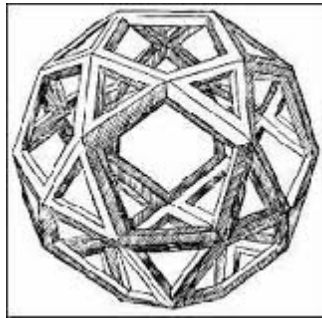


## Philosophy of Physics 146



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 physical geometry and topology conventional in some sense? how do we know the physical geometry of space? does relativity prove that time does not flow? that time travel is possible? what does  $E=mc^2$  really mean? does quantum non-locality threaten relativity? Tackling these questions will help one better understand both the physics of spacetime and the philosophy of science.

Instructor Professor Craig Callender  
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Coordinates WLH 2206, TuTh 3:30-4:50

Final Exam 3-20-12, Fri 3-6

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. Students with non-technical backgrounds have succeeded in this course; but if you are math-o-phobic, this is not the course for you.

Reading I have ordered two books for the course:

- Geroch, General Relativity from A to B.
- Huggett, Space: From Zeno to Einstein

And we will also use many articles in journals. These will be found on [jstor.org](http://jstor.org), [reserves.ucsd.edu](http://reserves.ucsd.edu), and elsewhere on the internet.

You can also use John Norton's *Einstein for Everyone*

[http://www.pitt.edu/~jdnorton/teaching/HPS\\_0410/chapters/index.html](http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/index.html)

for background. If you're nervous going without a general guide for the whole course, then I suggest purchasing Dainton's Time and Space. Also, I recommend supplemental reading at times (dubbed "extra" on the syllabus). Doing this will more than repay the effort.

- 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. Anything short of regular attendance will severely damage your grade.
- Grades** The grade will be determined by an in-class midterm examination (30%), final examination (30%) and other assignments (40%) consisting of homeworks, small essays, and attendance. Homework will be assigned in class on a more or less random schedule depending on where we are in the material.
- Fine Print** In your essays, homework, and so on, 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 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](http://www.senate.ucsd.edu/manual/appendices/app2.htm). Students who wish to write 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, etc., during lecture is not allowed.

For the full schedule of readings, go to:  
[philosophyfaculty.ucsd.edu/faculty/ccallender/PHIL146Winter12syllabus.pdf](http://philosophyfaculty.ucsd.edu/faculty/ccallender/PHIL146Winter12syllabus.pdf)

- Week 1      **Zeno's Paradoxes of Motion**
- Huggett chapter 3  
 Arntzenius, "Are Instantaneous Velocities Real and Really Instantaneous?" <http://www.jstor.org/pss/27903678>  
 Laraudogoitia, "A Beautiful Supertask" <http://www.jstor.org/pss/2254538>
- Week 2      **Aristotelian, Newtonian & Galilean Spacetimes**
- GRAB, 3-36; 37-52  
 Huggett ch. 6 (just 72-83) and ch. 7
- Extra: Norton, "What is a Four-Dimensional Space Like?"
- Week 3      **Is Space a Substance? The Leibniz-Clarke Debate and the Handedness Debate**
- Huggett ch.8, 9,10  
 Maudlin, "Buckets of Water and Waves of Space: Why Spacetime Is Probably a Substance" *Philosophy of Science* 60, 1993, 183-203. JSTOR Read sections 1-4
- Extra: <http://plato.stanford.edu/entries/newton-stm/>  
[www.earlymoderntexts.com/leibclar.html](http://www.earlymoderntexts.com/leibclar.html)  
<http://plato.stanford.edu/entries/spacetime-theories/>
- Week 4      **Relativity: Minkowski Spacetime**
- GRAB, 53-112  
 Notes
- Extra: Huggett, ch. 14  
 Norton, Origins, and Special Relativity  
 Luminet, "Time, Topology and the Twin Paradox"
- Week 5      **Is the Whoosh of Time Eliminated?**
- Putnam, "Time and Physical Geometry"  
*Journal of Philosophy* 64 (1967): 240-247. JSTOR.  
 Callender, "Shedding Light on Time" JSTOR
- Week 6.1      Midterm!

- Week 6.2      **Curvature**
- Lecture notes
- Extra: Norton, Non-Euclidean Geometry and Spaces of Variable Curvature
- Week 7      **General Relativity and Conventionality**
- Geroch, GRAB, 159-185  
 Background: Norton, General Relativity  
 Christopher Ray, "A Conventional World?" in *Time, Space and Philosophy*. *Reserves.ucsd.edu*  
 "A Cosmic Hall of Mirrors" *Physics World* 2005  
 physicsworld.com/cws/article/print/23009  
 Psillos, "Underdetermination Thesis, Quine-Duhem Thesis" *Encyclopedia of Philosophy*,  
 phs.uoa.gr/~psillos/Publications\_files/Underdetermination.pdf
- Extra: John Baez's GR Tutorial:  
<http://math.ucr.edu/home/baez/gr/gr.html>  
 Advanced Extra: David Malament's notes:  
[www.lps.uci.edu/malament/FndsofGR/GR.pdf](http://www.lps.uci.edu/malament/FndsofGR/GR.pdf)
- Week 8      **Time Travel**
- Weingard, R. "General Relativity and the Conceivability of Time Travel" *Philosophy of Science* 46 (2):328-332. JSTOR  
 Arntzenius, F. "Time Travel: Double Your Fun" *Philosophical Compass*, 2006. E-library.  
 Gödel, *tbd*  
 Wuthrich, *tbd*
- Week 9      **Relationism versus Substantivalism: the Final Showdown?**
- Maudlin, "Buckets of Water and Waves of Space: Why Spacetime is Probably a Substance" *Philosophy of Science* 60, 1993, 183-203. JSTOR. Sections 5 and 6.  
 Weingard, "On the Ontological Status of the Metric in General Relativity" *The Journal of Philosophy*, Vol. 72, No. 14, (Aug. 14, 1975), pp. 426-431. JSTOR.
- Week 10      **Does Quantum Non-locality Threaten Relativity?**
- Maudlin, "Bell's Theorem: The Price of Locality"  
<http://onlinelibrary.wiley.com/doi/10.1002/9781444396973.ch1/pdf>

<http://plato.stanford.edu/entries/bell-theorem/>

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**Final Exam**

Monday, 3-6, location tba

More?

The following are some useful books/chapters in philosophy of spacetime physics.

*Introducing Time* by Craig Callender, Totem, 3<sup>rd</sup> ed, 2005.  
This is a silly little book, but it might help if you're in trouble.  
*Time and Space* by Barry Dainton, 2001.  
Nice readable book that you may wish to purchase.  
*Foundations of Spacetime Physics* by Michael Friedman.  
Advanced, but excellent in all ways.  
*World Enough and Spacetime*, John Earman.  
Best advanced source on substantivalism issue  
*Bangs, Whimpers, Crunches and Shrieks*, John Earman.  
Advanced and excellent; e-copy in library  
*Space, Time, and Spacetime*, Larry Sklar.  
Medium-advanced, just about the right level for this course  
*Space From Zeno to Einstein*, Nick Huggett.  
Classic readings with insightful and readable commentary.  
*Oxford Handbook in Philosophy of Time*, Craig Callender  
Lots of good articles on time  
*Blackwell Guide to the Philosophy of Science*,  
Ch. 9 on spacetime by Craig Callender and Carl Hoefer.