INQ 250: Astronomy Controversies of the Modern Era
Fall 2017

Meeting: Trexler 273 Time: MWF 1.10–2.10p (Block 5) Instructor: Matthew C. Fleenor Office: Trexler 266D email: fleenor@roanoke.edu Office Hours: R 1–2.30p webspace: http://www.roanoke.edu/mcsp/fleenor/ W 2.15–4p, or by appt.

Required Readings (you need to purchase):

Galileo's Daughter (GD), Dava Sobel
Miss Leavitt's Stars (MLS), George Johnson
Heart of Darkness (HoD, Ostriker & Mitton
Any used copy of an introductory astronomy textbook

Portions of the following (I will provide):

Skywatchers (S), Anothony Aveni
A Brief History of Time (BHT), Stephen A. Hawking
Theoretical Concepts in Physics (TCP), Malcolm Longair

Components of Learning

There are several factors that make a course "good" (by good, I mean a healthy combination of the intellectual and the affective). Good courses are also clear about their essential components. Below is an attempt to be clear about how will I operate within INQ 250, as well as my expectations of a student who is enrolled in INQ 250.

Descriptions

Aspiration: How do the scientific processes of observation, measurement, and theorizing help to create and resolve controversy within the sciences? Is it healthy to maintain controversy regarding theories and models in the sciences; i.e., do the sciences thrive on controversy? How is controversy received and interpreted by the larger society and culture? By examining some well-known controversies within the astronomical sciences, we will explore both the quantitative arguments and the historical contexts in answering the above questions. Since physics is the proper background for astronomical studies, the course will also focus on the physical concepts and processes associated with astronomical objects. You will also take measurements, observe astronomical objects with telescopes, and interpret graphically-presented data through a required weekly night lab. The aspiration is that you will better understand the process of carrying out science and determine what makes 'good science.'

Goals & Objectives: Remember, you are primarily enrolled in the Controversies class because it satisfies the lab-science component of your liberal arts, general education program. All sections of INQ 250 share a common set of learning outcomes related to the skills students will develop in this course. These outcomes can be found at `http://roanoke.edu/Academics/Core_Curriculum/Types of Courses/Perspectives Courses in Natural Sciences.htm`.

An outcome is a newer term in education and represents what people traditionally think of as a goal or an objective. In the 'Controversies' section of INQ 250, the common outcomes above will be developed in specific assignments tied to specific outcomes. A specific list of outcomes for *this specific course* is found under "Course Learner Outcomes" beginning on page 4.

Attendance: I will aspire to track daily attendance, and the following modes of learning also highlight a student's presence or absence: group work, discussion, and quizzes within the class hour. You are allowed a total of 3 absences (either un/excused) for which I do not require a note, but only an email ahead of time forewarning me of your absence (if possible). *At the third un/excused absence, I will request a meeting with you and send an email to you, your Advisor, and the Registrar alerting them of the situation.* After the fourth absence, you will be dropped (forcibly, with a "DF" or "DP," or willingly with a "W" before the ninth week) from the class. Besides the 'Participation' portion of the

grade, one makes the best case for a "+" with a history of regular attendance and interest. Late arrivals greater than 10 minutes will constitute an official absence.

Office Hours: Besides the normal class hours, my office door is open to each student (at least) three more hours each week. If these times conflict with your schedule, please seek me out to set a time that meets your needs.

Inquire (NQR): The information found within the NQR environment is an essential component to the course itself. Notes, announcements, readings, web links, and course documents will all be placed within the course NQR. Please do NOT forget to check NQR before you come to class or if you have a question about previous assignments.

Academic Integrity (AI): All freedoms imply responsibility, and your responsibility to the RC AI policy ensures your academic freedom. I want to foster a mutual respect for the classroom hours that we have together, and AI is primarily about mutual respect (because responsibility and accountability accord). In light of this, please silence cell phones, PDAs, etc. before class and come prepared (e.g., book, paper, and pencil). Classroom computers are designed for academic learning and should be used in this manner during class; i.e., no email exchanges and/or surfing during class.

Reading, reflection, and research all involve the activity of recognizing the good thinking of others. Plagiarism exists when someone takes personal credit for another's creative (usually written) work. Hacker's *A Writing Reference* gives very clear examples for citing the work of others from a broad spectrum of sources (including the internet). Please use this guide when citing work during the writing that you will complete in the course. Lastly, please be advised that the RC AI policy will be upheld within this course as detailed online at – http://roanoke.edu/A-Z_Index/Registrar/Policies_and_Information/Academic_Integrity.htm Included here is an explanation of how violations of the College's academic integrity policy are handled.

A Word about Late Work: Please note that for all assignments a total of 50% will be deducted after one week past the due date. After two weeks past the originally-assigned due date, no credit will be awarded for the assignment.

Grades: For better and for worse, you will receive a letter grade for this course. Basic letter grades (A–F) are assigned according to the following minimum scale: "A"(92–100), "A–" (91) "B+"(88–90), "B"(83–87), "B–"(80–82), "C+"(78–79), "C"(74–77), "C–"(70-73), "D"(60–69), "F"(< 60).

Observing Lab: There is a required laboratory (WED, 5.30 – 8.30p) for the course that involves telescope observing, taking data, and drawing conclusions supported by those data. The observing lab meets at the Elizabeth Campus (EC) in Hundley Hall. Please consult the NQR site for a map to Hundley at EC. However, when the weather is poor, we may meet in TREX 273. Within the laboratory component, we will explore *both* astronomical observation *and* the physical principles supporting astronomical measurements.

You *must* register for both the course and lab sections.

Collaboration: One stark distinctive of 21st century science is the degree of collaboration within the astronomical community. To gain some insight into this process, much time will be spent in group collaboration in/outside of class. We will spend some time discussing the difference between "collaboration" and "plagiarism." In short, collaboration relies on the individual strengths and contributions of each group member to produce a deeper level of understanding.

Modes of Learning

Rubric

Your grade is determined according to the following distribution.

Exams (4)	30%	Classwork/homework	12%	Public Media Journal	12%
Participation	5%	Observing Lab	17%	Written Reflections	12%
		Quizzes	12%		

Descriptions

There are several researched and proven learning methodologies that we will employ to gain a better understanding of the material and its context. Below I have listed some of them and given a brief description.

Quizzes. Weekly written and/or online quizzes are completed individually in class and graded. Quizzes are intended to be simple and direct measures of new and cumulative knowledge that you have obtained and retained. Quizzes will only consist of a few questions, usually four or less. They could relate to the reading from the assigned selections, or these questions could be taken from the multiple choice questions at the beginning of (almost) every class. Alternatively, the quiz questions could be graphical in nature.

Public Media Journal. Astronomy is discussed in all sorts of venues and contexts, including newspapers, television, popular science magazines, and artistic interpretation. At certain times, you will search for a connection point with astronomy in the public media, where you will comment on the scientific accuracy of the statements made and other questions that may be pertinent. These articles and written comments (2 paragraphs or so) will be submitted electronically and graded on merits of coherence and creativity.

(NOTE: Almost all internet material proceeds from source material, such as articles, books, magazines, etc. For the media journal, you must cite the source material as well as the website.)

Written Reflection. Besides the media journal reflections, there will also be several opportunities within the course to communicate about a particular article or story. You will have less control on choosing the article and/or reading because I want to ask specific questions from you. Answers to the questions will be written in paragraph form. Your final submission will include grammar, structure, coherence, and creativity as grading criteria.

Written Lab Reports. A portion of your laboratory grade is based on written reports that you will submit one week after completing a particular "experiment" (or observation). Some of these reports will be collaborative (group reports) and some will be individually written. The structure of a lab report is quite different than the above reflections, so we will discuss these differences during lab.

Exams. Exams (4) will cover the build-up of material through the class discussion, writing, quizzes, and laboratory investigation. These exams will contain questions of varying type: thought experiments, short essay (explanative and opinionated), and graphical interpretation. All exams will contain comprehensive material from the previous chapters, probably the *most* missed problems from the previous exam/quizzes. Make-up exams will only be allowed as a result of a discussion with me *beforehand* or an emergency note

(death, hospitalization, misdemeanor, etc.) *signed* by a governing official (medical doctor, parent, law enforcer, etc.). The final exam is scheduled for 13 DEC (WED), 2.00 – 5.00p.

Intended Learner Outcomes

Course-wide

Successful students will:

- Identify underlying foundational tenets that shape wrong (and right) models and theories.
- Examine datasets that lead to a re-creation of the scientific arguments and a re-calculation of resultssupporting both sides of the controversy.
- Analyze and interpret the personal and historical stories that shape individual science paradigms.
- Synthesize data analysis and third sources to draw conclusions about a current, unresolved contro-versy.

Successful students will have improved their skills in:

- Identifying supporting arguments based on data versus philosophical extrapolation.
- Constructing a summative paragraph for a scientific argument.
- Constructing an informed graph and calculating the slope with its proper units.
- Manipulating simple data-taking instruments for the purpose of understanding proportions of vari-ables.

Galileo and the Copernican Revolution

Successful students will:

- read original documents from the Galilean era that discuss science arguments and group them as supporting or opposing.
- observe differences between early models of the solar system and determine how these differencesincorporate observation and/or reasoning.
- verify Kepler's third law with data from Jupiter's Galilean moons
- analyze socio-religious correspondence (e.g., Galilean era) written in response to scientific observations and identify bias and/or support.

The Great Debate of 1920

Successful students will:

- manipulate original data (Shapley GC data) to construct maps of the Milky Way that show the sunis not at the MW center.
- differentiate between measurement and inference when establishing a scientific argument, which in-cludes identifying hidden or unstated assumptions.

Big Bang versus the Steady-State Models

Successful students will:

- extract meaningful spectroscopic results from mock observations.
- re-construct a plot of Hubble expansion (velocity vs. distance) and calculate the Hubble constantvalue (slope).
- read and critique personal biography (e.g., Hubble) and autobiographical correspondence (e.g., Bur-bidge) as it reveals underlying beliefs of particular scientists.
- utilize simple carts and timers to demonstrate that speed and acceleration are proportional.

Missing Mass, Dark Matter, and MoND

Successful students will:

- recognize the apparent imbalance between observational measurement and theoretical prediction.
- weigh the implications of creating and/or adding to established laws and models.
- measure and calculate the rotation speed of a spiral galaxy compared with an elliptical.

Final Research Project

Successful students will:

- organize pre-processed data into meaningful graphical representation as it relates to an unresolvedscientific argument.
- read and summarize third source material (e.g., periodical literature NOT research journal) as itrelates to current science topics.
- build a portfolio that contains both graphical representation of data as well as written argumentationin support of a side in a current controversy in astronomy.

Course Outline & Reading Guide

Please see the Outline in the following document for the exact dates of meeting for the course. The Outline also shows the daily activity and course content for our educational experience. If you have questions about scheduling, please refer to this Outline first. There is also a Reading Guide in the following documents to provide detailed information about the reading assignment for each class and the due date for assignments.

INQ250 Course Outline FALL 2017

Week	Date	Controversy	Topic	Concept(s)
	30-Aug		Introduction- What are we trying to do?	
1	1-Sep		Scope and Limitations of Science (Astronomy)	Inference
	4-Sep	How much	Cosmology, Astrology, and Maya Influence	Solar system
2	6-Sep	astronomy did	Eclipse Cycles – Solar and Lunar	eclipses
	8-Sep	the Maya know?	Mayan astronomy and Codices	Cyclic periodicity
	11-Sep		Sidereal and synodic measurements	Sidereal/Synodic
3	13-Sep	What killed the	Chicxulub Crater Impact: History	
	15-Sep	dinosaurs?	Chicxulub Crater Impact: Science	Potential/kinetic E
	18-Sep		Alternative Ideas and Theories	Dating-Radioactive
4	20-Sep		NEOs and NEAs/ Extinction Events	Gravitational Key
	22-Sep		**In-class Exam 1**	
	25-Sep	For what reasons	Greek Influence on Astronomy	Epicycle/circumf
5	27-Sep	did Galileo incur	Observations- Aristotle and Catholicism	
	29-Sep	persecution?	Copernicus & the rise of heliocentrism	
	2-Oct		Optics- Focal Length & Telescopes	Image formation
6	4-Oct		Galilean Observations as Astronomy	verification
	6-Oct		Tycho Brahe and measurement	"error" in science
	9-Oct		Kepler Jigsaw Activity	3 Kepler Laws
7	11-Oct		ps. Newton's formulation of Kepler	gravitation
	13-Oct		**In-class Exam 2**	
	16-Oct			*No lab*
	18-Oct		*No Classes - Fall Break*	*this week*
	20-Oct			
	23-Oct	Is there one	Nature of Light & Telescopes	spectral features
9	25-Oct	galaxy or many?	Types of stellar objects- diffuse nebulae	photons, e/m rad
	27-Oct		Cepheid Variables/ Globular Clusters	stellar evolution
	30-Oct		2D/3D Mapping	coordinate graph
10	1-Nov		Dust Reddening/ Absorption & Emission	correlation
	3-Nov		Radial velocities and Distance Ladder	
	6-Nov	Did the universe	ps. Hubble Expansion of the Universe	
11	8-Nov	have a	Early Models and Theories	State variables
	10-Nov	beginning?	Evidences for the Big Bang	CMBR
	13-Nov		Stellar Evolution & Nucleosynthesis	H-R Diagram
12	15-Nov		Time, Space, and the (multi-)Universe	
	17-Nov		Cosmology Revisited	
	20-Nov		**In-class Exam 3**	
13	22-Nov		No Classes – Thanksgiving Break	*No lab this week*
	24 Nov			
	27-Nov	What is the	Early Evidence of Missing Mass	Conserve Energy
14	29-Nov	nature of	Rotation Curves of Spiral Galaxies/ 21cm	Newton Gravitate
	1-Dec	Dark Matter?	Gravitational Lensing – macro- and micro-	
15	4-Dec	Curiosier and	What does it mean to alter the laws of Nature?	
	6-Dec	Curiosier	Dark Energy, Inflation, and Exotic Material	
	8-Dec		Why should We Pay for This?	Budget + spinoffs
	13-Dec	**FINAL EXAM: 2.00 – 5.00 PM**		