Quest 2: On the nature of time and being: an astrophysics-informed approach to the big questions

Primary General Education Designation: Physical Sciences

Secondary General Education Designation: International

I. Course Information

Quest 2 IDS2935/XXXX, Spring 2020
Meeting Day/Time: TBA
Location: TBA
General Education Designation: [Physical Sciences, International, WR 4000]
* A minimum grade of C is required for general education credit *

Instructor

Zachary Slepian, PhD
zslepian@ufl.edu; (352) 294-1851
Office Hours: Days TBD, Time TBD
302 Bryant Space Science Center

Course Description

What is the nature of time? What is the nature of space (and space-time)? And *where do we fit in?*

These are hard questions, and this course will not offer final answers. Rather, in this course we will acquire the tools and language to think critically about these questions. We will thoroughly investigate some of the most interesting topics in contemporary physics— the arrow of time, irreversibility, quantum mechanics, cosmology—through the lens of these big questions. Throughout, we will attack these areas via many different channels. This class should be accessible to non-physics majors—indeed, to those with minimal technical background at all—so we will focus on the concepts, exploring the key ideas with almost no math. At the same time, we will mix in ideas from philosophy, history, and art that also bear on these questions. This will make the course relevant and exciting both for those who feel a strong affinity with the arts and humanities as well as for those for whom science resonates more.

Importantly, the course will also expose what the scientific method is and how science has been shaped by broader currents in history, culture, and philosophy, and in turn, how it has shaped them. This delicate dance, of science and art, philosophy and physics, scientist and his or her time, is chock-full of thought-provoking narratives that also reveal a broader message. We will explore not only historical narratives, but also how this history has shaped our world today. We will also analyze how the same patterns can be seen playing out in contemporary society—that the delicate dance of science and art, philosophy and physics, social context and scientist, continues now.

Finally, the course will have a strongly contemporary, intercultural inflection. In particular, we will investigate three themes that anchor the course in our modern, multicultural world. First, how has technology in the present day shaped our relationship to and conception of time and space? Second, how has contemporary art from a variety of cultures responded to scientific ideas regarding time and space? And third, how do different cultures today conceptualize time and space, and how does this dialog with and complicate our scientific notions of time and space?

Required & Recommended Course Materials (to purchase/rent)

Required

There will be a few required books to be read in whole, and the rest of the readings will be in a Course Reader made up of excerpts. Below are listed the required texts to be bought in whole, and then under a separate heading the excerpts to go in the Course Reader.

In full

Dillard, A., "For the time being", New York: Vintage Press, 2000.

Lightman, A., "Einstein's Dreams", New York: Vintage Press, 2004.

Price, H. "Time's Arrow and Archimedes' Point", Oxford: Oxford University Press, 1966. (won't read all of but useful to own the full text).

In Course Reader (some are short articles, some are excerpts; most are also available online freely)

Hume, D. "An Enquiry Concerning Human Understanding," 2nd edition, ed. Eric Steinberg. Hackett Publishing Company, Indianopolis/Cambridge, 1993. (excerpt~10 pages)

Gott, JR. "Time Travel in Einstein's Universe: The Physical Possibilities of Travel through Time," Houghton-Mifflin: New York, 2001. (excerpt~1 to 2 chapters)

Brown, H. "Physical Relativity: Space-time Structure from a Dynamical Perspective," Oxford: Clarendon Press, 2005. (excerpt~1 chapter)

Weinberg, S. "Anthropic Bound on the Cosmological Constant," Physical Review Letters 59, 2607, 1987. (short article).

Peacock, J. "The Anthropic Principle in Cosmology," 1999. (short article).

Mosterin, J., "Anthropic Explanations in Cosmology," 2004. (short article).

Einstein, A., 1905, “On the electrodynamics of moving bodies” (will read excerpts only; this is a translation of the original article presenting special relativity, “Zur Elektrodynamik bewegter Körper,” in Annalen der Physik. 17:891, 1905) (short article).

Hesiod, “Theogony” (excerpts).

Nietzsche, F. “The Gay Science”, trans. Walter Kaufmann, New York: Vintage Books, 1974.

Nehamas, A. “Nietzsche: Life as Literature”, Princeton: Princeton University Press, 1985.

Wallace, D., “The Arrow of Time in Physics”, 2012, in the Blackwell Companion to the Philosophy of Time (short article).

Brown, H. and Uffink, J., “The Origins of Time Asymmetry in Thermodynamics: The Minus-First Law”, in Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics 32 (4):525-538 (also available online). (short article).

Hubble, E., “A Relation between Distance and Radial Velocity among Extra-Galactic Nebulae,” Proceedings of the National Academy of Sciences of the United States of America, vol. 15, Issue 3, pp. 168-173, 1929. (short article).

Lemaitre, G., “Un Univers homogene de masse constante et de rayon croissant rendant compte de la vitesse radiale des nebuleuses extra-galactiques,” Annales de la Societe Scientifique de Bruxelles, A47, pp. 49-59, 1927. (short article, translated).

Price, H. (2004). “Why there is still a puzzle about the low-entropy past?” In C. Hitchcock (Ed.), Contemporary Debates in the Philosophy of Science, pp. 219–239. Oxford: Blackwell. (short article).

Callender, C., "Thermodynamic Asymmetry in Time", The Stanford Encyclopedia of Philosophy (Winter 2016 Edition), Edward N. Zalta (ed.). (short article).

Chang, H. "Operationalism", The Stanford Encyclopedia of Philosophy (Fall 2009 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/fall2009/entries/operationalism/. (short article).

Bridgman, P. “The Logic of Modern Physics,” New York: MacMillan, 1927. (excerpt).

Franklin, B. “Experiments and Observations on Electricity,” St. John’s Gate: 1751. (excerpt).

Norton, John D., "The Hole Argument", The Stanford Encyclopedia of Philosophy (Spring 2019 Edition), Edward N. Zalta (ed.), https://plato.stanford.edu/archives/spr2019/entries/spacetime- holearg/ (short article).

Stachel, J. “The Hole Argument and Some Physical and Philosophical Implications,” (2014), https://link.springer.com/article/10.12942/lrr-2014-1 (short article).

For Reference

Ostlie C. and Carroll B., “An Introduction to Modern Astrophysics”, San Francisco: Pearson. Addison-Wesley, 2007.

Stanford Encyclopedia of Philosophy (online), (https://plato.stanford.edu/about.html#desc).

Ryden, B. “Introduction to Cosmology,” 2nd ed., Cambridge: Cambridge University Press, 2016.

Recommended Materials

“The Chicago Manual of Style,” 17th ed. University of Chicago Press: Chicago, 2017.
Strunk, O. and White, E.B., “The Elements of Style,” 4th ed. Boston: Allyn & Bacon, 2000.

Statement on Materials and Supplies Fees

n/a

II. Coursework & Schedule

1. List of Graded Work

Assignments are also described in detail in the appropriate week, but summarized below

Work	Description	Word Count	Points
Journal entry (week 2)	Keep a journal for the week on how you interact with time and timekeeping devices throughout the day. Journal should be roughly 2 paragraphs per day, and polished in writing style; will be graded and feedback given. Will also be circulated in a small group of peers for discussion in class.	1000	10
Class presentation (week 2)	See week 2 for detailed description.	n/a	10
Measuring distance to the moon (week 4)	See week 4 for detailed description.	n/a	10

Space-time diagram of your day (week 5)	This should use the space-time diagram techniques discussed in class and in the text by JR Gott "Time Travel in Einstein's Universe" and should show understanding of how the ST diagram changes as you change direction, stop, and change speed. It should be formally presented with appropriate labels and be a polished product ready for display. Use of color and artistry is encouraged.	n/a	10
Class debate (week 6) on Nietzsche's eternal recurrence and determinism in physics	See week 6 for further details.	n/a	15
Marked essay: on Hume and causation (week 9)	A polished, 2 page essay that concisely outlines Hume's ideas on causation and addresses the questions posed under week 7. It should be 12 point Times New Roman, single-spaced, 1 inch margins. A separate third page should include references (they do not count towards the length). Use the Chicago Style Guide and Strunk and White for guidance on clarity of writing. This essay will be handed back for revision with comments, and a revision due a week after it is handed back.	1000	7 for initial draft, 8 for revision = 15 total
Marked essay: on quantum mechanics and free will (week 12)	A polished, 2 page essay that concisely addresses the questions posed under week 9. Same requirements on formatting as previous essay, and same scoring.	1000	7 for initial draft, 8 for revision = 15 total

Marked essay: on anthropic principle (week 14)	A polished, 2 page essay that concisely addresses the questions posed under week 12. Same requirements on formatting as previous essay, and same scoring	1000	7 for initial draft, 8 for revision = 15 total
Class presentations (week 16)	These will be 15 minute (10 minute talk + 5 Q&A) individual presentations that present one of the themes of the class in a form suitable for a public outreach talk. It will require students to synthesize material as well as present their own original ideas, and create polished visual means of communicating these. Feedback will be given both by instructors and peers.	n/a	20
Class participation	Are you an active, engaged learner in class discussions? See Participation Grading Rubric for more details.	n/a	20
Midterm Exam		n/a	15
Final Exam		n/a	20

2. Weekly Course Schedule

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 1 7-9 Jan	Overview of fundamental questions for the course: What is time? What is space? Where do we stand in both? -and why they matter: causation requires notion of time; many cultures' search for meaning (will discuss examples) involves a story about the Universe's origins (cosmogony) and their place in it. -we are all subjects to the laws of physics and the passage of time: these shape what it means to be human. Overview of approach: meld science, philosophy, history, art to attack these questions. *Readings: Hume's "Enquiry Concerning Human Understanding" (excerpts), Hesiod's Theogony (excerpts)—course packet*.

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 2	How do we define time? How do we measure it? History of science-focused outline of development of human technologies for measuring time and their links to the science of their time -How do we measure time now? (atomic clocks—will seed discussion of quantum mechanics later in the term) Historical connection: importance of time to navigation, the development of mercantile systems in the Renaissance and early Enlightenment, voyages of discovery (and colonization): Galileo's ship and the moons of Jupiter -how GPS works in the modern day (will connect to later discussion of General Relativity) Experiential learning (see Assigned Work Table, week 2 as well): keep a journal of the different ways you interact with time and conceptualize time over a week (e.g. what ways to measure time are encountered? what is your subjective experience of time at different moments? how do different people you interact with conceptualize/use time?) -How has the way you think about time changed over your own life, from childhood to young adulthood? What changes do you perceive in the way society around you has considered time? Short essay (see Assigned Work Table, week 2 as well): 2 page write-up of results from journal (1,000 words) Class presentation (see Assigned Work Table, week 2 as well): 5 minute description of how one time-keeping technology you encounter works (e.g. how does your iPhone know what time it is? how does the UF clock tower? how about a sundial? atomic clock?) Short poem: Two 13 ways poem on subjective perception of time and views of and roles for time in contemporary society. *Readings: TBD on Renaissance mercantilism, TBD on Galileo's clock design (primary source planned), TBD on GPS, TBD on modern sociology of time; Wallace Stevens "Thirteen Ways of Looking at a Blackbird" to support writing a 13 ways poem on time.*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 3	Operationalism: only what can be measured is “real”-lecture outlining this movement in philosophy of science -Question this will raise: how do we define “real”? Is “scientifically measurable” exactly equivalent to “real”? -connection to Einstein’s work -link to Karl Popper’s criterion of “falsifiability” -compare and contrast with Occam’s razor as a criterion for scientific explanation Class debate: must all things that are “real” be measurable by physical means? (Randomly will assign half the class to each side and conduct, in section, Parliamentary-style debates, to develop students’ thinking, public speaking, spontaneity, and confidence) *Readings: Percy Bridgman, “The Logic of Modern Physics” (excerpts), “Operationalism” article in the Stanford Encyclopedia of Philosophy (online).*
Week 4	Einstein’s special relativity: space, time, and spacetime -where did Einstein’s idea come from? Previous experiments on speed of light (Bradley, aberration of light, Michelson-Morley) -connection to operationalism: Einstein & the trains of Bern -time in the patent office -Mach’s principle: an attempt to place the Newtonian idea of inertia on solid ground (seeding a question for further consideration in week 6) -present the theory of special relativity Experiential learning: measure distance to moon using time-delay in historical recording of astronauts during moon landing (finite speed of light is the key idea here, as it is in Einstein’s special relativity), use this plus other measurements to compute mass and orbital velocity of Moon, measure Newton’s gravitational constant G from this and compare with independent, terrestrial measurements. *Readings: Brown, “Spacetime Structure . . .”, excerpts. Readings on Mach’s principle.*
Week 5	Why is time different from space? -time travel is impossible; space travel is not. -discussion of time travel; closed timelike curves. -infinity of space and time? are both infinite? -connection of finite age of Universe to finite size of observable Universe - spacetime diagrams Experiential learning/visual presentation: make a space-time diagram of one day in your week and present it. *Readings: Gott, “Time Travel in Einstein’s Universe”, excerpts.*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 6	Einstein's Inertia and Newton's World: Reversibility 1 -further investigate the Newtonian way of thinking that Einstein began with -Idea of inertia, requirement for a reference frame to define it; Mach's principle, returning to week 4 -looking backwards in time, return to Galileo's ship (from week 1) -mechanical reversibility in Newton's laws -determinism; implications for free will? -the ultimate culmination of this: Poincare's recurrence -connection to the philosopher Nietzsche's idea of the "eternal recurrence" Class debate: if you had to live your life over, could it be any different? Could you change just one thing without changing the rest? What does Newtonian mechanics actually mean for this? *Readings: Nietzcshe, "The Gay Science," Nehamas, "Life as Literature" (excerpts).*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 7	**Enlightenment science: the solar system and the French *philosophes*** **-Discuss the work of Newton, Lagrange, Laplace, etc. on the solar system and orbital dynamics in the Newtonian framework** **-Immanuel Kant: from celestial mechanics to categorical imperative—tease out how Kant's PhD in astronomy may have influenced his later, better-known work in philosophy** **-American colonial science: Ben Franklin and friends** **-David Hume and causation: discuss importance of time in the philosopher Hume's analysis of causation** **-implications of Hume for notions of the "laws of physics"** **-Diderot and the Encyclopedia; Voltaire and his lover Mme. Chatelet** Short essay (2 pages) (see Assigned Work Table, week 7 as well): Explicate Hume's notion of causation based on primary and secondary source readings. Does Hume mean that when we say "causation" we mean nothing more than precedence in time and constant conjunction, or does he mean that "causation" as a concept cannot **ever logically** mean more than this? Experiential learning: visit UF Museum of Art and look at art from the Enlightenment period; this will support possible final projects as well as in class-discussion and debate. -listen to excerpts from music of this period. -in class demonstration of instruments and discussion of playing in this period (to be arranged with UF Music department). Short writing on thoughts on this visit and this music: what struck you? How would you characterize the art and music? What didn't you like? How is it different from music you hear today? *Readings: excerpts from Kant on the Categorical Imperative (in "Groundwork of the Metaphysics of Morals," Kant on astronomy in "Universal Natural History and Theory of the Heavens" (excerpts). Excerpts from Ben Franklin's "Experiments and Observations on Electricity."* *Review reading of Hume in light of what we have done in the course to this point. Readings on Enlightenment art, music TBD.*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 8	The Romantic Era in Science: Carnot and his Engine—Heat Death and the Death of Boltzmann -begin with Fourier (late 1700s) and the heat problem, to motivate transition from Enlightenment-era to Romantic-era science -connection of Carnot to his Napoleonic-era historical context (French engineering and artillery academies) -Carnot engine and the development of thermodynamics -from thermodynamics to statistical mechanics: Boltzmann, the H-theorem (growth of entropy), irreversibility and his suicide -connection to American science of that era: Josiah Willard Gibbs -Boltzmann brains and the past hypothesis -implications for the scientific endeavor and the connection of data to laws of nature *Readings: from Price, Brown, and Callender works on reading list (in course packet); from Stanford Encyclopedia of Philosophy.*
Week 9	**Irreversibility 2: Wave Function Collapse and the Quantum** **-basic overview of relevant principles of quantum mechanics** **-breakdown of predictability and reversibility** **-key question: what is the relationship between predictability and reversibility? -does quantum mechanics have implications for free will that run counter to Newtonian mechanics? determinism?** Short essay (2 pages) (see Assigned Work Table week 9 as well): does quantum mechanics have any implications for free will? (using readings and students' own research) *Readings: from Price and Callender works on reading list.*
Week 10	Einstein's General Relativity and the Basics of Cosmology -Mach's principle: a return to the question of inertia -experimental tests of GR (solar eclipse in 1919, Shapiro time delay in 1964) -the expanding Universe: Lemaitre's 1927 work on expanding solutions to Einstein's equations, Hubble's 1929 discovery and further developments, Einstein's "greatest blunder" -Dark energy *Readings: from Ryden "Introduction to Cosmology", original articles by Hubble, by Shapiro, readings on dark energy TBD.*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 11	**The cosmological arrow of time** **-connection of GR back to thermodynamics and statistical mechanics ideas presented in week 8** **-why does the Universe on the largest scales seem to have an arrow of time? yet gravity itself is time-reversible?** **-discussion of structure formation in the Universe** Experiential learning: use public data from the Sloan Digital Sky Survey to explore the development of clustering of galaxies in the Universe as cosmic time progresses. Brief presentation in section: Discuss one current or future scientific mission to probe structure formation in the Universe. *Readings: TBD, to support presentations in section. Wallace "The Arrow of Time in Physics."*
Week 12	**Zoom out: historical context for turn of the century (~1900s) science (GR and quantum):** **-logical positivists: Carnap and his circle, later connection to W.V.O. Quine - Bertrand Russell, Gödel, Wittgenstein** **-developments in turn of the century Vienna, Berlin, and Bern** **-Klimt, Hindemith, Kokoschka (visual art of the period)** **-Mahler (music of the period)** **-Emmy Noether (to emphasize women's contributions to physics and math) - and: discuss artistic *response* to Einstein's ideas: the "Dimensionism" movement** Experiential learning/writing, option 1: use archived exhibit on Dimensionism from Berkeley Art Museum and Pacific Film Archive (BAMPFA) to identify a piece of dimensionist art. Then identify another work by the same or a similar artist in the UF Museum of Art, or, alternatively, a contrasting piece, and write a brief essay discussing the two and how they respond to contemporary ideas of space and time. Experiential learning/writing, option 2: Listen to a piece of music from the period and discuss how it responded to contemporary ideas of space and time. (e.g. Schoenberg's 12-tone composition system and its connection to the formal logical developments being pursued in philosophy of science at that time) Experiential learning/writing, option 3: Compare and contrast an Enlightenment-period musical composition with one from the early 1900s, and then in parallel compare and contrast scientific ideas from these 2 periods. *Readings: as needed to support the essay option chosen. Instructor will provide more detailed reading suggestions for each option at the time.*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 13	Recent developments in cosmology -with the the historical context for week 11 in hand (from week 12), return to pick up our thread of "cosmology" and discuss modern-day developments in cosmology -dark energy, 72% of our Universe that remains unknown -implications of dark energy for the arrow of time -anthropic reasoning (e.g. Steven Weinberg): is this satisfying? *Reading: Weinberg, "Anthropic Bound on the Cosmological Constant," Ryden "Introduction to Cosmology," Mosterin, "On Anthropic Explanation in Cosmology" (in course packet).*
Week 14	**Is space-time real?** **-this week will pull together the Newtonian and Einsteinian concepts of space and time (and space-time) and explore what each means for the structure of reality -explore the philosophy of physics debate: substantivalism (space-time is a real substance) vs. relationalism (all physics can be captured in differences in position, time, etc. and space-time is just a convenient fiction or coordinate system) -Earman's hole argument, discuss other pieces of this in philosophy of physics literature** *Reading: Stachel review on the Hole argument, Norton's "The Hole Argument" in Stanford Encyclopedia of Philsophy.* Short essay (see Assigned Work table, week 14): discuss whether anthropic reasoning, in the context of dark energy, is a scientific form of explanation (based on material from week 13).
Week 15	**Beginnings and initial conditions** **-Does time have a beginning?** **-Does space?** **-What does modern cosmology tell us about these questions? -Cosmic Inflation as our Universe's origin story** **-scientific tests of inflation** **-theoretical problems with it, and alternative theories (e.g. ekpyrotic)** **-Big Bang theory: predictions and tests** **-Fundamental problems still facing us: inflationary multiverse, "graceful exit", anthropic reasoning—will tie in with material from week 13 on anthropic reasoning, and offer another example through which to consider anthropic reasoning -formation of regular matter ("baryons"), Charge-Parity-Time (CPT) symmetry -above will tie in with discussion of Emmy Noether's work on symmetries from week 12, and, more generally, tie the course together from the perspective of symmetries** *Readings: TBD, from Ryden and other appropriate texts on CPT, baryogenesis. etc. Particle physics and society: Case study on CERN and Large Hadron Collider interplay with community in Geneva. This connects to the work on particle physics we will discuss as part of this week.*

Week/ Date	Topic Area/Objectives/Assignments (work listed in X week is due via Canvas/in class the following week)
Week 16	**Class presentations**

III. Grading

3. Statement on Attendance and Participation

Attendance and Participation:

Class attendance is expected. Each unexcused absence will result in a 10 point reduction in the final grade. Excused absences are consistent with university policies in the undergraduate catalog (https://catalog.ufl.edu/ugrad/current/regulations/info/attendance.aspx) and require appropriate documentation.

Students who can demonstrate that they were unable to submit an assignment by the deadline due to an excused absence and who can provide appropriate documentation for the absence will be given a reasonable period of time to make up the late work.

- Attendance: will be taken daily and recorded in the Canvas gradebook. You are allowed four "personal days" for the semester, after which each absences that does not meet university criteria for "excused" will result in a two point deduction from your final grade.
- Participation: Consistent informed, thoughtful, and considerate class participation is expected and will be evaluated using the rubric below. The instructor will inform you of your participation grade to date when mid-term exams are returned, and schedule a conference if you are earning below 70% of the possible points.
- NOTE: If you have personal issues that prohibit you from joining freely in class discussion, e.g., shyness, language barriers, etc., see the instructor as soon as possible to discuss alternative modes of participation.

Participation Grading Rubric:

	High Quality	Average	Needs Improvement
Informed: Shows evidence of having done the assigned work.	6.66	4	2
Thoughtful: Shows evidence of having understood and considered issues raised.	6.66	4	2
Considerate: Takes the perspective others into account.	6.66	4	2

3a. WR Statements and Grading Rubric

- The Writing Requirement (WR) ensures students both maintain their fluency in writing and use writing as a tool to facilitate learning.

- WR Course grades have two components. To receive writing requirement credit, a student must receive a grade of C or higher and a satisfactory completion of the writing component of the course.
- ***The WR designation will be satisfied by several marked formal writing assignments throughout the term, totaling 4,000 words. We will learn from excellent examples of expository writing through the class readings, and feedback will come both through multiple drafts marked by the instructors and through peer review and editing.***

Writing Assessment Rubric

	SATISFACTORY (Y)	UNSATISFACTORY (N)
CONTENT	Papers exhibit at least some evidence of ideas that respond to the topic with complexity, critically evaluating and synthesizing sources, and provide at least an adequate discussion with basic understanding of sources.	Papers either include a central idea(s) that is unclear or off-topic or provide only minimal or inadequate discussion of ideas. Papers may also lack sufficient or appropriate sources.
ORGANIZATION AND COHERENCE	Documents and paragraphs exhibit at least some identifiable structure for topics, including a clear thesis statement but may require readers to work to follow progression of ideas.	Documents and paragraphs lack clearly identifiable organization, may lack any coherent sense of logic in associating and organizing ideas, and may also lack transitions and coherence to guide the reader.
ARGUMENT AND SUPPORT	Documents use persuasive and confident presentation of ideas, strongly supported with evidence. At the weak end of the Satisfactory range, documents may provide only generalized discussion of ideas or may provide adequate discussion but rely on weak support for arguments.	Documents make only weak generalizations, providing little or no support, as in summaries or narratives that fail to provide critical analysis.
STYLE	Documents use a writing style with word choice appropriate to the context, genre, and discipline. Sentences should display complexity and logical sentence structure. At a minimum, documents will display a less precise use of vocabulary and an uneven use of sentence structure or a writing style that occasionally veers away from word choice or tone appropriate to the context, genre, and discipline.	Documents rely on word usage that is inappropriate for the context, genre, or discipline. Sentences may be overly long or short with awkward construction. Documents may also use words incorrectly.

MECHANICS	Papers will feature correct or error-free presentation of ideas. At the weak end of the Satisfactory range, papers may contain some spelling, punctuation, or grammatical errors that remain unobtrusive so they do not muddy the paper's argument or points.	Papers contain so many mechanical or grammatical errors that they impede the reader's understanding or severely undermine the writer's credibility.

4. Grading Scale

For information on how UF assigns grade points, visit: https://catalog.ufl.edu/UGRD/academic-regulations/grades-grading-policies/

A	94 - 100% of possible points		C	74 - 76%
A-	90 - 93%		C-	70 - 73%
B+	87 - 89%		D+	67 - 69%
B	84 - 86%		D	64 - 66%
B-	80 - 83%		D-	60 - 63%
C+	77 - 79%		F	<60

IV. Quest Learning Experiences

5. Course Delivery and Engagement

Number of Seats Anticipated: ___49_____
Delivery Method: ___classroom_____

This course will engage students through a variety of learning modalities. Some of the course will be delivered as lectures using both powerpoint and a chalkboard; some will involve class discussions. There will be recorded music used in the class where appropriate (see week by week) as well as a mandatory visit to the Harn Art Museum.

6. Details of Experiential Learning Component

Experiential learning: measure distance to moon using time-delay in historical recording of astronauts during moon landing (finite speed of light is the key idea here, as it is in Einstein's special relativity), use this plus other measurements to compute mass and orbital velocity of Moon, measure Newton's gravitational constant G from this and compare with independent, terrestrial measurements.

7. Details of Self-Reflection Component

Week 2 Journal: Keep a journal for the week on how you interact with time and timekeeping devices throughout the day. Journal should be roughly 2 paragraphs per day, and polished in writing style; will be graded and feedback given. Will also be circulated in a small group of peers for discussion in class.

There is also a poem about perceptions of time (ungraded) and a space-time diagram (graded) that will provide additional opportunities for self-reflection.

8. What is the essential/pressing question your course explores?

This course explores the nature of time and space and how that has shaped and continues to shape the human condition.

III. General Education and Quest Objectives & SLOs

General Education Objectives and Learning Outcomes

This course confers General Education credit for Physics (P) with a secondary designation of International (N). It also offers fulfillment of 4,000 words towards the Writing Requirement (WR). Details of these credits are given below.

Physical Sciences (P)

Physical science courses provide instruction in the basic concepts, theories and terms of the scientific method in the context of the physical sciences. Courses focus on major scientific developments and their impacts on society, science and the environment, and the relevant processes that govern physical systems. Students will formulate empirically-testable hypotheses derived from the study of physical processes, apply logical reasoning skills through scientific criticism and argument, and apply techniques of discovery and critical thinking to evaluate outcomes of experiments.

For this course: ***this designation will be addressed by thorough discussion of a large number of concepts in science, specifically cosmology but also to include mechanics, quantum mechanics, thermodynamics, and astronomy. Experiential learning will allow students to practice the scientific method themselves, and presentations will encourage students to engage with current events in science such as the very recent discovery of dark energy and next-generation missions to map the large-scale structure of the Universe.***

International (N)

This designation is always in conjunction with another program area: International courses promote the development of students' global and intercultural awareness. Students examine the cultural, economic, geographic, historical, political, and/or social experiences and processes that characterize the contemporary world, and thereby comprehend the trends, challenges, and opportunities that affect communities around the world. Students analyze and reflect on the ways in which cultural, economic, political, and/or social systems and beliefs mediate their own and other people's understanding of an increasingly connected world.

For this course: ***students will draw on examples from intellectual history and history of science and then look for the same patterns in present-day society. In short, the shaping we will explore in historical examples—of science by society, art and philosophy and of society, art, and philosophy by science—will undergird critical analysis of these themes in the contemporary world. Students will consider modern conceptions of time, evolution in these conceptions both within their own life and over their own lifespan, and will also explore current debates in science that have broader impact on the world around them.***

Further, students will explore the response of contemporary art to scientific ideas of time and space. Through engagement with works by

-Pablo Picasso (Cubism—deconstruction of space),

-Salvador Dalí (surrealism—famous for his flowing clocks hinting at a complex, non-linear relationship with time)
-the Dimensionist movement (Joseph Cornell, Barbara Hepworth, Wassily Kandinsky, Helen Lundeberg, Man Ray, André Masson, Roberto Matta, Joan Miró, László Moholy-Nagy, Henry Moore, Isamu Noguchi, Pablo Picasso, Yves Tanguy, and Dorothea Tanning), a response to developments in Einstein's relativity,

-response to our exploration into space beyond Earth (Alexander Calder, Andy Warhol, Wassily Kandinsky, Joseph Cornell, Georgia O'Keeffe, Agnes Denes, Joan Miró, Joseph Beuys, Robert Rauschenberg)

We will develop a nuanced understanding of the interplay between art and science in the modern. This will then complicate, strengthen, and dialog with the historical examples we also investigate regarding the interplay between art and science.

Students will also explore different modern cultures understandings' of time. This will be done using films, poetry, and short stories from multiple contemporary sources. For example, we will engage with (to offer just a subset) work by, or on:

-Wallace Stevens (early 20th century; American)
-Adrienne Rich (late 20th century; American)
-Wole Soyinka (Yoruba concepts of time, e.g. in "Death and the King's Horseman"; contemporary, African)
-John Ayoade (Yoruba philosophy of time; contemporary, African)

-Native American conceptions of time and place
-Krzysztof Kieślowski (e.g. in "La Double Vie de Veronique"; Eastern European early 1990's, Iron Curtain)
-John Barth (post-modern ideas of time)
-Art of Peter Sacks—South African artist responding to the Apartheid era through layered art that shows the accumulation of personal and political history over time, and how it often conceals the past as much as reveals it

These will be integrated throughout the course.

Finally, students will do a case study of CERN, the organization in Geneva where the Large Hadron Collider resides, looking at how the thousands of scientists there interplay with the broader community around this modern-day behemoth particle physics collaboration. How do scientists change and respond to the local culture? This case study (ungraded) will help students grapple with the fact that, as they will have seen in the historical portions of the course, science never happens in a vacuum, but is in constant and complex interplay with the society around it.

Writing (WR)

This designation is always in conjunction with another program area: Written assignments that count toward the University of Florida Writing Requirement should contain extended analysis and develop original, sophisticated ideas, not merely present hastily written or cursory thoughts. UF Writing Requirement assignments should include such elements as well-crafted paragraphs, a thesis or hypothesis, a persuasive organizational structure (e.g., introduction, body, conclusion; introduction, methods, results, discussion), well-supported claims, and appropriate and effective stylistic elements.

For this course: ***The WR designation will be satisfied by several marked formal writing assignments throughout the term, totaling 4,000 words. We will learn from excellent examples of expository writing through the class readings, and feedback will come both through multiple drafts marked by the instructors and through peer review and editing.***

The Course Student Learning Objectives are:

For this course: ***Outline and investigate our conceptions of time and space through the two lenses of physics and philosophy, with additional color added by historical and cultural exploration/intellectual history.***

Gain familiarity with the scientific method and important distinct philosophical strands on what science is (e.g. Karl Popper, Thomas Kuhn).

Investigate science as an endeavor intimately linked with the intellectual, artistic, political, and economic culture of the time in which it occurs, with the particular goal of identifying patterns in the historical development of science that help us understand the interplay of science, culture, and society in the contemporary world through focused case studies.

At the end of this course, students will be expected to have achieved the following learning outcomes in content, communication and critical thinking:

- Content: Students demonstrate competence in the terminology, concepts, theories and methodologies used within the discipline.
  For this course: ***Articulate a strong understanding of different ways of conceptualizing time and space, contextualizing them both scientifically and historically.***
  Achievement of this learning outcome will be assessed through in-class participation, written work throughout the class including an extended essay and extended personal reflection/narrative, and a final presentation.

- **Communication:** *Students communicate knowledge, ideas and reasoning clearly and effectively in written and oral forms appropriate to the discipline.*
  For this course: ***Articulate a strong understanding of how the scientific method works and synthesize different strands in philosophy of science into a working understanding of the scientific endeavor. They will be able to back this up with specific examples from history of science.***
  Achievement of this learning outcome will be assessed through in-class participation, written work throughout the class including an extended essay and extended personal reflection/narrative, and a final presentation.

- Critical Thinking: Students analyze information carefully and logically from multiple perspectives, using discipline-specific methods, and develop reasoned solutions to problems.
  <u>For this course:</u> Students will gain a nuanced yet clear understanding of science as an endeavor embedded in a larger context, and present that understanding via writing, visualization, reasoned debate with their peers, and polished, accessible public talks (see Final Project).
  Achievement of this learning outcome will be assessed through in-class participation, written work throughout the class including an extended essay and extended personal reflection/narrative, and a final presentation.

Quest 2 Program Goal

Grounded in the modes of inquiry and analysis characteristic of the social and/or biophysical sciences, Quest 2 courses invite students to address pressing questions facing human society and the planet—questions that outstrip the boundaries of any one discipline and that represent the kind of open-ended, complex issues they will face as critical, creative, and thoughtful adults navigating a complex and interconnected world.

Quest 2 Course Objectives

Address in relevant ways the history, key themes, principles, terminologies, theories, or methodologies of the various social or biophysical science disciplines that enable us to address pressing questions and challenges about human society and/or the state of our planet.

Present different social and/or biophysical science methods and theories, and consider how their biases and influences shape pressing questions about the human condition and/or the state of our planet.
Enable students to analyze and evaluate (in writing and other forms of communication appropriate to the social and/or biophysical sciences) qualitative or quantitative data relevant to pressing questions concerning human society and/or the state of our planet.
Analyze critically the role social and/or the biophysical sciences play in the lives of individuals and societies and the role they might play in students' undergraduate degree programs.

Explore or directly reference social and/or biophysical science resources outside the classroom and explain how engagement with those resources complements classroom work.

Quest 2 Student Learning Outcomes (SLOs)

▪ **At the conclusion of the Quest 2 course, students will be able to...**
o Identify, describe, and explain the cross-disciplinary dimensions of a pressing societal issue or challenge as represented by the social sciences and/or biophysical sciences incorporated into the course. (Content)

• ***<u>For this course:</u> Our grappling with modern scientific ideas of time and space shapes every aspect of our culture and society. At the end of this course, students will have the content knowledge both of what physics and cosmology tell us about space and time, and how historically this developed and how that shapes the modern. Critically, students will also have explored modern-day conceptions of space and time across different art forms and cultures.***

o Critically analyze quantitative or qualitative data appropriate for informing an approach, policy, or praxis that addresses some dimension of an important societal issue or challenge. (Critical Thinking)

- ***<u>For this course:</u> The several marked essays, class debates, and vigorous discussion throughout will develop the skill of thinking critically about the way time and space shape our worldview. There will also be several experiential learning activities giving hands-on, quantitative analysis opportunities, such as measuring the distance to the Moon and the Newtonian gravitational constant G using time delay in recordings from the lunar landing, to analyzing modern-day data on the clustering of galaxies from the Sloan Digital Sky Survey.***
- ***Develop and present, in terms accessible to an educated public, clear and effective responses to proposed approaches, policies, or practices that address important societal issues or challenges (Communication).***
- ***The in-class debates and final, public-outreach presentation will help students practice this skill. See week-by-week and assignments for further details on these. Furthermore, students' work analyzing an upcoming mission to map the Universe's large-scale structure will further help them grapple with how an educated public responds to scientific progress.***
- ***Connect course content with critical reflection on their intellectual, personal, and professional development at UF and beyond (Connection).***

• Course activities such as journaling, poetry, and the final presentation will offer fora for reflection on how the course material is relevant for the students' own lives. For instance, students' work on how their own conception of time has evolved, as well as how society's has evolved over their lifetimes, will provide an ideal opportunity for critical reflection on intellectual and personal development. The strongly multi-disciplinary nature of the course will also tie in to many other educational experiences students will have or have had at UF, such as visits to the UF Art Museum, the UF Music Department (see week-by-week for further detail) as well as other courses in history, writing, philosophy, and art the students may have taken or take at UF.

IV. Required Policies

11. Students Requiring Accommodation

Students with disabilities requesting accommodations should first register with the Disability Resource Center (352-392-8565, https://disability.ufl.edu/) by providing appropriate documentation. Once registered, students will receive an accommodation letter which must be presented to the instructor when requesting accommodation. Students with disabilities should follow this procedure as early as possible in the semester.

12. UF Evaluations Process

Students are expected to provide professional and respectful feedback on the quality of instruction in this course by completing course evaluations online via GatorEvals. Guidance on how to give feedback in a professional and respectful manner is available at https://gatorevals.aa.ufl.edu/students/. Students will be notified when the evaluation period opens, and can complete evaluations through the email they receive from GatorEvals, in their Canvas course menu under GatorEvals, or via https://ufl.bluera.com/ufl/. Summaries of course evaluation results are available to students at https://gatorevals.aa.ufl.edu/public-results/.

13. University Honesty Policy

UF students are bound by The Honor Pledge which states, “We, the members of the University of Florida community, pledge to hold ourselves and our peers to the highest standards of honor and integrity by abiding by the Honor Code. On all work submitted for credit by students at the University of Florida, the following pledge is either required or implied: “On my honor, I have neither given nor received unauthorized aid in doing this assignment.” The Honor Code (https://www.dso.ufl.edu/sccr/process/student-conduct-honor-code/) specifies a number of behaviors that are in violation of this code and the possible sanctions. Furthermore, you are obligated to report any condition that facilitates academic misconduct to appropriate personnel. If you have any questions or concerns, please consult with the instructor or TAs in this class.

14. Counseling and Wellness Center

Contact information for the Counseling and Wellness Center: http://www.counseling.ufl.edu/cwc/Default.aspx, 392-1575; and the University Police Department: 392-1111 or 9-1-1 for emergencies.

15. The Writing Studio

The writing studio is committed to helping University of Florida students meet their academic and professional goals by becoming better writers. Visit the writing studio online at http://writing.ufl.edu/writing-studio/ or in 2215 Turlington Hall for one-on-one consultations and workshops.