hour drive away).

To get the basics, there are a number of individual eclipse videos and lectures available on YouTube. However, to learn more in-depth material, more is needed. Universities offer a means to learn about eclipses via courses with academic credit. However, the majority of universities do not offer eclipse courses. A few which do include the following.

At Rice U., Patricia Reiff[1] teaches three courses, including options for professional development (PD) hours for school teachers. There are offerings for 1.5 and 4 PD hours for viewing an eclipse training video and varying degrees

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[1] https://space.rice.edu/eclipse/eclipse_training.html

of responses, and 45 PD hours or 3 college credits for a full 500-level course, "Teaching Earth and Space Science". The latter covers solar system astronomy including eclipses, and uses mathematics with algebra, logarithms and trigonometry.

Doug Duncan of Colorado U. developed a free, massive online course for the 2017 eclipse which includes solar physics[2]. It contains videos, quizzes and discussion prompts, takes eight hours to complete and can grant a certificate for LinkedIn or a CV. It has an emphasis on filmed demonstrations of spectroscopy as a scientific tool.

At Providence U., Joseph Ribaudo will teach an interdisciplinary spring eclipse course using Nordgren (2016) as a primary source, among other references.

At Bowling Green St. U., Kate Dellenbusch and Andrew Layden are developing a one credit hour spring eclipse course, ASTR-2700. There are two face-to-face sections (one being honors) in their planetarium with 15 students each. The goal is to train students to be Eclipse Ambassadors. In addition, it is planned to be interdisciplinary, with guest talks by faculty from fields including arts, history and English.

Louisville KY is a half hour drive from totality. Publicity in the area about the 2024 eclipse has so far been limited. The local newspaper and TV meteorologists have mentioned it, but awareness among the public and the U. Louisville community to date is still low, although local schools will be closed on Apr. 8. The city is conveniently placed for eclipse-watchers to stay the day before and pass through afterward, and hotel prices have surged to near $1000/night[3]. It is hoped that an eclipse course can raise awareness of this cosmic event, so that people can enjoy and learn from this unique experience.

In this manuscript, I will describe the creation and execution of a one credit hour interdisciplinary "pilot eclipse course" in autumn 2023 at the Univ. of Louisville, and the preparation for a large, online course in spring 2024. I will then describe opportunities for collaboration by instructors in other universities and in schools.

## 2. AUTUMN 2023 FACE-TO-FACE PILOT COURSE

The development of an eclipse course took a number of steps started over a year in advance.

### 2.1. *Administrative Preparation*

In the autumn of 2022, I proposed to create a university course both to address common misconceptions about eclipses, both to reach university students, faculty and staff, and also to do public outreach in the region. One credit hour was proposed, because the envisioned eclipse material was too much to add significantly to an established general education course of three credit hours, but not enough to make a three credit hour course on its own. The ultimate goal was a massive online course in spring 2024, to reach the maximum audience. Because an eclipse course would only be intended for 2023-24, it was necessary to choose a title of "special topics" at the 100 (freshman) level. Administrative work through various committees to finalize the course approval continued through spring 2023. The one credit hour course had the additional advantage of making the academic burden as light as possible to minimize any barriers to taking the course, for both students and the public. In addition to the administrative work to create the course, in the summer of 2023 it was also necessary for me to take an online course in how to teach online.

The goals for an autumn course were threefold:
1) to develop the lectures, quizzes and other assignments,
2) to get critiques by students to improve the course for the next semester, and
3) to educate some teachers in the community to pass on the material.
Face-to-face format was chosen for maximum interaction with the students. It is hoped that other universities may already have a 100-level "current topics" course ready to use, without the need to create one.

### 2.2. *Student Recruitment*

I decided to recruit students mostly at the junior-senior level and beyond, who would not be challenged by the "beta-version" of a course and who would not be reluctant to give constructive criticism. I advertised to advanced physics majors and also to the stronger students whom I had taught in a general education course in the past. To recruit people who could teach about eclipses, I contacted local TV meteorologists, who often comment on events in the sky. In addition, I wrote to a number of school districts and local high school science teachers. Although I offered

[2] https://www.coursera.org/learn/eclipse

[3] https://www.wdrb.com/news/louisville-braces-for-a-wild-spring-4-marquee-events-bringing-tens-of-thousands-of-tourists/article_f9da2042-9ea3-11ee-8c69-77f37bd7827c.html

an option of professional development credit in lieu of university credit, only one teacher signed up: an alumnus whom I had taught in 2013-14, who was funded by a school district. In total, nine students signed up: 4 physics majors at the sophomore to senior level, 1 physics alumnus who was a teacher, 1 senior in political science, 1 senior in biology, 1 sophomore in business and 1 staff member working in the administration. Of these, three had taken my general education course, using Pasachoff & Filippenko (2019), and four had taken or were taking 1-2 semesters of calculus-based astrophysics, using Ryden & Peterson (2010), with an overlap of one. Lectures were chosen to be at 5:30pm to accommodate the teacher and staff member.

### 2.3. *Overview of Lectures*

The first five lectures shared much material with our general education course, though in greater depth: the sky and motions of the sun and moon, lunar and solar eclipses, the formation of the solar system and the structure/nature of the sun. After that, it became a challenge to cover more eclipse-related scientific material at the general education level. To make the course relevant to science today, a lecture was created on past and current eclipse research. Another lecture was produced on observing and photographing eclipses, which drew partly from a public lecture which had been given several times in 2017, but also included more technical topics in photography. These last two lectures took 3-5 days to research, write and illustrate, which were typical for lectures not using already prepared material from our general education course. Hyperlinks to short (typically 1-2 minute) videos and supplementary articles related to the material were put in for students who wished to explore further, as were image attributions when available. Many of the images are in the public domain, though not all. For more details, see the Appendix.

Several books were used for source material, including Nordgren (2016), Baron (2017), Dvorak (2017) and Buxner et al. (2019). These gave ideas for several more lectures on history, art, literature and film/TV. They were supplemented with extensive searches on the Internet and an article on eclipses in art by Blatchford (2016). Student attendance was good, with substantial discussion during and after each lecture. Lectures were video-recorded and available on BlackBoard for repeat viewing.

### 2.4. *Assignments, Grading and Results*

Seven quizzes of ten multiple choice questions were given, with five questions per lecture, and 10% weight for each quiz. Quizzes were administered and graded via BlackBoard, with unlimited tries and no monitoring. There were five discussion assignments of 2% each, graded on a three point scale, using BlackBoard Forum: an introduction to other students, a description of one's experience with the 2017 eclipse (if applicable), teaching/outreach plans for spring 2024, eclipse misconceptions after viewing *A Private Universe*[4] and between three and ten "things learned" in the course. There were two assignments of one page each with 10% weight, graded on a ten point scale. The first consisted of a description and a photograph from observations of the Oct. 14, 2023 annular eclipse (partial in Louisville, with an online option in case of clouds, which was needed). The second was "letter to the future", for students in the spring course and for viewers of the next eclipses in the US in 2044 and 2045. The grading scale was fixed, with 3-4% for each grade band and using the plus/minus system.

As this course did not fulfill a major or general education requirement but rather was a "free elective", it was not the highest priority for the students. This is understood and accepted, because the course was intended to primarily to be fun, to provide a public service and not to be an undue burden. The physics students found the course easy while the others sometimes found it more challenging, based on the number of quiz attempts made. At the end of the semester, it became necessary to grant a number of extensions and remind some students at the end of the semester to complete their assignments. The average grade upon course completion was A+, which is part of the appeal of the course.

[4] https://www.learner.org/series/a-private-universe/1-a-private-universe/

## 3. ONLINE SPRING 2024 COURSE

The spring course differs from the pilot course in two significant ways. First, it is online rather than face-to-face. Second, a larger number of students are targeted for the new course, with a substantial advertising effort which is time-intensive.

### 3.1. *Student Recruitment*

To justify the substitution of a one credit hour course for the regular three hour general education course usually taught each semester for part of a teaching load, it was important to target a large enrollment. This was done in a variety of ways, both for inside and outside the university. To advertise to university students, the following was done.
1) The head of academic advising was contacted in the early autumn, to encourage advisors to tell students about the course among all majors.
2) Six "yard signs" were erected on U. Louisville's two campuses in mid-November, when spring course enrollment started, with two of them paid by the department.
3) Posters were put up in several buildings with large lecture halls.
4) The offices of deans of several colleges were asked to advertise the course to their undergraduates.
5) Faculty at neighboring universities in the area participating in the Louisville "Metroversity" program were asked to encourage students to take the course as well.

To contact the public, two populations were targeted which had highly discounted tuition rates: (1) high school students (charged $93), and (2) those over 65 years of age (charged about $50). The University Office of Communications put out a press release about the course, which was picked up by a local TV station. General announcements were made on Facebook, LinkedIn and Reddit. To encourage high school students to sign up, a number of area science teachers were e-mailed, and some advertising was done directly to students when opportunities arose. The Office of Admissions also agreed to extend the high school admissions policy to middle and elementary school students for this unique opportunity. Parents are informed as well, when possible. Postings were made to teacher and home-schooling groups on Facebook and LinkedIn. To contact those over 65, efforts have so far been limited to word-of-mouth via the Louisville Astronomical Society and social media. Further work will be done with retirement organizations and directors of retirement homes.

As of Dec. 19, 2023, there were 48 students enrolled, out of approximately 16,000 undergraduates and 6,000 post-graduates/professional students at U. Louisville. These include:
29 undergraduates in the College of Arts & Sciences
4 undergraduates in the Speed School of Engineering
8 non-degree students, either members of the public or University staff
The rest are from the College of Business, School of Music, College of Education & Human Development, the Graduate School or a local high school. A gifted third grader is in the process of enrolling. Further enrollment is expected once administrative offices re-open on Jan. 2, when a flexible cap on registrations can be raised. It is possible that there will be more school students and members of the community in the course than University students, as so far only the most highly motivated University students have signed up.

### 3.2. *Course Content*

The lectures will be slightly revised for the online course, with new videos recorded. Some material may be added from the lists and descriptions of eclipses in literature, music, art etc. by Fraknoi (2022)[5]. Depending on the class size, some of the discussion assignments may be omitted, depending on how much help is available to grade them. The course website[6] provides a complete schedule, other details and links to start enrollment. Eventually, a website for references and further information may be constructed.

## 4. DISTRIBUTION OF MATERIALS TO OTHER INSTITUTIONS

The Univ. of Louisville course can likely serve a maximum of $\sim$ 1000 students due to instructor time/resource restrictions, in an optimistic case. That is a small fraction of the millions of people who will view the 2024 eclipse,

[5] http://bit.ly/eclipsesand

[6] https://www.physics.louisville.edu/williger/Pa195_2024sp

or who simply wish to learn more about it. Therefore, the slides, quizzes and videos (both from the pilot course and from the new course, as they are recorded) are being made available for instructors from other universities and schools to use and adapt. The slides are available on GitHub in PowerPoint format[7]. The files range from 6-32 Mb in size. The largest file (lecture 12 on eclipse scholars) is split to accommodate the 25 Mb maximum size of Github. They are presented with a Creative Commons license for non-commercial use, with attribution, and can be edited by instructors as desired.

The videos for the pilot course are available by a password-protected website, if desired. The file sizes are ∼350 Mb. The author should be contacted by e-mail in case of interest. Lecture 10 (literature) regrettably had an error made in the video settings. The audio is available, though no slide images were made. It will eventually be re-recorded with images in Mar. 2024. The quizzes (and answers) will be available by e-mail from the author, in an attempt to maintain academic integrity.

The course is taught in a 14 week university semester. However, it can easily be adapted to a short winter term, or a course for the second half of spring semester. The materials can be used for any type of class, though smaller, face-to-face sections with a discussion and/or writing component added to the slides and quizzes may be the most effective way to teach. It is regretted that the dissemination of this material was not done earlier in the semester due to the time needed to produce it, but it is hoped that some institutions, particularly smaller ones, may be able to add a similar course without excessive administrative work. It should be possible for a graduate student to lead discussion sessions while relying on the slides, videos and quizzes for most of the material.

## 5. INVITATION FOR COLLABORATION

An eclipse course taught using similar materials at a number of universities (and even schools) offers an opportunity for educational research. Instructors are invited for collaboration to construct a pre-course and post-course survey to evaluate learning, in particular how successfully misconceptions have been addressed. Kate Russo[8] has already contributed some question text. Colleagues in universities or schools who are interested should contact the author by e-mail and see an informational webpage[9]. A Slack channel has been created to facilitate discussion by those teaching special eclipse courses, if desired. Readers of this article are asked to pass along word of this course to anyone who may be interested to teach it.

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## APPENDIX

The following is a detailed but not exhaustive list of content, concepts or vocabulary for each lecture.

Lecture 1, Sky Motions: constellations, daily, monthly, annual motion of Sun and Moon, angles in astronomy: degrees, arcminutes, arcseconds; Right Ascension, declination, distances/scales in astronomy, triangulation/parallax, metric system, scientific notation (exponents)

Lecture 2, Lunar Eclipses: diffuse light vs. point source light, Earth's atmosphere and twinkling, logarithmic scales, ellipses, orbits and Kepler's Laws, special points in orbits: perigee, apogee, perihelion, aphelion; angular momentum, Moon phases, the umbra and penumbra, types of lunar eclipses, eclipse seasons and the line of nodes, future lunar eclipses

Lecture 3, Solar Eclipses: types of solar eclipses, tides, precession, synodic period, Saros Cycle, future solar eclipses

Lecture 4, Origin of the Solar System: elements, the interstellar medium, nebulae and Giant Molecular Clouds, protoplanetary disks and planet formation, heat transfer, planetesimals, formation/history of Earth, Van Allen Belts/aurorae, formation/history of the Moon, craters, center of gravity, isotopes

[7] https://github.com/gwilliger/Eclipsecourse_2024

[8] https://beingintheshadow.com

[9] https://www.physics.louisville.edu/williger/Pa195_2024sp/Share_eclipsecourse

Lecture 5, The Sun: the spectrum: X-rays, ultraviolet light, infrared light; parts of the Sun, magnetic fields, luminosity, energy, power, forces: gravity, pressure, how they balance; light: photons, wave-like nature, particle-like nature; spectral lines and electron transitions in atoms, sunspots, solar cycle, prominences, flares, coronal mass ejections, solar wind

Lecture 6, Eclipse Science: Earth latitude/longitude system, Einstein's theory of general relativity (without math), 1919 eclipse to prove relativity, variations in Earth's rotation, shadowbands, spectroscopy, ionization

Lecture 7, Observing Eclipses: pinhole projectors, eclipse glasses, solar filters, basics of photography, Diamond Ring effect, Baily's beads, citizen science for the eclipse

Lecture 8, Eclipses in History: Babylonians, Chinese, Arab and Mayan astronomy, Greek astronomy, Antikythera Mechanism, Athens, Peloponnesian War, crucifixion of Jesus Christ, birth of Mohammed, the fall of Constantinople, Columbus, Sir Isaac Newton, Edmond Halley, Capt. Cook, Lewis & Clark, Daguerrotypes, discovery of helium, proof of relativity

Lecture 9, Eclipses in Art: Australian aborigines, Irish Celts, Stonehenge, Serpent Mound, Hadrian's coin, Metz Sacramentary, Chaco Canyon, Mayan Codex, de Menabuoi, Regiomontanus, Raphael and Workshop, Antoine Caron, Rubens, Cornelis de Vos, Johannes Hevelius, Philippe de Champaigne, Cosmas Damian Asam, Giuseppe Simonelli, Duke of Wellington, Johann Schoeller, Jean Jacques Grandville, Camille Flammarion, Diego Rivera, George Grosz, Rufino Tamayo, Roy Lichtenstein, contemporary photos

Lecture 10, Eclipses in Literature: Bible, Gilgamesh, Homer, Aristophanes, W. Shakespeare, J. Milton, W. Wordsworth, J. Verne, K. Tsiolkovsky, H. Haggard, B. Prus, M. Twain, E. Dickinson, T. Hardy, E. Blyton, I. Asimov, Hergé, A.C. Clarke, A. Dillard, B. Moore, S. King, A. Monterroso, R. Sawyer, K. Oppel, W. Mass, G. del Toro & C. Hogan, V. Dave', D. Dickinson, E. Hart

Lecture 11, Eclipses in Folklore, Music, Film and TV: Carly Simon, Bonnie Tyler, The Eclipse (1907), King Solomon's Mines, Fantasia, A Connecticut Yankee in King Arthur's Court (Bing Crosby), Barrabas (Anthony Quinn, Ernest Borgnine), Pharaoh, 2001 A Space Odyssey, Tin Tin, Watcher in the Woods (Bette Davis), Ladyhawke (Matthew Broderick, Michelle Pfeiffer), Little Shop of Horrors (Rick Moranis), The Simpsons, Farinelli, Dolores Claiborne (Katy Bates, Jennifer Leigh), Wild Thornberrys, Hellboy (Dir. Guillermo del Toro), Apocalypto (Dir. Mel Gibson), Heroes (TV), The Strain (TV), Avatar: The Way of Water (Dir. James Cameron; Sigourney Weaver, Kate Winslet)

Lecture 12, Eclipse Scholars: Aristarchus, Ptolemy, al-Biruni, Al-Zarquali, Regiomontanus, Brahe, Kepler, Horrocks, Newton, Halley, Capt. Cook, Bessel, Baily, Janssen, Lockyer, Mitchell, the Todds, Hill & Brown, Pasachoff, Espenak, Habbal & Boe, Kerschbaum, Duncan, Druckmueller, Russo, Anderson, Samra, Hayakawa; (others may be added, for example Glenn Schneider)

Lecture 13, Transits: conjunctions, Transits of Mercury, Venus, expeditions of 1761, 1769, 1874, 1882, black drop effect, transits/eclipses of Jupiter's Galilean moons, transits of Titan, transits viewed from Mars (by rovers), recent/future transits

Lecture 14, Exoplanets: Anaximander, Leucippus, Democritus, Epicurus, Bruno, Newton, Struve, distance scale to stars, discovery methods: radial velocity, transits, direct imaging, Doppler effects for sound and light, Nobel Prize 2019 (Mayor & Queloz), how we know the mass, size, composition, temperature and atmosphere of an exoplanet; satellites to study exoplanets, citizen science with exoplanets, numbers/types of known exoplanets habitable planets, prospects for life on exoplanets

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