PHILOSOPHY OF PHYSICS   PHIL 146

Time: Tu/Th 3:30-4:50pm   Instructor: Charles T. Sebens
Location: 110 Solis Hall   Email: csebens@gmail.com
Office Hours: Tu/Th 5-6pm   Office: 8047 HSS

COURSE DESCRIPTION

In this course we will examine a number of physical theories with two main philosophical questions in mind. The first is the question of ontology: What really exists? The second is the question of locality: Does whatever exists interact only with things that are nearby or can it interact across gaps? We will begin by discussing whether physics can hope to answer such questions about the true nature of reality and where such questions arose in Newton's theory of gravity. We will next explore the question of whether electric and magnetic fields are real, noting that the theory of electromagnetism is only local if they are. We will then move from electromagnetism to Einstein's theory of special relativity. Studying special relativity will help us better understand the nature of electric and magnetic fields. In the final unit of the course we will examine quantum mechanics. Although this theory has been remarkably successful in generating predictions about experiments performed on subatomic particles, there is intense debate about why the experiments turn out as they do. The last two units will illustrate a deep tension in modern physics: it appears that special relativity requires nature to be local and yet quantum mechanics forbids it from being so.

This course does not have any formal prerequisites in math or physics. Some familiarity with calculus and basic physics is expected, but other bits of math and physics that are relevant to the course will be explained in class and/or in the readings. Students with non-technical backgrounds can certainly succeed in this course. However, if you're math-o-phobic, this is not for you.

TEXTBOOKS

An Introduction to the Philosophy of Physics (2002), Lange

Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics (2016), Lewis

ASSIGNMENTS

Essays (50%, 25% each)

So that you can focus on the topics that most interest you, you are required to write essays on only two of the four units of the course. Each essay should be between 1,800 and 2,500 words. A typed hard copy must be submitted in class and an electronic copy submitted through the course website. When your first essay is due depends on which unit you choose to write about. The due dates are indicated on the schedule below. Regardless of which unit you choose to write your second (final) essay on, it is due on 12/5. You are allowed to submit it earlier if you'd like (be sure to submit both a hard copy in class and an electronic copy).

In order to ensure that your writing best matches the schedule of the course, you cannot write your second essay on an earlier unit than your first. It follows from this rule that the only way to write an essay on unit I is to submit it as your first essay (on 10/18) and also that if you write your first essay on unit III you must write your final essay on unit IV. I encourage you to think ahead about which units you want to write essays for. You will receive further guidance on the essays in class on 10/6.

Problem Sets (40%)

There will be one problem set on each of the four units. This gives you an opportunity to engage with all of the topics covered in the course, not just what you decide to focus on for your essays. The problem sets must be submitted as hard copies in class. They can be typed or handwritten. You may work together on the problem sets, but each student must write their own answers.

Attendance and Participation (10%)

This part of your grade is determined primarily by your attendance, however participation is also a factor. You are expected to come to every class having done the assigned reading and to participate actively in the classroom discussion. Students who prefer not to speak in class can fulfill this course requirement by coming to office hours and discussing the material there. Two absences will be permitted without penalty. Additional absences will only be permitted with prior approval (by email) in cases of religious observance, illness, or personal or family emergency. If you write the name of a student who is not in class on the attendance sheet, you will have 5% deducted from your final grade in the course. Don't do it.

S<small>CHEDULE</small>

[*Note page numbers! Sometimes you don't have to read the whole chapter or article.*]

UNIT I: BACKGROUND

9/22 **Testability**
Reading: None

Optional: *The Character of Physical Law* (1965), Chapter 7: Seeking New Laws, Feynman (pg. 156-159)

Theory and Reality (2003), Chapter 4: Popper: Conjecture and Refutation, Godfrey-Smith

Language, Truth, and Logic (1936), Chapter 1: The Elimination of Metaphysics, Ayer

Philosophical Analysis in the Twentieth Century, Volume I: The Dawn of Analysis (2003), Chapter 13: The Rise and Fall of The Empiricist Criterion of Meaning, Soames

9/27 **Scientific Realism**
Reading: *An Introduction to the Philosophy of Physics* (2002), Preface, Lange

Optional: "Arguments Concerning Scientific Realism" (1980), van Fraassen (selections from *The Scientific Image*)

Theory and Reality (2003), Chapter 12: Scientific Realism, Godfrey-Smith

"A Confutation of Convergent Realism" (1981), Laudan

9/29 **The Development of Classical Mechanics: Aristotle and Galileo**
Reading: *Dialogue on the Two Chief World Systems* (1632), Galilei (selections from the 2nd day)

Optional: "Aristotle's Physics: A Physicist's Look" (2015), Rovelli

Philosophy and the Foundations of Dynamics (2013), Chapter 4: Precursors to Newtonian Dynamics, Section 4.1: Galileo, Sklar

❖**Unit I problem set distributed.**❖

10/4 **Newton's Classical Mechanics**
Reading: *Philosophical Writings* (2004), Newton, edited by Janiak (pg. xxiii-xxiv, 64-72, 92, 102-103, 106-117; these pages include selections from the *Principia* and Newton's correspondences with Bentley and Leibniz)

Optional: "Newton's Philosophy" (2014), Sections 1 & 4, Janiak (Stanford Encyclopedia of Philosophy)

The Construction of Modern Science: Mechanisms and Mechanics (1971), Chapter 2: The Mechanical Philosophy and Chapter 8: Newtonian Dynamics, Westfall

❖**Unit I essay topics distributed.**❖

10/6   **Locality / Tips on Writing the Essays**

Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 1: What is Spatiotemporal Locality?, Sections 1-4, Lange

Optional: *Writing Philosophy: A Student's Guide to Writing Philosophical Essays* (2006), Chapter 3: Rules of Style and Content for Philosophical Writing, Vaughn

❖**Unit I problem set due.**❖

UNIT II: ELECTROMAGNETISM

10/11   **Fields and Locality**

Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 2: Fields to the Rescue?, Sections 1-3, Lange

Optional: *The Feynman Lectures on Physics: Volume I* (1963), Chapter 28: Electromagnetic Radiation, Feynman, Leighton, and Sands

10/13   **The Limits of Physical Explanation**

Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 4: Locality and Scientific Explanation, Lange

Optional: "A Universe from Nothing?" (2012), Carroll

"Why Anything? Why This?" (1998), Parfit (with reply by Swinburne)

10/18   **The Conservation of Energy and Momentum**

Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 5: Fields, Energy, and Momentum, Sections 1-5, Lange

Optional: *Introduction to Electrodynamics* (1999), Chapter 2: Electrostatics, Griffiths (pg. 90-96)
❖**Unit II problem set distributed.**❖
❖**First essay due (if on unit I topics).**❖

10/20   **Charting The Flow of Energy**

Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 5: Fields, Energy, and Momentum, Sections 6-7, Lange

Optional: *The Feynman Lectures on Physics: Volume II* (1963), Chapter 27: Field Energy and Field Momentum, Feynman, Leighton, and Sands

Introduction to Electrodynamics (1999), Chapter 8: Conservation Laws, Griffiths (pg. 345-349)
❖**Unit II essay topics distributed.**❖

10/25   **Time-Reversal Invariance**

Reading: *Time and Chance* (2000), Chapter 1: Time-Reversal Invariance, Albert

Optional: "Transformation Properties of Electromagnetic Quantities under Space Inversion, Time Reversal, and Charge Conjugation" (1973), Rosen

❖**Unit II problem set due.**❖

UNIT III: RELATIVITY

10/27   The Unification of Electricity and Magnetism
Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 7: Relativity and the
            Unification of Electricity and Magnetism, Lange

Optional: "From the Magnet and Conductor to the Relativity of Simultaneity" (2006),
            Norton

            "On the Unification of Physics" (1996), Maudlin (pg. 129-133)

11/1   The Unification of Space and Time
Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 8: Relativity, Energy, Mass,
            and the Reality of Fields, Sections 1-3, Lange

Optional: *Spacetime Physics: Introduction to Special Relativity* (1992), 2nd ed., Chapter 1: Spacetime:
            Overview, Taylor and Wheeler

11/3   Relativity and the Nature of Time
Reading: *Space, Time, and Spacetime* (1974), Chapter 4: Causal Order and Temporal Order,
            Sklar (pg. 272-275)

Optional: "Time and Physical Geometry" (1967), Putnam
❖**Unit III problem set distributed.**❖
❖**First essay due (if on unit II topics).**❖

11/8   The Unification of Mass and Energy
Reading: *An Introduction to the Philosophy of Physics* (2002), Chapter 8: Relativity, Energy, Mass,
            and the Reality of Fields, Sections 4-6, Lange

Optional: *The Special Theory of Relativity* (1965), Chapter 19: The Equivalence of Mass and
            Energy and Chapter 23: More About the Equivalence of Mass and Energy, Bohm

            "The Equivalence of Mass and Energy" (2012), Fernflores (Stanford
            Encyclopedia of Philosophy)
❖**Unit III essay topics distributed.**❖

11/10   Going Faster Than Light
Reading: None

Optional: *The Special Theory of Relativity* (1965), Chapter 28: The Question of Causality and the
            Maximum Speed of Propagation of Signals in Relativity Theory, Bohm

            "Causal Paradoxes in Special Relativity" (1990), Arntzenius
❖**Unit III problem set due.**❖

UNIT IV: QUANTUM MECHANICS

11/15   Introduction to Quantum Physics
Reading: *Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics* (2016), Chapter 1:
            Phenomena and Theory, Lewis

Optional: *The Character of Physical Law* (1965), Feynman, Chapter 6: Probability and
            Uncertainty – the Quantum Mechanical view of Nature (also available as a video)

11/17 **Anti-Realism**

Reading: *Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics* (2016), Chapter 2: Realism, Lewis

Optional: "Quantum Theory Needs No 'Interpretation'" (2000), Fuchs and Peres

Physics and Philosophy (1959), Heisenberg, Chapter 3: The Copenhagen Interpretation of Quantum Theory

"What Bell Did" (2014), Maudlin (also available as a video)

11/22 **Realist Alternatives: GRW and Bohmian Mechanics**

Reading: *Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics* (2016), Chapter 3: Underdetermination, Lewis (pg. 44-59)

Optional: *Measure for Measure: Quantum Physics and Reality* (2014), Greene, Albert, Carroll, Goldstein, and Schack (video from the World Science Festival)

"Are there Quantum Jumps?" (1987), Sections 1-3 and 5, Bell

"Bohmian Mechanics" (2013), Goldstein (Stanford Encyclopedia of Philosophy)

LMUcast: FAQ on Bohmian Mechanics (2013), workgroup on Bohmian mechanics at Ludwig-Maximilians-Universität München (video)

❖**Unit IV problem set distributed.**❖
❖**Unit IV essay topics distributed.**❖
❖**First essay due (if on unit III topics).**❖

11/29 **Realist Alternatives: The Many-Worlds Interpretation**

Reading: *Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics* (2016), Chapter 3: Underdetermination, Lewis (pg. 59-71)

Optional: *The Hidden Reality* (2011), Greene, Chapter 8: The Many Worlds of Quantum Measurement

"The Everett Interpretation" (2013), Wallace

12/1 **Quantum Non-Locality**

Reading: *Quantum Ontology: A Guide to the Metaphysics of Quantum Mechanics* (2016), Chapter 5: Causation, Lewis

Optional: *An Introduction to the Philosophy of Physics* (2002), Chapter 9: Quantum Metaphysics, Lange

❖**Unit IV problem set due.**❖

12/5 **Final Essay Drop-off**
3-6 pm, location TBA
❖**Final essay due.**❖

ATTENDANCE AND READING

Engaged participation and careful preparation are important to your success in this course. Learning to raise questions and present your own ideas in a skilled, accurate, professional, and persuasive manner is an invaluable skill in life. By engaging in class discussion you will improve your ability to do this and come to understand the material covered in the course better.

During discussion you will often find yourself disagreeing with other students. When this happens, strive to be respectful. If you can't understand why someone would believe *that*, then you have something to learn from your interlocutor. The most compelling arguments are offered by those who see the appeal of the other side.

Much of the time you spend learning philosophy will be spent reading and re-reading the texts. Reading philosophy is challenging. So is physics. Philosophy of physics can be especially impenetrable. I recommend that you re-read confusing parts of the text and take notes, bringing prepared questions with you to class or office hours.

The readings that are not from the textbook are all available on the TritonEd course website (including optional readings and links to the videos). Readings should be completed in advance of the class meeting they are associated with.

The optional readings are provided so that you have a place to go if you want to delve deeper into a certain topic or to get a different perspective. You do not need to read them as we go, but they will be useful resources when you are working on your essays.

LATE ASSIGNMENTS

Late assignments should be placed in my mailbox on the 7th floor of the HSS building. If the assignment is an essay, you must also submit an electronic copy by email.

Late assignments will receive a one letter-grade deduction if they are submitted within 48 hours of the original deadline. After that, they will not be accepted. An extension may be granted if requested in advance of the due date for the assignment. In general, extensions will only be granted for reasons of religious observance, illness, or personal or family emergency.

EMAIL

You can reach me at: csebens@gmail.com. Please only email me about logistical concerns: requesting extensions, scheduling additional office hours, etc. I find it is more effective to discuss course content face-to-face. I am happy to meet with you in office hours to discuss any philosophical questions and to schedule additional meetings as needed. Please do not hesitate to setup a meeting with me outside of office hours, especially if you'd like to discuss your plans for writing an essay.

SPECIAL ACCOMMODATIONS FOR STUDENTS WITH DISABILITIES

If you require any special arrangements for completing the course assignments or participating fully in class meetings, please let me know at the beginning of the course.

PLAGIARISM

You are encouraged to discuss your work with other students and even to share drafts with each other to get feedback. However, the work you submit should be your own. If you incorporate the ideas of others, cite those sources. Do not copy language too closely. Even when summarizing and paraphrasing cited sources, you must use your own language and present the ideas in an original way. Please ask me if you have any questions about what counts as plagiarism. We will discuss plagiarism and academic integrity in more detail on 10/6 (see also academicintegrity.ucsd.edu).

If I have reason to believe that you have engaged in academic misconduct, I will report the case to the Academic Integrity Office for review. If they determine that it is indeed a case of academic dishonesty, you will receive a zero on the assignment.