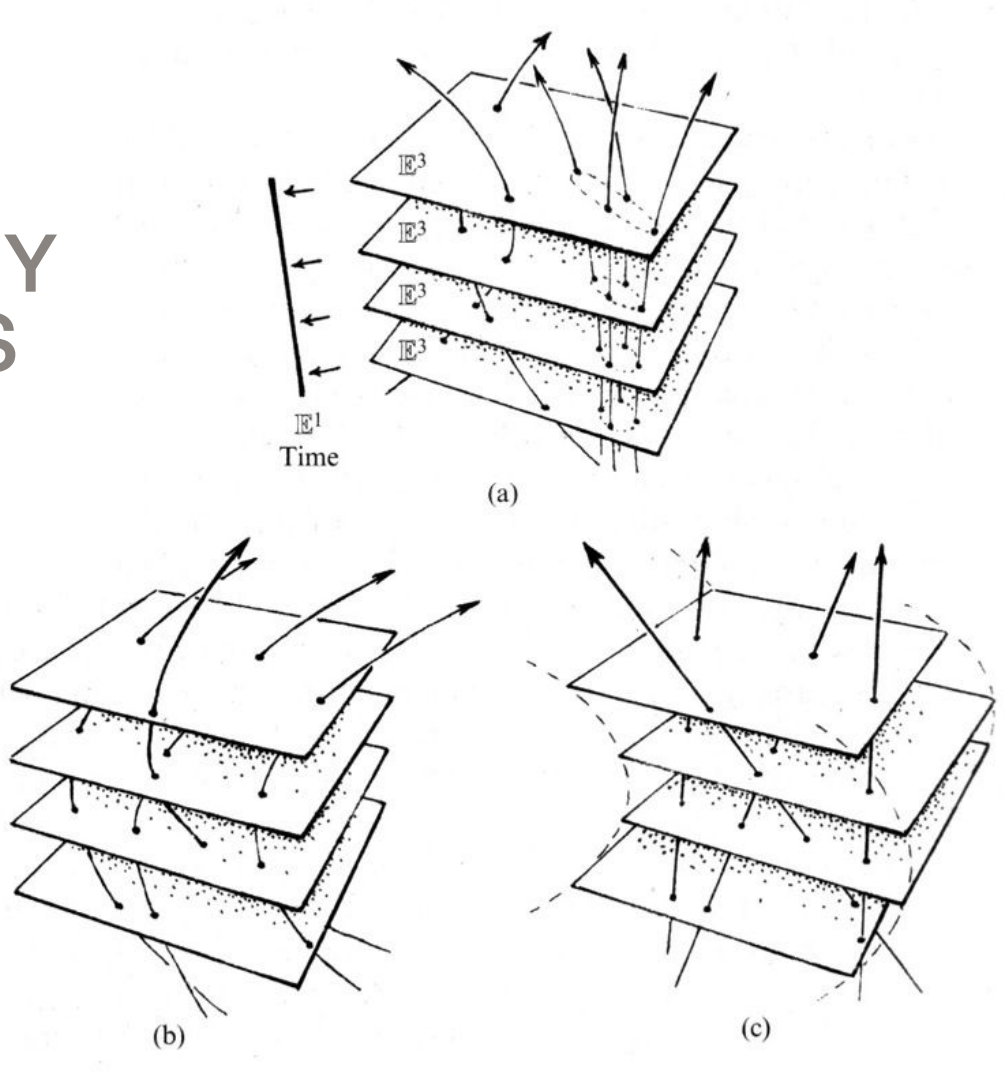
PHIL 146

PHILOSOPHY OF PHYSICS



Nature of Space and Time

Fall 2020, TuTh 2-3:20

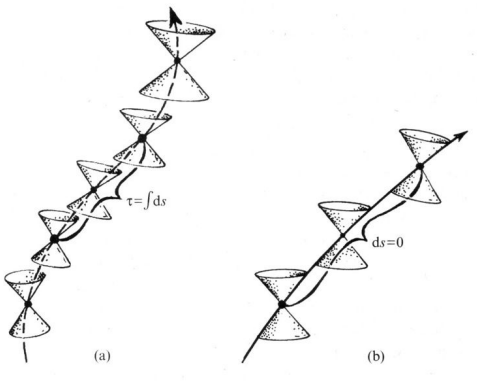
Prof Craig Callender

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 science and philosophy, e.g., Descartes, Galileo, Newton, Leibniz, Kant, Reichenbach, Einstein, Gödel.

We'll focus on many deep questions, including: Are space and time (or spacetime) genuine substances? Does time "flow"? What is the "shape" of space? Is physical geometry conventional in some sense? Is time travel possible or paradoxical? Does quantum nonlocality conflict with relativity?

Tackling these questions will help one better understand both the physics of spacetime and the philosophy of science.

There is no prerequisite for the course. Students without technical backgrounds can thrive in this course, so long as they have a tolerance for math. Every effort will be made to present the physics as cleanly and accessibly as possible.



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Grader

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Reading

Free journal articles, chapters, etc on Canvas.
Tim Maudlin, *Philosophy of Physics: Space and Time*
Robert Geroch, *General Relativity A to B*
I'll describe the reading each week in a Canvas announcement.

Attendance

Class will be live on Zoom and recorded for those in distant time zones. 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 and discussion, anything short of regular attendance will severely damage your grade.

Grade

5 short assignments/quizzes (5x5=30%), Canvas discussion answers (25%), a take-home midterm (25%) and a take-home final examination (25%). More info and details via Canvas and lecture.

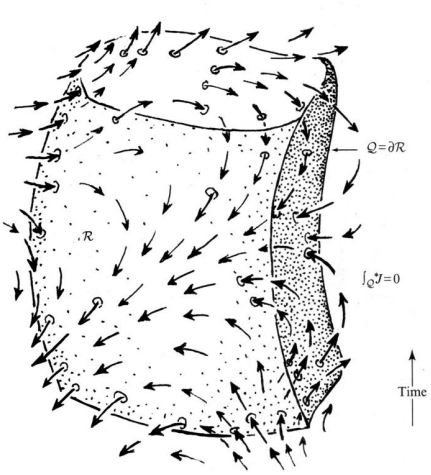
Zoom

A zoom link and password will be sent out from Canvas. I encourage you to come, turn video on and speak up. Interacting with you helps me teach better. Please do not surf the web, text and so on during class.

Fine Print

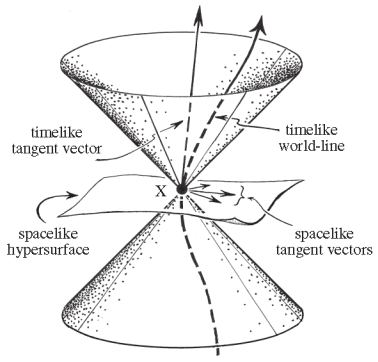
In your assignments, all sources must be appropriately acknowledged. All answers given must be in your own wording. Closely paraphrasing or simply copying the work of others (such as authors of books or articles, or classmates, or Wikipedia) is not allowed. Plagiarism, the stealing of an idea or actual 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 may be subject to submission for textual similarity review to Turnitin.com for the detection of plagiarism. Use of the Turnitin.com service is subject to the terms of use agreement posted on the Turnitin.com site. For official policy see www.senate.ucsd.edu/manual/appendices/app2.htm. Students who wish to hand in material late must inform me (by email) well ahead of time. In order to qualify for late hand in's of assignments, 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. Students requesting accommodations for the course must produce an AFA letter from OSD. OSD can be called at 858-534-4382.

Ancient and Classical Spacetimes. We'll warm up with Zeno's famous paradoxes of motion. Students then will be introduced to the mathematical and physical concepts (especially the distinctions among topological, affine, and metrical transformations) we'll need. We'll focus on how physics determines spatiotemporal structure, in particular, how properties of Aristotelian and Newtonian dynamics demand particular types of spatiotemporal structure. We'll then tackle two big philosophical topics, (a) Leibniz versus Clarke on whether space is absolute/substantial, and (b) Kant on handedness and space.



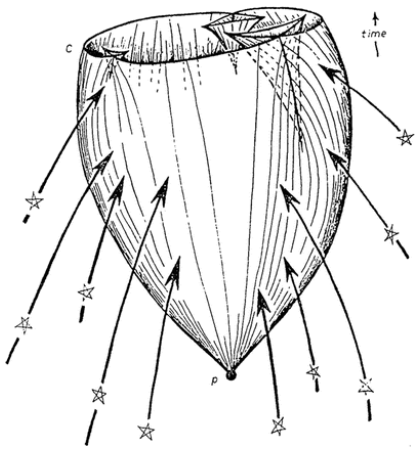
10-1	Introduction, Zeno's Paradoxes,
10-6	Zeno and Modern Mathematics Handout, Huggett selections
10-8	Metrics, Topology, Coordinates, and All That Geroch, 3-36, Maudlin, 24-34
10-13	Newtonian Physics and Newtonian Spacetime Newton, *The Principia*, Scholium Geroch, 37-52 Maudlin 1-24
10-15 10-20	Leibniz vs Newton: Absolute, Relational and Substantival Space The Leibniz-Clarke Correspondence, selections (L2:1, C2:1, L3, C3:2-5, L4:3-7, 13) Maudlin, 34-46
10-22	Galilean Spacetime Maudlin, 47-66
10-27	Kant, Hands, Space Huggett, chapter 11

Minkowski Spacetime. In 1905 Einstein discovered the special theory of relativity. His supervisor, Minkowski, later developed the spacetime appropriate to this physics, Minkowski spacetime. After learning this theory, focusing especially on its basic assumptions and puzzles, e.g., the "twin paradox," we'll briefly revisit the Leibniz-Clarke debate and then turn to the question of whether time flows.

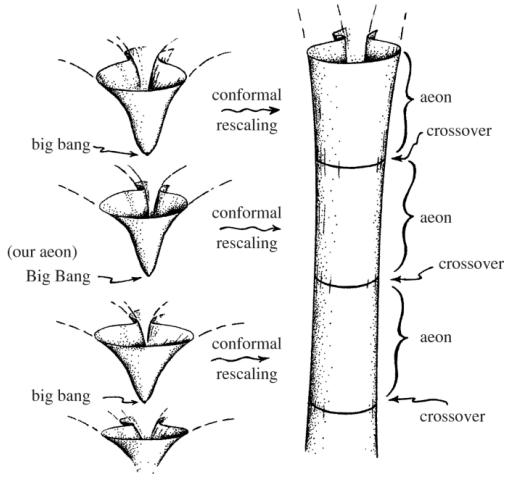


10-29 11-3	Special Relativity Einstein, "The Problem of Space, Ether and the Field in Physics" Geroch, 53-112 Special Relativity, Clocks, Barns, Twins, and All That, Maudlin 67–126
11-5	Does Time Flow? Watch video: Is Time Real? Dyke, The Metaphysics of Time
11-10	Putnam, "Time and Physical Geometry"
11-12	Callender, What Makes Time Special? ch. 1 Hartle, "The Physics of Now"
11-17	**MIDTERM**

General Relativistic Spacetimes. Between 1912-1917 Einstein developed a theory that handles gravitational phenomena as well as electromagnetic phenomena. Crucially, gravitational "forces" are understood to be aspects of spatiotemporal curvature. Unlike special relativity, this theory is technically challenging — but we can obtain a great understanding of the causal structure of general relativistic spacetimes via Geroch even if leave the fancy differential geometry to another course. The rich variety of possible spacetimes permitted by GR raises many deep philosophical questions, new and old.



11-19 11-24	General Relativity Geroch 159-185, Maudlin 126-140
12-1	Black Holes Geroch, chapter 8, Maudlin 140-146
12-3	The Epistemology of Geometry Ray, "A Conventional World?" Norton, chapter 5, sections 5.2 Luminet, A Cosmic Hall of Mirrors
12-8	The "Uniformity" of Time Poincare, The Measure of Time Norton, chapter 5, section 5.3
12-10	Time Travel: Conceptual Issues Lewis, "The Paradoxes of Time Travel" Gödel, "A Remark About the Relationship between Relativity Theory and Idealistic Philosophy"



Here are some suggestions for further reading:

John Earman, World Enough and Spacetime
Nick Huggett, Space from Zeno to Einstein
Hans Reichenbach, The Philosophy of Space and Time
Lawrence Sklar, Space, Time, and Spacetime
Michael Friedman, Foundations of Space-Time Theories
Barry Dainton, Time and Space
Craig Callender, What Makes Time Special?
John Norton, Einstein for Everybody