

Syllabus – AST215H5S: Astronomical Revolutions – Winter 2020

Course description: This course offers an examination of the revolutions that have shaped astronomy from the time of Copernicus to the current day. Emphasis is placed on the process of discovery that has led to major advances in our knowledge about the Universe. The course includes an outline of the puzzles that have inspired the important shifts in our understanding of the Universe. These have been central to the development of astronomy, but also to physics and earth science, as well as philosophy, and the current discoveries of other solar systems is likely to have a major impact on the life sciences. This course is suited for both science and non-science students.

Course objectives: Upon completing this course, students will be able to:

- explain major changes in the history of astronomy and cosmology from the early modern period to the present
- recognize and describe the ideas of key figures in the history of astronomy and cosmology
- identify intellectual and social factors that cause scientific knowledge to change over time
- identify and describe scientific instruments that have shaped astronomy and cosmology
- evaluate historians' arguments about key figures and developments in history
- synthesize material from different topics to make arguments about particular subjects and about the history of astronomy and cosmology in general
- write a cogent essay about the development of astronomy and cosmology

Lectures: MN 3180, Monday, Wednesday, and Friday, 11:00 am-12:00 pm

Instructor: Adam Richter, PhD

Office hours: Mondays, 12:00-1:30 pm., DV4059C

Contact:

I prefer to communicate by email. You can reach me at adam.richter@mail.utoronto.ca. **Please begin the subject line with “AST215” or I might miss your email.** I will try to respond to your emails within 48 hours, but this is not always possible. If necessary, you can leave a message for me at the Chemical and Physical Sciences Department by calling 905-828-5351 or by coming to the C&PS office in the Davis Building, Room 4037A.

Grade breakdown

- Short essay: 15% - **Due January 30 (online)**
- Midterm: 20% - **February 14**
- Research essay: 30% - **Due on March 22 (online)**
 - Optional oral presentation worth half the essay grade – see below
- Final exam: 25% - **April (Exam period)**
- Attendance: 10%

Readings

The textbook for the class is **Craig Fraser, *The Cosmos: A Historical Perspective*** (Westport: Greenwood, 2006), and it is available in the UTM bookstore. Most classes have a short reading from the textbook, with page numbers given on the schedule below. The textbook is abbreviated “F”. Some classes

will have additional readings, available online or on Quercus, and these are also indicated on the schedule below. Please complete the readings before class.

Instrument workshop

On February 26, representatives from the University of Toronto Scientific Instruments Collection (UTSIC) will bring some astronomical instruments from the collection to our class, and teach us about their use and history. I recommend, of course, you attend all classes throughout the semester, but you certainly will not want to miss this one!

Schedule

Week 1: Introduction / The Problem of the Planets 1

Monday, January 6: Introduction (F 1-4)

Wednesday, January 8: Background: Greek and Roman astronomy (F 13-26)

Friday, January 10: Background: medieval contributions (F 35-44)

Week 2: The Problem of the Planets 2

Monday, January 13: Copernicus (F 44-51)

Wednesday, January 15: Early Copernicans (F 51-53; Georg Rheticus, “Narratio Prima,” in *Three Copernican Treatises*, 3rd ed., trans. Edward Rosen [New York: Octagon, 1971], pp. 142-151, available on Quercus)

Friday, January 17: Tycho and Kepler (F 55-65)

Week 3: The Problem of the Planets 3

Monday, January 20: Galileo’s astronomy (F 65-68; Galileo Galilei, *The Starry Messenger*, available at <https://people.rit.edu/wlrgsh/Galileo.pdf>)

Wednesday, January 22: Galileo’s *Dialogue* and trial (Galileo Galilei, *Dialogue concerning the Two Chief World Systems*, trans. Stillman Drake [New York: The Modern Library, 2001], 5-7, 389-395 available on Quercus)

Friday, January 24: Newton’s astronomy and cosmology (F 68-72)

Week 4: Astronomy, Physics, and Philosophy

Monday, January 27: Descartes (John North, *Cosmos: An Illustrated History of Astronomy and Cosmology* [Chicago: University of Chicago Press, 2008], 403-406; Descartes, *The World*, ch. 8-10, available at <https://www.princeton.edu/~hos/mike/texts/cartes/world/worldfr.htm>)

Wednesday, January 29: Newton’s philosophy and religion (Isaac Newton, letter to Bentley, December 10, 1692, available at <http://www.newtonproject.ox.ac.uk/view/texts/normalized/THEM00254>)

*****DOCUMENT ANALYSIS DUE ON JANUARY 30*****

Friday, January 31: Global history of science: astronomy on Jesuit missions (Agustín Udías, *Jesuit Contribution to Science* [Cham: Springer, 2015], 79-84, available on Quercus)

Week 5: Remaining Problems in the Solar System

Monday, February 3: Huygens and Saturn (Nicole Howard, “Rings and Anagrams: Huygens’s System of Saturn,” *The Papers of the Bibliographical Society of America* 98 [2004]: 477-510, available on Quercus)

Wednesday, February 5: Comets (Roger Ariew, “Theory of Comets at Paris during the Seventeenth Century,” *Journal of the History of Ideas* 53 [1992]: 355-372, available on Quercus)

Friday, February 7: Eclipses and transits (Daniel Hudon, “A [Not So] Brief History of the Transits of Venus,” *Journal of the Royal Astronomical Society of Canada* 99 (2004): 6-20, available on Quercus)

Week 6: Beyond the Solar System

Monday, February 10: The speed of light / searching for parallax (F 73-78)

Wednesday, February 12: Stellar astronomy / the Herschels (F 78-82)

Friday, February 14: ***MIDTERM – IN CLASS*** (no reading)

READING WEEK – NO CLASS FEBRUARY 17-21

Week 7: Early Astrophysics

Monday, February 24: Spectroscopy (F 84-85; John B. Hearnshaw, *The Analysis of Starlight: Two Centuries of Astronomical Spectroscopy*, 2nd ed. [Cambridge: Cambridge University Press, 2014], 15-32, available on Quercus)

Wednesday, February 26: **Instrument workshop (no reading)**

Friday, February 28: Astronomical photography (Robert Gendler and R. Jay Gabany, “The Birth and Evolution of Astrophotography,” in *Breakthrough! 100 Astronomical Images that Changed the World* [Cham: Springer, 2015], 1-13, available on Quercus)

Week 8: Galaxies / The Limits of the Newtonian Universe

Monday, March 2: The island-universe hypothesis / Hubble and extragalactic nebulae (F 87-91, 92-94, 96-99)

Wednesday, March 4: **Guest Lecture: Craig Fraser, Institute for the History and Philosophy of Science and Technology** – Hubble and the expanding universe (F 111-115; Edwin Hubble, “A Relation between Distance and Radial Velocity among Extragalactic Nebulae”, *PNAS* 15 [1929]: pp. 168-173, available at <https://www.pnas.org/content/pnas/15/3/168.full.pdf>)

Friday, March 6: Searching for Vulcan (William Sheehan and Richard Baum, “Vulcan Chasers: The Search for an Inside Planet,” *Astronomy* 25 [1997]: 42-47, available on Quercus)

MARCH 8: DROP DEADLINE FOR WINTER TERM

Week 9: Physics and the Origins of the Universe 1

Monday, March 9: **Guest Lecture: Toby Reid, Institute for the History and Philosophy of Science and Technology** – Relativity and Cosmology (Readings TBA)

Wednesday, March 11: Einstein, Philosophy and Religion (F 105-111; James Robert Brown, “Who Gets Einstein?” *Queen’s Quarterly* 108 [2001]: 74-83, available on Quercus)

Friday, March 13: **Guest Lecture: Andrew Oakes, Institute for the History and Philosophy of Science and Technology** – (Early) modern Canadian astronomy (C.A. Chant, R.K. Young, “Evidence

of the Bending of Rays of Light on Passing the Sun, Obtained by the Canadian Expedition to Observe the Australian Eclipse,” *Publications of the Dominion Astrophysical Observatory* 2 (1923): 275-285; Richard A. Jerrell, “J. S. Plaskett and the Modern Reflecting Telescope,” *Journal of the History of Astronomy* 30 [1999]: 359-390, available on Quercus)

Week 10: Physics and the Origins of the Universe 2

Monday, March 16: The Big Bang and Steady State Theories (F 123-129; Donald H. Menzel, “Blast of Giant Atom Created Our Universe,” *Popular Science Monthly* 121 [1932]: 28-29, 105; available on Quercus)

Wednesday, March 18: Radio astronomy and the cosmic microwave background (F 131-136)

Friday, March 20: Space exploration and space-based observation (F 137-141)

*****RESEARCH ESSAY DUE MARCH 22*****

Week 11: Recent Developments

Monday, March 23: The Pluto debate (Lisa R. Messeri, “The Problem with Pluto: Conflicting Cosmologies and the Classification of Planets,” *Social Studies of Science* 40 [2010]: 187-214, available on Quercus)

Wednesday, March 25: Exoplanets (David Wilkinson, “Searching for Another Earth: The Recent History of the Discovery of Exoplanets,” *Zygon* 51 [2016]: 414-430, available on Quercus)

Friday, March 27: Einstein’s legacies: gravitational waves and black holes (F 144-147; Dennis Overbye, “Darkness Visible, Finally: Astronomers Capture First Ever Image of a Black Hole,” *New York Times* [April 10, 2019], available on Quercus)

Week 12: Today’s Puzzles

Monday, March 30: Extraterrestrial life (Milan M. Ćirković, “Fermi’s Paradox – The Last Challenge for Copernicanism?” *Serbian Astronomical Journal* 178 [2009]: 1-31, available on Quercus)

Wednesday, April 1: Dark matter and dark energy (F 147-153)

Friday, April 3: Exam review (no reading)

Assignments

Short essay: This short writing assignment will focus on our first major topic for the course: the “problem of the planets”. Your essay will compare two major thinkers (e.g.. Eudoxus, Aristotle, Ptolemy, al-Tusi, Copernicus, Tycho, Kepler, Galileo) in terms of how they explain planetary motion. It is perfectly fine to base this essay on lecture material and assigned readings, but you can conduct additional research if you would like to do so. The maximum length will be **750 words**.

In-class midterm: The midterm will last for the one hour of class time on February 14. It will cover all material from lectures and readings up to that point in the course. The midterm will include multiple choice, fill-in-the-blank, identification, and short-answer questions.

Research essay: This essay will allow you to conduct in-depth research on a subject of your choice. The subject can be any person, discovery, invention, instrument, event, or social factor that has contributed to a revolution in the history of astronomy and cosmology since the time of Copernicus. The goal is to

make and defend a clear **argument** about this contribution to the history of astronomy. We will discuss strategies for constructing an argument in class.

Optional oral presentation: You have the option of giving a 15-minute oral presentation in class on the subject of your research essay. The grade for this presentation will constitute half of the grade of the essay. For those students who choose this option, we will schedule a presentation during the last three or four weeks of class. There is no penalty for choosing not to give the presentation. **If you want to give a presentation, you must sign up for this option in class during the week of February 24-28.**

Final exam: The final exam will be scheduled during the **exam period (April 6-22)**. It will cover material from lectures and readings from the entire course, but it will be weighted toward material since the midterm. The exam will include multiple choice, fill-in-the-blank, identification, and short answer questions, and a single essay question. You will have a choice of which essay question to complete.

Attendance: This grade will be based on your attendance at lectures. If you cannot attend class due to a medical or significant personal reason, allowances will be made. Medical reasons will require a note signed by a medical professional. If possible, please let me know in advance why you will be missing class.

Policy for late work:

The grade on late essays will be reduced by **3% per calendar day, to a maximum of 15%**, with one day considered to have elapsed at 12:01 a.m. at the end of the day when the essay is due. If your essay is more than five days late, I will not accept it at all and your grade on the assignment will be 0.

Students may submit a request for special consideration within one week of the assignment due date or date of the missed test, quiz, or discussion period, by noon of that day. Requests for special consideration may be made by e-mail to the Course Instructor, from a valid University of Toronto e-mail account, with additional documentation to be submitted in person, as follows. Valid documents include the University of Toronto (UofT) Verification of Student Illness or Injury form and death certificates, such as a Medical Certificate of Death or Proof of Death Certificate (signed by a licensed funeral director), where special consideration is being requested for bereavement. Medical certificates other than an original, valid UofT Verification of Student Illness or Injury form will not be considered. Students must also successfully complete an online absence declaration via ROSI/ACORN and provide the Course Instructor with a confirmation of this declaration in hardcopy along with the other documents included in their petition for special consideration. The Course Instructor will inform the student by e-mail (as per the communication policy) whether special consideration is granted following due diligence on the documentation provided.

Grading scale:

Your work will be evaluated in accordance with the university's 4.0 grading scale, which you can consult here: <https://www.utsc.utoronto.ca/registrar/u-t-grading-scheme>

Academic honesty:

Please note that the university takes breaches of academic honesty very seriously, and that offences can have lasting academic consequences far worse than failing an assignment. Academic dishonesty includes, but is not limited to, plagiarism. All work that you submit must be entirely your own. **Unacknowledged borrowing from any source, published or unpublished, will not be tolerated. Nor will any effort to portray someone else's work as your own.** Academic honesty requires citing sources fully and properly. Chicago Style is preferred in history. You may use a different citation style if you wish, as long as you use it consistently and correctly. If you have any doubts about how to cite correctly, or what constitutes

academic dishonesty, feel free to contact me. Finally, please remember that in the age of the Internet, it is very easy to detect plagiarism, so it is simply not worthwhile.

It is your responsibility as a student at the University of Toronto to familiarize yourself with, and adhere to, both the Code of Student Conduct and the Code of Behaviour on Academic Matters. Please review the materials available at <https://www.academicintegrity.utoronto.ca> for more information.

Electronic devices:

Please set all cell phones, tablets, and smart watches to “Do Not Disturb”, or better yet leave them at home. Any use of such devices in class is disruptive and distracting, so, as a matter of courtesy to me and to your classmates, please do not use them in any capacity (including calls, texts, games, apps) except for emergencies. You may take notes on a laptop or tablet, but please do not browse the Internet, check your email, or engage in social networking during class. We have much to cover in a short time, and electronic distractions will cause you to miss a lot of material.

Special needs and accessibility issues:

If you have any special needs that need to be accommodated, please discuss with me within the first week of class. You may also want to visit Accessibility Services or Test and Exam Services.