

HPS 1612: Philosophy of 20th Century Physics

Spring 2023

Instructor: Dr. Siddharth Muthukrishnan (you can call me 'Siddharth')

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Time: Mon & Wed 4.30 pm -5.45 pm

Location: 130 Cathedral of Learning

Office hours: Times: TBA. Location: Cathy 10th floor, Grunbaum library. I very much welcome dropping into my office hours whenever you'd like, even if you don't have any specific questions, or you have questions that are only tangentially related to the course material, or you would like to simply chat. If you cannot make the regularly scheduled times, email me and we can work out a separate meeting time.

Course Description:

The first few decades of the 20th century witnessed the birth of two of the most strikingly beautiful and deeply counterintuitive theories in the history of science: relativity and quantum mechanics. Despite their immense success, there remain thorny questions about what these theories tell us about what the world is like and our place in the world. There also remain important conceptual questions about how best to formulate and understand these theories. In this course, we will consider metaphysical, epistemological, and conceptual questions that arise from relativity and quantum mechanics. These include questions about the nature of space and time, the relation between matter and spacetime, the quantum measurement problem, 'interpretations' of quantum mechanics, and quantum non-locality. If time permits, we will briefly touch upon some questions in the general theory of relativity and in quantum field theory. We will find that the tools of philosophy are useful in analyzing these issues emerging from physics.

Expectations

You are expected to make the most of this opportunity by coming to class ready to engage with each other in an informed discussion of the material assigned. This means you should have read the assigned material at least once in advance of each class meeting.

Please be courteous, cooperative, and supportive of each other at all times.

Evaluation:

Participation and Reading comments (15%)

As a member of this course, you are expected to attend class regularly and actively engage in discussion. You should also have read the assigned course material. Every week, everyone is expected to send one or two short sentences with some comment on the readings for that week. This could be a question or comment or request for clarification about anything in the readings for that week.

Two short papers (15% each = 30% total)

These short papers will be roughly 500 words each. They will be short and sharp answers to a specific question.

Two longer papers (25% + 30% each = 55% total).

You will be asked to write two papers. Each paper will be roughly 1500 words. The first paper will be due in the middle of semester (say around Week 8), and second at the end of the semester.

These papers will also be answers to specific questions, but you are expected to go into a bit more depth in these papers.

Writing philosophy papers is hard! We will spend time in class going through how this should be done and I'm always here to help. But please start working early: It always takes more time that you think.

Recommended Texts:

David Wallace, *Philosophy of Physics: A Very Short Introduction* (Oxford University Press, 2021).

Tim Maudlin, *Philosophy of Physics: Space and Time* (Princeton University Press, 2015).

Tim Maudlin, *Philosophy of Physics: Quantum Theory* (Princeton University Press, 2019).

Sean Carroll, *Something Deeply Hidden* (Dutton, 2019).

It might be useful to purchase these books but not required. I'll try to make sure that all the readings are available for you to download from Canvas. If I forget to do so, please feel free to email me and remind me.

Additional articles and book chapters will be assigned, and supplied via Canvas.

Schedule

The list of readings and questions is somewhat tentative. Also I'm always open to suggestions, so if you have any topics or works that you would particularly like to see covered, please let me know and I'll see if I can include them.

Week 1 Introduction: What is Philosophy of Physics?

Readings:

David Wallace, *Very Short Introduction*, Introduction & Chap. 1.

Carlo Rovelli, Physics Needs Philosophy / Philosophy Needs Physics, Scientific American, 2018.
(<https://blogs.scientificamerican.com/observations/physics-needs-philosophy-philosophy-needs-physics/>)

Week 2 Newton on Space and Time

Isaac Newton, *Philosophiae Naturalis Principia Mathematica* (1687), "Scholium to Definition VIII".
(Motte translation, available here: <https://plato.stanford.edu/entries/newton-stm/scholium.html>)

Tim Maudlin, *Philosophy of Physics: Space and Time*, Chap. 1.

Week 3 Leibniz's Arguments and Galilean Spacetime

James Weatherall, *Void*, Chap. 1: The Plenum and the Void.

Shamik Dasgupta, Substantivalism vs Relationalism About Space in Classical Physics, *Philosophy Compass*. (2015), Secs. 3-6.

Week 4 Special Relativity I

Tim Maudlin, *Philosophy of Physics: Space and Time*, Chap. 4.

David Wallace, *Very Short Introduction*, Chap 3.

(First short paper due.)

Week 5 Special Relativity II

Tim Maudlin, *Philosophy of Physics: Space and Time*, Chap. 5.

Harvey R. Brown and James Read, *The dynamical approach to spacetime theories*, Secs. 1-3.

Week 6 General Relativity

Richard Feynman, *Feynman Lectures on Physics Vol. II*, Chap. 42 Curved Space.
(https://www.feynmanlectures.caltech.edu/II_42.html)

James Weatherall, *Void*, Chap. 2: Waves of Space Itself.

Week 7 Spacetime Wrap-Up

No reading. Time to review what we have covered. Go over open questions. Expand on themes.

Week 8 Intro to Quantum Mechanics

Tim Maudlin, *Philosophy of Physics: Space and Time*, Chap. 1.

David Albert, *Quantum Mechanics and Experience*, Chap. 1

(First Long Paper Due.)

Week 9 Measurement Problem

David Wallace, *Very Short Introduction*, Chap 5: Mysteries of the Quantum.

John Bell, Against Measurement, *Physics World* (1990).

Week 10 “Interpreting” Quantum Mechanics

David Wallace, *Very Short Introduction*, Chap 6: Mysteries of the Quantum.

Chris Fuchs and Asher Peres, Quantum Theory Needs No ‘Interpretation’. *Physics Today* (2000)

Week 11 Many Worlds

Sean Carroll, *Something Deeply Hidden*, Chaps. 2 & 6: The Courageous Formulation & Splitting the Universe.

David Wallace, *The Emergent Multiverse*, Chap. 2: The Emergence of Multiplicity.

(Second short paper due.)

Week 12 Quantum Nonlocality

Einstein, B. Podolsky and N. Rosen, "Can Quantum-Mechanical Description of Reality be Considered Complete?", *Physical Review* 47 (1935).

David Albert and Rivka Galchen, A Quantum Threat, *Scientific American* (2009).

Week 13 Particles and Fields

Sean Carroll, Lecture on Fields, *The Biggest Ideas in the Universe*
[https://www.youtube.com/watch?v=Dy1LNk_B6IE].

Sean Carroll, *The Particle at the End of the Universe*. Chapter 7: Particles in the Waves.

Week 14 Wrap up

Optional topics if time permits: Probability; Other Interpretations of Quantum Mechanics; Quantum information; Black Holes; Quantum Gravity;

(Final long paper due.)

POLICIES:

Disability resources and services:

If you have a disability for which you are or may be requesting an accommodation, you are encouraged to contact both your instructor and Disability Resources and Services, 140 William Pitt Union, 412-648-7890 as early as possible in the term. Disability Resources and Services will verify your disability and determine reasonable accommodations for this course. For more information, visit <https://www.studentaffairs.pitt.edu/drs/Links to an external site.> .

Academic integrity and plagiarism:

Cheating/plagiarism will not be tolerated. Students suspected of violating the University of Pittsburgh Policy on Academic Integrity will be required to participate in the outlined procedural process as initiated by the instructor. A minimum sanction of a zero score for the quiz, exam or paper will be imposed. For the full Academic Integrity policy, go to: www.as.pitt.edu/faculty/policy/integrity.htmlLinks to an external site..

Violation of the Academic Integrity Code requires the instructor to submit an Academic Integrity Violation Report to the Dean's Office.

Classroom recording policy:

To ensure the free and open discussion of ideas, students may not record classroom lectures, discussion and/or activities without the advance written permission of the instructor, and any such recording properly approved in advance can be used solely for the student's own private use.

Copyright Notice

Course materials may be protected by copyright. United States copyright law, 17 USC section 101, et seq., in addition to University policy and procedures, prohibit unauthorized duplication or retransmission of course materials. See [Library of Congress Copyright Office \(Links to an external site.\)](#) and the [University Copyright Policy \(Links to an external site.\)](#).

E-mail policy:

Each student is issued a University e-mail address (username@pitt.edu) upon admittance. This e-mail address may be used by the University for official communication with students. Students are expected to read e-mail sent to this account on a regular basis. Failure to read and react to University communications in a timely manner does not absolve the student from knowing and complying with the content of the communications. The University provides an e-mail forwarding service that allows students to read their e-mail via other service providers (e.g., Hotmail, AOL, Yahoo). Students that choose to forward their e-mail from their pitt.edu address to another address do so at their own risk. If e-mail is lost as a result of forwarding, it does not absolve the student from responding to official communications sent to their University e-mail address.

Cell phone and laptop policy:

All cell phones and other electronic communication devices are to be turned to the off setting during class. Laptops are not allowed unless you get permission from me prior to the class. If you do use a laptop, they are strictly for note-taking purposes only.

Non-discrimination policy:

As an educational institution and as an employer, Pitt values equality of opportunity, human dignity, and racial/ethnic and cultural diversity. Accordingly, the University prohibits and will not engage in discrimination or harassment on the basis of race, color, religion, national origin, ancestry, sex, age, marital status, familial status, sexual orientation, gender identity and expression, genetic information,

disability, or status as a veteran. For more information, visit <http://cfo.pitt.edu/policies/documents/policy07-01-03web.pdf>[Links to an external site.](#)

Gender-Inclusive language guidelines:

Aspiring to create a learning environment in which people of all identities are encouraged to contribute their perspectives to academic discourse, the University of Pittsburgh Gender, Sexuality, and Women's Studies Program provides guidelines and resources regarding gender-inclusive/non-sexist language (gsws.pitt.edu/node/1432). Following these guidelines fosters an inclusive and welcoming environment, strengthens academic writing, enriches discussion, and reflects best professional practices.

Language is gender-inclusive and non-sexist when we use words that affirm and respect how people describe, express, and experience their gender. Gender-inclusive/non-sexist language acknowledges people of any gender (e.g. first-year student versus freshman, chair versus chairman, humankind versus mankind). It also affirms non-binary gender identifications, and recognizes the difference between biological sex and gender expression. Students may share their preferred pronouns and names, and these gender identities and gender expressions should be honored.

These guidelines fulfill the best intentions of the University of Pittsburgh's Non-Discrimination Policy: <https://www.cfo.pitt.edu/policies/policy/07/07-01-03.html>[Links to an external site.](#)

Sexual misconduct, required reporting, and Title IX:

The University is committed to combatting sexual misconduct. As a result, you should know that University faculty and staff members are required to report any instances of sexual misconduct, including harassment and sexual violence, to the University's Title IX office so that the victim may be provided appropriate resources and support options. What this means is that as your professor, I am required to report any incidents of sexual misconduct that are directly reported to me, or of which I am somehow made aware.

There are two important exceptions to this requirement about which you should be aware:

A list of the designated University employees who, as counselors and medical professionals, do not have this reporting responsibility and can maintain confidentiality, can be found here: <http://www.titleix.pitt.edu/report/confidentiality>[Links to an external site.](#)

An important exception to the reporting requirement exists for academic work. Disclosures about sexual misconduct that are shared as part of an academic project, classroom discussion, or course assignment, are not required to be disclosed to the University's Title IX office.

If you are the victim of sexual misconduct, Pitt encourages you to reach out to these resources:

* Title IX Office: 412-648-7860

* SHARE @ the University Counseling Center: 412-648-7930 (8:30 A.M. TO 5 P.M. M-F) and 412-648-7856 (AFTER BUSINESS HOURS)

If you have a safety concern, please contact the University of Pittsburgh Police, 412-624-2121. Other reporting information is available here: <http://www.titleix.pitt.edu/report-0>Links to an external site.