PHIL 146: Philosophy of Physics

Topic: Arrows of Time

Fall 2019. UCSD

Syllabus

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1 Course Description

This course will provide an introduction to topics in the philosophy of physics. Our focus will be on the problems of the arrows of time.

2 Course Information

- Meeting time: Tuesday & Thursday 9:30 - 10:50 am. First class on Thur Sept 26.
- Class location: Sequoyah Hall Room 148
- Office hours: Tuesday at 11:00am - 12:00pm, Thursday at 11:00am - 12:00pm. Other times by appointment.
- Prerequisites: no formal requirements. But a solid high-school physics background would be recommended. A college-level physics background would definitely be sufficient.
- Required texts:

  David Albert, *Time and Chance* (Harvard University Press, 2000; any version is fine).

  Sean Carroll, *From Eternity to Here: The Quest for the Ultimate Theory of Time* (Dutton, 2010; any version is fine).

3 Philosophy of Physics

Why study philosophy of physics? Well, Phil Physics is one of the most exciting areas of philosophy; it brings together philosophy and physics, and it intersects many domains, such as philosophy of science, metaphysics, epistemology, logic, and philosophy of language! If you wonder about the following questions, then this course is for you!

- What is the nature of space and time? What is the meaning of relativity?
- How to make sense of quantum mechanics?
- What is a physical field? What are particles?
- What is the meaning of probability in physical theories?
- What kind of things are laws of nature (such as Newton's laws and the Schrörindger equation)? What are symmetries and invariances?
- Why is mathematics so effective at describing the physical world, from medium-sized dry goods to fundamental physical theories?
- How does physics relate to the rest of the sciences such as biology and psychology?
- What is the place of the mind and of the consciousness in a physical world?

We won't be able to address all of these questions. We will focus on some questions having to do with the asymmetries in time or arrows of time:

- Why, and in what ways, is time different from space?
- Why is time asymmetric between the past and the future? And what does the asymmetry tell us about the nature of time?
- Why do we have memories of the past and no memories or records of the future?
- Why do we have abilities to influence the future but no longer the past?
- Why do things seem to move in one direction of time, such as the melting of ice, the mixing of cream in coffee, and the dispersion of gas?
- What is the explanation for the Second Law of Thermodynamics? And what is its relation to cosmology, the study of the entire universe?

Traditionally, these questions belong to a subfield in philosophy of physics called the philosophical foundations of statistical mechanics and thermodynamics. Since many of the philosophical issues can be appreciated without advanced background in mathematics or physics, I will not assume familiarity with advanced mathematical physics. But if you know some math and physics, that will certainly help. We have planned multiple Math/Physics Interludes where we will break things down so that everyone can be on the same page for the philosophical discussions. To understand the problems of the arrows of time and the various solutions, we will start with the most familiar cases found in Newton's laws. :-)

4 About Me

I am an assistant professor in the department of philosophy at UCSD. I am also a fellow of the newly established John Bell Institute for the Foundations of Physics. I did my graduate studies at Rutgers University, NJ, where I received a PhD in philosophy, a master in mathematical physics, and a graduate certificate in cognitive science. My research interests include: philosophy of physics, philosophy of science, philosophy of mathematics, metaphysics, and decision theory. I am also interested in philosophy of mind, philosophy of religion, and Chinese philosophy.

In philosophy of physics, I have done research on the foundations of quantum mechanics and statistical mechanics. I have published papers about the meaning of the quantum wave function, the fundamentality of physical space, the nature of density matrices, and a simple choice of the initial state of the universe. You can find out more about me on my website: www.eddykemingchen.net.

5 Learning Goals

Our main goal is to gain an understanding and appreciation of the philosophical issues about the directions of time and more generally the philosophical issues in the foundations of physics.

6 Work and Grading

- Grade assignment: $100 \geq A \geq 92 \geq A- \geq 88 \geq B+ \geq 85 \geq B \geq 82 \geq B- \geq 78 \geq C+ \geq 75 \geq C \geq 72 \geq C- \geq 68 \geq D \geq 59 \geq F \geq 0$.

- Problem sets: 30%

  There will be weekly problem sets consisting of multiple-choice questions and short essay questions.

- In-class quizzes: 8%

  At the beginning of each class, there will be a short quiz about the readings for the class. I will also use this to mark attendance. Please do not miss classes. If you miss more than two classes, please come and see me.

- Participation: 2%

  I expect lively discussions. However, if you are usually quiet in class, you can choose to email me your thoughts or reflections before or after class. If you have any questions, please feel free to ask in class and during office hours.

- Take-home test: 10%

  The take-home test will take place around the third week or the fourth week. It will include no more than six questions about the reading and lecture materials covered before.

- Mid-term exam: 20%

  The midterm exam will help with memory consolidation and provide feedback to the instructor.

- Final exam: 30%

  The final exam will take place on December 12th.

- Extra credit presentations: 5%

  I think the best way for one to truly understand something is to teach it to others. There will be many options (15 minutes in each class) for you to do in-class oral presentations, such as a summary and a critique of the readings. However, you will be required to prepare powerpoints slides and/or paper handouts. You are very encouraged to talk with me if you would like to present on any topic you find interesting. You will be rewarded a minimum of 1 and a maximum of 5 extra points towards your final grade.

- Since this is an upper-level class, please feel free to visit my office hours to discuss your questions about the class materials. If you cannot come to my regular office hours, I am happy to make appointments with you to accommodate your schedule.

- Please do not be late. Please do not text or call on your phone, or surf the internet (Twitter, Facebook, Instagram) during class. A maximum of 10 points can be deducted from your final grade.

7 Accessibility

I would like to make sure that everyone in the class feels safe and respected. If you have any particular need, please contact the UCSD Office for Students with Disabilities at the beginning of the semester. They will forward the necessary information to me. We can work out the details in person.

From the website of the UCSD Office for Students with Disabilities:

The Office for Students with Disabilities (OSD) at UC San Diego works with undergraduate, graduate, and professional school students with documented disabilities, reviewing documentation and, through an interactive process with the student, determining reasonable accommodations. Disabilities can occur in the following areas: psychological, psychiatric, learning, attention, chronic health, physical, vision, hearing, and acquired brain injuries, and may occur at any time during a student's college career. We encourage you to contact the OSD as soon as you become aware of a condition that is disabling so that we can work with you. Students registered with the OSD have the same responsibilities as other students: getting to class regularly, meeting with faculty and peers to study and learn, and finally demonstrating understanding and mastery of course content. OSD helps students with disabilities navigate that system by establishing a set of academic accommodations based on each student's individual disability. In order to receive support, students must schedule an appointment with the

OSD to discuss obtaining reasonable accommodations based on their current, functional limitations, particularly as they pertain to a higher education academic setting.

8 Course Plan

There will be a reading quiz at the beginning of each class starting on Week 2. "[PDF]" just means the reading is uploaded as a PDF document and is available for download on the course Canvas website.

- **Week 0. Introduction.**

  September 26. What is the problem of the direction of time? What is philosophy of physics?

  Assignments:

  - *From Eternity to Here.* Prologue.
  - Reichenbach, *The Direction of Time.* Chapter 1 "The Emotive Significance of Time" [PDF]
  - (Optional; overview of the topic) North, "Time in Thermodynamics" [PDF]

- **Week 1. Arrows of Time; Newton's Laws.**

  October 1. Qualitative Properties of Time; Macroscopic Arrow of Time

  - *From Eternity to Here.* Chapter 1 and Chapter 2 (up until page 32).
  - Reichenbach, *The Direction of Time.* Chapter 2 "The Qualitative Properties of Time" [PDF]
  - Horwich"Asymmetries" [PDF]

  October 3. Newton's Laws

  - *Time and Chance.* Chapter 1.
  - (Optional) Feynman, *The Character of Physical Law*, Chapter 1 "The Law of Gravitation, an Example of Physical Law" [PDF]

Problem set #1 due at 5:00pm Friday, October 4.

- **Week 2. Time Reversal Invariance; Determinism and Indeterminism.**

  October 8. Time Reversal Invariance.

  - *Time and Chance.* Chapter 1.
  - *From Eternity to Here.* Chapter 7, up to p.134 (the rest of the chapter is option).
  - (Optional) Feynman, *The Character of Physical Law*, Chapter 5 "The Distinction of Past and Future" [PDF]

  October 10. Indeterminism.

- (Optional) Arntzenius, "Indeterminism and the Direction of Time" [PDF]

Problem set #2 due at 5:00pm Friday, October 11.

- **Week 3. Thermodynamic Arrow of Time**

  October 15. Thermodynamics.

  - *Time and Chance.* Chapter 2.

  October 17. Thermodynamic Arrow of Time.

  - *Time and Chance.* Chapter 2.

  Problem set #3 due at 5:00pm Friday, October 18.

- **Week 4. Statistical Mechanics**

  October 22. Statistical Mechanics.

  - *Time and Chance.* Chapter 3.
  - *From Eternity to Here.* Chapter 8

  October 24. Statistical Mechanics, continued.

  - Goldstein, "Boltzmann's Approach to Statistical Mechanics" [PDF]

  Problem set #4 due at 5:00pm Friday, October 25.

- **Week 5. Statistical Mechanics**

  October 29. Statistical Mechanics. The meaning of probability.

  - Sklar, *Physics and Chance*, Chapter 3, "Probability" [PDF]
  - (Optional) North, "An Empirical Approach to Symmetry and Probability" [PDF]

  October 31. Mid-term exam.

- **Week 6. Reversibility, Recurrence, and the Past Hypothesis**

  November 5. Reversibility objection, and Poincaré recurrence.

  - *Time and Chance.* Chapter 4.
  - *From Eternity to Here.* Chapter 10.

  November 7. The Past Hypothesis.

  - *Time and Chance.* Chapter 4.
  - *From Eternity to Here.* Chapter 10.

  Problem set #5 due at 5:00pm Friday, November 8.

- **Week 7. Knowledge and Intervention**

  November 12. The Asymmetries of Knowledge and Intervention.

  - *Time and Chance.* Chapter 6.

  November 14. The Asymmetries of Knowledge and Intervention, continued.

  - *Time and Chance.* Chapter 6.
  - (Optional) Fernandes, "Time, Flies, and Why We Can't Control the Past" [PDF]

Problem set #6 due at 5:00pm Friday, November 15.

- **Week 8. The Mentaculus; Self-location in a large universe**

  November 19. The Mentaculus Vision.

  - Loewer, "The Mentaculus Vision." [PDF]

  November 21. Boltzmann Brains and self-locating probabilities.

  - Chen, "Time's Arrow and Self-Locating Probabilities" [PDF]
  - (Optional) Lewis, "Attitudes De Dicto and De Se" [PDF]
  - (Optional) Perry, "The Problem of the Essential Indexical" [PDF]

Problem set #7 due at 5:00pm Friday, November 22.

- **Week 9. Questions about the Past Hypothesis**

  November 26. Questions about the Past Hypothesis

  - Earman, "'The Past Hypothesis': Not Even False" [PDF]

  November 28. Thanksgiving break!

- **Week 10. Time's Arrow in a Quantum Universe; some speculative cosmologies**

  December 3. Guest lecture on black hole thermodynamics by Professor Craig Callender

  - Readings TBD

  December 5. Quantum statistical mechanics.

  - *Time and Chance.* Chapter 7.
  - (Optional) Chen, "Quantum Mechanics in a Time-Asymmetric Universe: On the Nature of the Initial Quantum State" [PDF] and "Time's Arrow in a Quantum Universe: On the Status of Statistical Mechanical Probabilities" [PDF]

Problem set #8 due at 5:00pm Friday, December 6.

- **Week 11.**

  December 10. No class.

  December 12. Final exam.