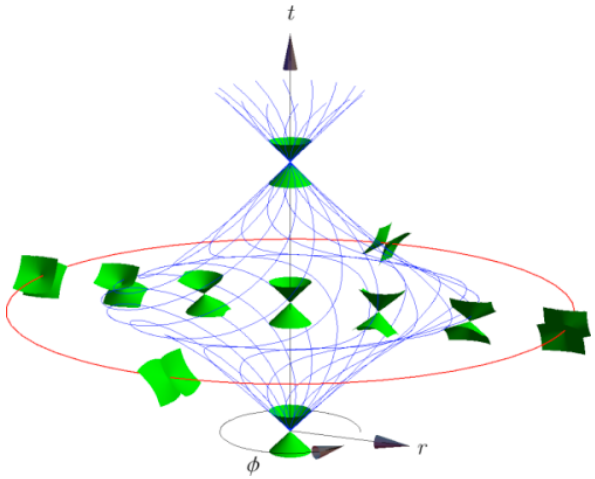
Philosophy of Physics 146



This quarter the course will focus on the philosophical foundations of spacetime physics, both classical and relativistic. This topic is an exceptionally rich one, for it has attracted some of the all-time greatest thinkers in philosophy and physics, e.g., Descartes, Galileo, Newton, Leibniz, Kant, Reichenbach, Einstein, Gödel, and others. We'll focus on a diverse array of deep questions, e.g.: are space and time (or spacetime) substances? is physical geometry conventional in some sense? does relativity prove that time doesn't "flow"? Or that that time travel is possible? Tackling these questions will help one better understand both the physics of spacetime and the philosophy of science.

Instructor	Professor Craig Callender http://philosophy.ucsd.edu/faculty/ccallender/ Office: HSS 7010; Office hrs: Tues 1-2 and by appt Contact: ccallender@ucsd.edu Grader: Nat Jacobs, njacobs@ucsd.edu
Coordinates	WLH 2114, TuTh 2-3:20
Final Exam	Thurs, 3-20-14, 3:00pm
Prerequisites	Most or all of the math/physics needed will be presented in class, assuming only a small bit of calculus. Every effort will be made to present the *technicalia* as cleanly and simply as possible. Plenty of students with non-technical backgrounds have succeeded in this course; that said, if you're math-o-phobic, this is not for you.
Reading	I have ordered two books for the course:

- Maudlin, Philosophy of Physics: Space and Time
- Geroch, General Relativity from A to B

And we will also use some journal articles available online.

Attendance — I guarantee that every single lecture will contain material not found in the reading—indeed, typically there will be a lot of such material. Given all the quizzes, anything short of regular attendance will severely damage your grade.

Grades — The grade will be determined by quizzes and homeworks (50%), a paper project (25%), and a final examination (25%). Homework and quizzes will be assigned in class on a more or less random schedule depending on where we are in the material.

Fine Print — In your assignments, all sources, including discussions with classmates, must be appropriately acknowledged. All answers given must be in your own wording. Closely paraphrasing or simply copying the work of others (such as authors of books or articles, or classmates, or Wikipedia) is not allowed and will be severely penalized. You must ask me in case you are uncertain whether something constitutes plagiarism. Plagiarism, the stealing of an idea or actual text, and other forms of academic dishonesty will be immediately reported to the Academic Integrity Office. Students agree that by taking this course all required papers, quizzes and homework will be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. All submitted papers will be included as source documents in the Turnitin.com reference database solely for the purpose of detecting plagiarism of such papers. Use of the Turnitin.com service is subject to the terms of use agreement posted on the Turnitin.com site. You should read the University's Policy on Integrity of Scholarship at www.senate.ucsd.edu/manual/appendices/app2.htm. Students who wish to take a make-up exam must inform me (by phone or email) well ahead of time. In order to qualify for a make-up exam, appropriate evidence of the most severe circumstances must be produced by the student. I will determine, in consultation with the student, what qualifies as appropriate evidence. Finally, texting, emailing, facebook, etc., during lecture is not allowed.

For the most up-to-date schedule of readings, go to:
philosophyfaculty.ucsd.edu/faculty/ccallender/PHIL146Winter14syllabus.pdf

I. Ancient and Classical Spacetimes

After introducing students to the necessary mathematical and physical concepts (especially the distinctions among topological, affine, and metrical transformations), we'll look at how physics determines spatiotemporal structure.

We'll see how properties of Aristotelian and Newtonian dynamics demand particular types of spatiotemporal structure. We'll tackle at least three philosophical problems: (a) Leibniz versus Clarke on whether space is a substance, (b) Kant on handedness, and (c) Zeno's paradoxes.

Class 1 Metrics, Topology, and All That

Maudlin chapter 1
Geroch 3-36

Class 2 Newtonian Physics and Newtonian Spacetime

Maudlin chapter 2
Geroch 37-52

Class 3 Is Space a Substance? Leibniz vs Newton

Maudlin chapter 2
Leibniz vs Clarke, www.earlymoderntexts.com/leibclar.html

Class 3 "Galilean" Spacetime and Leibniz-Clarke

Maudlin, chapter 3

Class 4 Kant, Hands and Space

Tbd

Class 5 Zeno's Paradoxes of Motion I

Huggett, plato.stanford.edu/entries/paradox-zeno/

Class 6 Zeno's Paradoxes of Motion II

Laraudogoitia, "A Beautiful Supertask"
http://www.jstor.org/pss/2254538

II. Minkowski Spacetime

In 1905 Einstein published the special theory of relativity. His former supervisor, Minkowski, later developed the spacetime appropriate to this physics, Minkowski spacetime. After learning this theory, focusing especially on its basic assumptions and challenging puzzles, we'll revisit the Leibniz-Clarke debate and turn to a new one, the question of whether relativity claims that time doesn't flow in some sense.

Class 7 Special Relativity

Maudlin, chapter 4
Geroch, 53-112

Class 8 Special Relativity

Maudlin, chapter 5
Geroch, 53-112

Class 9 Does Relativity Eliminate the Whoosh of Time? I

Putnam, "Time and Physical Geometry"
Journal of Philosophy **64** (1967): 240-247. JSTOR
Callender, “Shedding Light on Time” JSTOR

Class 10 Does Relativity Eliminate the Whoosh of Time? II

Class 9’s reading continued

III. General Relativistic Spacetimes

Between 1912-1917 Einstein developed a theory to incorporate gravitational phenomena as well as electromagnetic phenomena. The laws of this theory allow for indefinitely many possible spacetimes. Crucially, gravitational “forces” are understood to be aspects of spatiotemporal curvature. We’ll get a great understanding of the causal structure of general relativistic spacetimes via Geroch, even if we must leave detailed calculations to another course. The rich variety of spacetimes raises many deep philosophical questions, new and old.

Class 11 Gaussian Curvature and Non-Euclidean Geometry

Callender, class handout

Class 12 General Relativity

Maudlin, chapter 6
Geroch 159-185

Class 13 General Relativity Continued: Black Holes

Geroch, chapter 8

Class 14 Underdetermination, Conventionalism, Realism I

Poincare, “Space and Geometry” from *Science and Hypothesis* (google – no copyright)
Callender handout

Class 15 Underdetermination, Conventionalism, Realism

Luminet, "A Cosmic Hall of Mirrors" *Physics World* 2005 physicsworld.com/cws/article/print/23009
Magnus, “Reckoning the Shape of Everything: Underdetermination and Cosmotopology”
http://bjps.oxfordjournals.org/content/56/3/541.short

Class 16 The Philosophy of Time Travel

Lewis, “The Paradoxes of Time Travel”
http://www.csus.edu/indiv/m/merlinos/Paradoxes%20of%20Time%20Travel.pdf

Class 17 General Relativity and Time Travel

Arntzenius and Maudlin, “Time Travel and Modern Physics”
http://plato.stanford.edu/entries/time-travel-phys/

Class 18 Does General Relativity Eliminate the Whoosh of Time?

Gödel, “A Remark About the Relationship between Relativity Theory and Idealistic Philosophy”

Class 19 Leibniz vs Clarke in General Relativity

Maudlin 146-152

Class 20 Review

Supplements?

Both the physics and philosophy of relativity are beautifully developed in many texts and articles. Here are suggestions for any further reading, in rough order of difficulty.

SpecRel Physics	Mermin, *It’s About Time*
	Naber, *The Geometry of Minkowski Spacetime*
GenRel Physics	Schutz, *Gravity from the Ground Up*
	Callahan, *The Geometry of Spacetime*

	Carroll, *Spacetime and Geometry* Wald, *General Relativity* Malament, *Topics in the Foundations of GR…*
Philosophy	Callender, *Introducing Time* Dainton, *Time and Space* Norton*, Einstein for Everyone*, free online Huggett, *Space: From Zeno to Einstein* Sklar, *Space, Time, and Spacetime* Earman, *World Enough and Spacetime* Friedman, *Foundations of Spacetime Physics* Earman, *Bangs, Whimpers,Crunches and Shrieks*,

There are also great opportunities for learning on the web, ranging from John Baez's physics tutorial on GR to the many excellent encyclopedia entries in the *Stanford Encyclopedia of Philosophy*. Just ask me if you would like more reading advice.