



PHIL 146: Philosophy of Physics Topic: Arrows of Time

- Instructor: Prof. Eddy Keming Chen
- Lecture 1. September 26, 2019

Welcome to this course!

Outline of today's class:

- Introduction
- Overview of the topics
- Syllabus

About me

- Prof. Eddy Keming Chen
- Please feel free to call me Eddy or Prof. Chen, whatever you feel comfortable.
- Assistant professor in philosophy, faculty member at UCSD (also affiliated with Eleanor Roosevelt College)
- PhD in philosophy, Msc in mathematics, graduate certificate in cognitive science, all from Rutgers University, New Brunswick, NJ in 2019.
- My first quarter at UCSD.

About me

- I'm also a fellow at the John Bell Institute for the Foundations of Physics.
- Main areas of research: philosophy of physics, philosophy of science, metaphysics.
- In philosophy of physics: research on the foundations of quantum mechanics and statistical mechanics.
- Also work on: decision theory, philosophy of mathematics, Chinese philosophy, philosophy of mind, and philosophy of religion.
- My website: www.eddykemingchen.net

Please tell us something about yourself

1. Your name, college, year, major / minor
2. Favorite food
3. Why you want to take this class



About this course

- This course will provide an introduction to several topics in philosophy of physics.
- Focus of this course: the arrows of time

Time

- What do we know about time?
- How would you define time?
- How is time different from space?

Arrows of Time

- One of the most striking and mysterious features of time is that it has a direction.
- “The most mysterious thing about time is that it has a direction: the past is different from the future. That’s the arrow of time—unlike directions in space, all of which are created pretty much equal, the universe indisputably has a preferred orientation in time.”
- “The reason why time has a direction is because the universe is full of irreversible processes—things that happen in one direction of time, but never the other. You can turn an egg into an omelet, as the classic example goes, but you can’t turn an omelet into an egg. Milk disperses into coffee; fuels undergo combustion and turn into exhaust; people are born, grow older, and die. Everywhere in Nature we find sequences of events where one kind of event always happens before, and another kind after; together, they define the arrow of time.” (Carroll, *From Eternity to Here*, p.2)

Arrows of Time

- The direction of time shows up in our experiences as certain arrows or asymmetries of time
 - Asymmetries of knowledge: memory and records of the past and not of the future
 - Asymmetries of influence: ability to influence the future but no longer the past
 - Asymmetries in physical process: physical processes seem to go in one direction---the past is more orderly and the future is more chaotic
 - Second law of thermodynamics: isolated systems do no decrease in **entropy**

Arrows of Time

- What explains such arrows of time?
- Can we explain it with fundamental physics?
- Fundamental equations such as $F=ma$ is symmetric in time. It does not explain the wide-spread asymmetries.
- Very much an open question.
- In this course, we will try to understand this question more precisely. And we will look at some suggested and promising solutions.

What is philosophy of physics?

- You might rightly wonder: isn't the question part of physics? Why are we studying it in a course about the philosophy of physics?
- Great questions!
- In the cutting-edge research fields, many questions do not have determinate boundaries. Philosophy of physics, foundations of physics, and theoretical physics sometimes overlap significantly.

What is philosophy of physics?

- But what is philosophy of physics?
- We don't attempt to give a precise definition.
- But something like: a systematic, critical, and rigorous attempt to understand the foundational issues in physics. We study questions such as:
 - What is the nature of space and time?
 - What is the meaning of quantum mechanics?
 - What are fields and particles?
 - How to interpret probability and chance in physics?
 - What are laws of nature? And symmetries?
 - Why is mathematics so effective in describing the physical world?
 - Can everything be explained by physics?

What is philosophy of physics?

- Knowledge about physics and mathematics can be tremendously helpful to those questions.
- But for every one of these questions, it is difficult to make progress without certain philosophical training or sophistication.
- “Often the process of reformulating the question and giving the answer is the same process. Looking for answers, we discover new meanings and find out what it was that we were asking for.”
- “This is the scientific approach. Do not expect answers before you have found clear meanings. But do not throw away unclear questions. Keep them on file until you have the means at the same time to clarify and to answer them. Often these means result from developments in other fields, which at first sight appear to have nothing to do with the question.”
(Reichenbach, *The Direction of Time*, p.3)

What is philosophy of physics?

- Therefore, in our course, let's try to:
 - Set aside our preconceived notions about space and time
 - Be open minded
 - Be precise
 - Be sensitive to conceptual issues that seem simple but are often very challenging to have a clear understanding
 - Ask for clarifications
 - We will use weekly problem sets as a main method of assessment.

Logistical details

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.

Logistical details

- Prerequisites: no formal requirements. But a solid high-school physics background would be recommended. A college-level physics background would definitely be sufficient.
- Required books:
 1. David Albert, *Time and Chance* (Harvard University Press, 2000; any version is fine).
 2. Sean Carroll, *From Eternity to Here: The Quest for the Ultimate Theory of Time* (Dutton, 2010; any version is fine).

Work and Grading

- Grade assignment:
- $100 \geq A \geq 92 \geq A- \geq 88 \geq B+ \geq 85 \geq B \geq 82 \geq B- \geq 78 \geq C+ \geq 75 \geq C \geq 72 \geq C- \geq 68 \geq D \geq 59 \geq F \geq 0$.
- **Warning: This is not an easy class!**
- Philosophy of physics is one of the most difficult subjects in philosophy, and even physicists often get confused about the basic conceptual issues.
- If you don't do the readings or actively engage in class discussions, you will have a hard time keeping up with the class.
- The course is often offered at a much higher level, and it's usually taught to Master or PhD students. You will be expected to do a lot.
- But please don't panic. You are UCSD students. You can do well if you put in the work. Come and see me in office hours if you have any questions or concerns.

Work and Grading (40%)

- Problem sets: 30%

There will be weekly problem sets consisting of multiple-choice questions and short essay questions. [First one due next Friday at 5pm]

- 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. [First quiz on Monday]

- 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 or during office hours.

Work and Grading (60%)

- 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.

Work and Grading (bonus 5%)

- 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 to 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.

- Please do not be late (talk to me today if there are scheduling problems). 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.

Office Hours

- 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.
- Office hours: Tues and Thur 11am-12pm.
- Office: Humanities and Social Sciences Building (H&SS) Room 8004

Class discussion policies

- Please be respectful to each other
- An inclusive classroom atmosphere where everyone is encouraged and should feel comfortable to speak up

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.

Course plan (roughly)

- Introduction (week 1)
- Newton's Laws and time reversal invariance (weeks 2-3)
- The Second Law of Thermodynamics (week 4)
- Statistical mechanics (weeks 5-6)
- Reversibility, recurrence, and the Past Hypothesis (week 7)
- Asymmetries of knowledge and intervention (week 8)
- Implications and questions about the Past Hypothesis (weeks 9-10)
- Going Quantum (week 11) [typo]
- Buffer and final exam (week 12)

For next Monday:

- Readings [**warning**: different styles of writing]:
 - Carroll, *From Eternity to Here*, Chapter 1 and Chapter 2 (until p.32)
 - Reichenbach, *The Direction of Time*, Chapter 2 [PDF on Canvas]
 - Horwich, *Asymmetries in Time*, Chapter 1 [PDF on Canvas]
- Reading quiz in class on Monday
- Class starts at 9:30am. Please don't be late.
- Problem set #1 will be uploaded on Canvas by Monday and due on Friday Oct 4th at 5pm on Canvas

See you on Monday!

