PHIL 4605/5605: Space and Time (Fall 2018, 3 units)

September 16, 2018

Instructor: Prof. Samuel C. Fletcher (scfletch@umn.edu)
Class Meetings: Tu/Th 9:45–11:00 in Blegen 115
Office Hours: Tu/Th 11:15–12:15 in Heller 754, and by appointment

Course Website: `https://canvas.umn.edu/courses/70805/`. Please check Canvas often for course updates.

Required Texts:

- Robert Geroch, *General Relativity from A to B*, University of Chicago Press, 1978. (Hereafter *GRAB*.)
- Nick Huggett, ed., *Space from Zeno to Einstein*, MIT Press, 1999. (Hereafter *SZE*.)
- Tim Maudlin, *Philosophy of Physics: Space and Time*, Princeton University Press, 2012. (Hereafter *PPST*.)

All are available at the campus bookstore; GRAB and PPST are on reserve at the Wilson library, while SZE is available as an e-book through the University of Minnesota library.

Other Required Materials: Please bring to every class meeting loose-leaf paper and either a pencil or a pen in blue or black ink.

Description and Objectives

The goal of this course is to explore a geometric perspective on how ideas about the structure of space and time have developed in the course of Western natural philosophy. This includes attending to the philosophical foundations of spacetime physics, that is, the physics of location, duration, direction, motion, and change as considered by Aristotle, Descartes, Newton, Leibniz, Clarke, Berkeley, du Châtelet, Cockburn, Kant, Mach, Einstein, Minkowski, Poincaré and others. That said, our study will not be primarily *historical*—that is, focused on the business of reconstructing the philosophical views of past thinkers in their all their subtleties. Rather, we will use the historical texts as prompts for broader discussion on some deep questions about the nature of space and time: Are space and time substances themselves, or only relations between material objects? Does time really pass, or is this just

an illusion? What of motion is absolute, and what only relative? Is physical geometry conventional? Unknowable? Is time travel possible? What does Einstein's theory of relativity say, and not say, about these questions? We'll use modern geometric methods and ideas to investigate these and other questions, but informally through pictures: no mathematics background beyond high school algebra and geometry is presupposed.

By the end of the semester, students will:

1. understand some of the central debates about the nature of space, time, and motion in the history of Western natural philosophy;

2. develop a qualitative facility with different models of space-time and their properties and structure; and

3. have exercised this facility creatively to think in new ways about space, time, and motion.

Students should be ready to be challenged in lecture to think about physics—and philosophy—in a different way than they may be accustomed.

Grading

Basis for Evaluation

Electronic Journal (25%) You will be responsible for keeping an "electronic journal," in which you record your thoughts on the course readings *and* class discussions as they pertain to the following sorts of questions: What is confusing or hard to understand? Which arguments, premises, or conclusions seem most interesting and important to remember? What am I inclined to agree or disagree with? About what would I like to know more? There will be *five* "journal entries," each worth 5%, due during the course of the semester (indicated below in the course schedule), each of which will cover the reading and discussion over the previous *five* class periods and will be turned in via Canvas. Because this is informal and exploratory writing designed to capture your thoughts for later reflection and use, each journal entry will be graded according to a simple rubric: completed well (5), completed adequately (4), partially completed (3), not completed (0). No late journal submissions will be accepted without prior approval.

Final Project/Term Paper (30%) Students enrolled in 5605 will be responsible for writing a 2,000–4,000-word (8–16-page, double-spaced) research paper elaborating a novel discussion of or argument concerning some topic from the course. Students enrolled in 4605 will instead group into teams of *two* for a capstone project: the creation and description of a spacetime model novel to the class. This will be a multi-stage project involving: first, the coalescence of the project groups and brainstorming discussions; second, a meeting with me to discuss an initial outline (250–500 words) of your team's idea (6%); third, the submission of a description (500–1,000 words) of your spacetime, its structure and properties, etc. (12%); and fourth, the presentation of your model

(∼10 min.) during the last class session (12%). The spacetime model itself may be constructed using a variety of media, including text, drawing, paper art, wood, metal, computer rendering, etc. The due dates for each step are provided in the course schedule below; further details on the assignment will be provided in class and on Canvas. (Students in 4605/5605 may petition to do the 5605/4605 requirement, respectively, during the first week of classes.)

Midterm Exam (20%) The midterm exam will take place during the normally scheduled class period on Tuesday, October 16 and will focus on material in the readings and lectures in the first half of the course through a variety of question types, e.g., multiple choice, short answer, and fill-in-the-blank.

Final Exam (25%) The final exam will take place in our usual classroom from 1:30 p.m.–3:30 p.m. on Tuesday, December 18 and will focus (though not exclusively) on material in the readings and lectures in the second half of the course through a variety of question types, e.g., multiple choice, short answer, and fill-in-the-blank.

Understanding Your Letter Grade

How to Compute Your Letter Grade

	$90 > \text{B+} \geq 87$	$80 > \text{C+} \geq 77$	$70 > \text{D+} \geq 67$	
$\text{A} \geq 93$	$87 > \text{B} \geq 83$	$77 > \text{C} \geq 73$	$67 > \text{D} \geq 63$	$\text{F} < 60$
$93 > \text{A-} \geq 90$	$83 > \text{B-} \geq 80$	$73 > \text{C-} \geq 70$	$63 > \text{D-} \geq 60$	

Grades in the following ranges represent the following corresponding levels of achievement relative to the level necessary to meet course requirements:

A: Outstanding.
B: Significantly above.
C: Adequate in every respect.
D: Worthy of credit despite not fully meeting course requirements.
F: Not meeting enough course requirements to be deserving of credit.

Students taking this course "pass/fail" will receive an "S," representing satisfactory achievement, for any standard final letter grade of "C-" or higher that he or she would have been assigned. Such students will receive an "N," representing unsatisfactory achievement, for any standard final letter grade of "D+" or lower that he or she would have been assigned.

For additional information about University policies about grading and transcripts, please refer to: `http://policy.umn.edu/education/gradingtranscripts`.

Policies

Student Conduct Code

The University seeks an environment that promotes academic achievement and integrity, that is protective of free inquiry, and that serves the educational mission of the University.

Similarly, the University seeks a community that is free from violence, threats, and intimidation; that is respectful of the rights, opportunities, and welfare of students, faculty, staff, and guests of the University; and that does not threaten the physical or mental health or safety of members of the University community.

As a student at the University you are expected adhere to the Board of Regents Policy: Student Conduct Code. To review the Student Conduct Code, please see: `http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf`.

Note that the conduct code specifically addresses disruptive classroom conduct, which means "engaging in behavior that substantially or repeatedly interrupts either the instructor's ability to teach or student learning. The classroom extends to any setting where a student is engaged in work toward academic credit or satisfaction of program-based requirements or related activities."

Use of Personal Electronic Devices in the Classroom

Using personal electronic devices in the classroom setting can hinder instruction and learning, not only for the student using the device but also for other students in the class. To this end, the University establishes the right of each faculty member to determine if and how personal electronic devices are allowed to be used in the classroom. (For complete information, please reference: `http://policy.umn.edu/education/studentresp`.)

In this class, the use of laptops, tablets, and other electronic devices is permitted as long as it would not reasonably be a distraction to others. Reasonable distractions include movies and social media. Students violating this policy will be asked to put their offending device away for the rest of the class session.

Writing Resources

Student Writing Support (SWS) offers free writing instruction for all University of Minnesota students at all stages of the writing process. In face-to-face and online collaborative consultations, SWS consultants help students develop productive writing habits and revision strategies. SWS consultants are teachers of writing: graduate and undergraduate teaching assistants and professional staff. Some consultants specialize in working with multilingual writers, and others have experience with writing in specific disciplines. Consulting is available by appointment online and in Nicholson Hall, and on a walk-in basis in Appleby Hall. For more information, go to writing.umn.edu/sws or call 612-625-1893. In addition, SWS offers a number of web-based resources on topics such as avoiding plagiarism, documenting sources, and planning and completing a writing project.

Scholastic Dishonesty

You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using test materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to

obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, or misusing a University academic record; or fabricating or falsifying data, research procedures, or data analysis. (Student Conduct Code: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Student_Conduct_Code.pdf.) If it is determined that a student has cheated, he or she may be given an "F" or an "N" for the course, and may face additional sanctions from the University. For additional information, please see: http://policy.umn.edu/education/instructorresp.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions pertaining to scholastic dishonesty: http://www1.umn.edu/oscai/integrity/student/index.html. If you have additional specific questions regarding what would constitute scholastic dishonesty in the context of this class, please ask.

Make-up Work for Legitimate Absences

Students will not be penalized for absence during the semester due to unavoidable or legitimate circumstances. Such circumstances include illness (inclusive of dependents), whether mental or physical, medical conditions related to pregnancy, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, and religious observances. Such circumstances do not include voting in local, state, or national elections. For complete information, please see: http://policy.umn.edu/education/makeupwork.

Under such legitimate circumstances leading a student to be absent for any graded activity, that student must contact me about it at least two weeks in advance, or as soon as possible if the circumstances are known later.

Appropriate Student Use of Class Notes and Course Materials

Taking notes is a means of recording information but more importantly of personally absorbing and integrating the educational experience. However, broadly disseminating class notes beyond the classroom community or accepting compensation for taking and distributing classroom notes undermines instructor interests in their intellectual work product while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community. For additional information, please see: http://policy.umn.edu/education/studentresp.

Sexual Harassment

"Sexual harassment" means unwelcome sexual advances, requests for sexual favors, and/or other verbal or physical conduct of a sexual nature. Such conduct has the purpose or effect of unreasonably interfering with an individual's work or academic performance or creating an intimidating, hostile, or offensive working or academic environment in any University activity or program. Such behavior is not acceptable in the University setting. For additional information, please consult the Board of Regents' policy on the matter: http://regents.umn.edu/sites/regents.umn.edu/files/policies/SexHarassment.pdf.

In my role as a University employee, I am required to share information that I learn about possible sexual misconduct with the campus Title IX office that addresses these concerns.

This allows a Title IX staff member to reach out to those who have experienced sexual misconduct to provide information about the personal support resources and options for investigation that they can choose to access. You are welcome to talk with me about concerns related to sexual misconduct. Within the requirements of my job, I will be as responsive to your requests for confidentiality and support as possible. You can also or alternately choose to talk with a confidential resource that will not share information that they learn about sexual misconduct. Confidential resources include The Aurora Center (`http://aurora.umn.edu/`), Boynton Mental Health (`https://boynton.umn.edu/clinics/mental-health`) and Student Counseling Services (`https://counseling.umn.edu/`).

Equity, Diversity, Equal Opportunity, and Affirmative Action

The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, disability, public assistance status, veteran status, sexual orientation, gender identity, or gender expression. To this effect, please notify me if you have a preferred name or pronoun not indicated in your official enrollment data. For more information, please consult the Board of Regents' policy on the matter: `http://regents.umn.edu/sites/regents.umn.edu/files/policies/Equity_Diversity_EO_AA.pdf`.

Disability Accommodations

The University of Minnesota is committed to providing equitable access to learning opportunities for all students. The Disability Resource Center (DRC) is the campus office that collaborates with students who have disabilities to provide and/or arrange reasonable accommodations. If you have, or think you may have, a disability (e.g., mental health, attentional, learning, chronic health, sensory, or physical), please contact the DRC at 612-626-1333 to arrange a confidential discussion regarding equitable access and reasonable accommodations. If you are registered with the DRC and have a current letter requesting reasonable accommodations, please contact me as early in the semester as possible to discuss how the accommodations will be applied in the course. For more information, please see the DRC website, `https://diversity.umn.edu/disability/`.

Mental Health and Stress Management

As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University of Minnesota services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the Student Mental Health Website: `http://www.mentalhealth.umn.edu`.

Academic Freedom and Responsibility

Academic freedom is a cornerstone of the University. Within the scope and content of the course as I have defined it, this includes the freedom to discuss relevant matters in the classroom. Along with this freedom comes responsibility. Students are encouraged to develop the capacity for critical judgment and to engage in a sustained and independent search for truth. Students are free to take reasoned exception to the views offered in any course of study, but they are responsible for learning the content of any course of study for which they are enrolled. Reports of concerns about academic freedom are taken seriously, and there are individuals and offices available for help, including me, the Philosophy Department Chair Prof. Valerie Tiberius (tiberius@umn.edu), your adviser, or College of Liberal Arts Associate Dean for Arts and Humanities Jane Blocker (block023@umn.edu).

Tentative Course Schedule

As the section title indicates, the course schedule is open to (reasonable) modification in light of the class's progress. Texts other than SZE, GRAB, and PPST will be linked in the Canvas site. Units that will occupy multiple class days (e.g., Leibniz-Clarke Correspondence I/II) may have their respective readings listed only on the first. Generally, there is between 22–30 pages of reading per class period, but some have less and others more. Readings from SZE and GRAB are listed by chapter or section, and those from PPST by page. You are advised to have the reading assigned for a particular day done before that day's lecture.

Date	Topic	Reading	Assignments Due
	Aristotle to Newton		
Tu 9/4	Introduction/Space-Time	Course Syllabus, GRAB 1, SZE 10.2	
Th 9/6	Aristotelian Space-Time	PPST pp. 1–4, GRAB 2	
Tu 9/11	Aristotelian Tradition to Descartes	SZE 5–6	
Th 9/13	Newtonian Space-Time	SZE 10.3, PPST pp. 4–16, 24–34	
Tu 9/18	Newton's Space-Time Ontology	SZE: *De Grav*, 7.1–3, Stein ('16)	Journal #1
	Newton to Mach		
Th 9/20	Buckets and Frames	SZE: *Principia*, 7.4–5, PPST pp. 17–24	
Tu 9/25	Leibniz-Clarke Correspondence I	PPST pp. 34–46, SZE 8, Hutton	
Th 9/27	Leibniz-Clarke Correspondence II	↑	

Date	Topic	Reading	Assignments Due
Tu 10/2	Cockburn on Substantivalism	Berkeley, Thomas	
Th 10/4	Machian Space-Time?	SZE 9	Journal #2
	Kant to Einstein		
Tu 10/9	Kant: Incongruent Counterparts	SZE 11, Sklar ('74)	
Th 10/11	Galilean Space-Time	SZE 10.4, PPST pp. 54–66, GRAB 3	
Tu 10/16	Midterm Exam		←
Th 10/18	Special Relativity I	GRAB 4–5, PPST pp. 67–87	
Tu 10/23	Special Relativity II	↑	Journal #3
	Implications of Special Relativity		
Th 10/25	Special Relativity III	PPST pp. 87–111, 124–5, GRAB 6	
Tu 10/30	Special Relativity IV	↑	
Th 11/1	(Class Canceled)		
Tu 11/6	Conventionality of Simultaneity	Norton, Poincaré	project group assignments
Th 11/8	Temporal Passage Lost?	Putnam, Stein ('68) Callender	
Tu 11/13	Temporal Passage Regained?	Ismael, Hartle	Journal #4
	General Relativity and World Geometry		
Th 11/15	General Relativity	GRAB 7, PPST pp. 126–40	
Tu 11/20	Black Holes	PPST pp. 140–6 GRAB 8	project meetings
Tu 11/27	Time Travel	PPST pp. 153–65 Lewis, Weingard	
Th 11/29	Underdetermination of Geometry	Magnus, Luminet	
Tu 12/4	Epistemology of Geometry	SZE 13, Sklar ('92)	Journal #5, project description
Th 12/6	Final Project Presentations I		← (4605)
Tu 12/11	Final Project Presentations II		← (4605)
Tu 12/18	Final Exam		← 1:30pm–3:30pm
Th 12/20	Term Papers		← (5605)

References

[Berkeley] George Berkeley (1710), *A Treatise Concerning the Principles of Human Knowledge*, Aaron Rhames.

[Read only sections 100–117.]

[Callender] Craig Callender (2000), "Shedding Light on Time," *Philosophy of Science* 67(Supplement): S587–S599.

[Read only sections 1, 2, and 4.]

[Hartle] James B. Hartle (2005), "The Physics of Now," *American Journal of Physics* 73(2): 101–109.

[Skip the appendix.]

[Hutton] Sarah Hutton (2012), "Between Newton and Leibniz: Emilie du Châtelet and Samuel Clarke," in *Emilie du Châtelet between Leibniz and Newton*, Ruth Hagengruber (ed.), Springer, pp. 77–95.

[Ismael] Jenann Ismael (2011), "Temporal Experience," in *The Oxford Handbook of Philosophy of Time*, Craig Callender (ed.), Oxford University Press, pp. 460–482.

[Skip sections 4 and 5.]

[Lewis] David Lewis (1976), "The Paradoxes of Time Travel," *American Philosophical Quarterly* 13(2): 145–152.

[Luminet] Jean-Pierre Luminet (2005), "A Cosmic Hall of Mirrors?" *Physics World* 18: 22–28.

[Magnus] P. D. Magnus (2005), "Reckoning the Shape of Everything: Underdetermination and Cosmotopology," *The British Journal for the Philosophy of Science* 56(3): 541–557.

[Norton] John D. Norton (2017), "Philosophical Significance of the Special Theory of Relativity, or, What does it all mean? Morals About Time," *Einstein for Everyone*, `http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/significance_3/index.html`.

[Poincaré] Henri Poincaré (1913), "The Measure of Time," in *The Foundations of Science (The Value of Science)*, Science Press, pp. 222–234. Originally published in 1898 as "La mesure du temps," *Revue de métaphysique et de morale* 6: 1–13.

[Putnam] Hilary Putnam (1967), "Time and Physical Geometry," *The Journal of Philosophy* 64(8): 240–247.

[Sklar ('74)] Lawrence Sklar (1974), "Incongruous Counterparts, Intrinsic Features, and the Substantiviality of Space," *The Journal of Philosophy* 71(9): 277–290.

[Sklar ('92)] Lawrence Sklar (1992), "How Do We Know the True Geometry of the World?" in *Philosophy of Physics*, Westview, pp. 53–69.

[Stein ('68)] Howard Stein (1968), "On Einstein-Minkowski Space-Time," *The Journal of Philosophy* 65(1): 5–23.

[Skip section 1.]

[Stein ('16)] Howard Stein (2016), "Newton's Metaphysics," in *The Cambridge Companion to Newton*, 2nd ed., I. Bernard Cohen and George E. Smith (eds.). Cambridge University Press, pp. 256–307.

[Read only pp. 263–272, stopping before the discussion of bodies.]

[Thomas] Emily Thomas (2013), "Catherine Cockburn on Substantival Space," *History of Philosophy Quarterly* 30(3): 195–214.

[Weingard] Robert Weingard (1979), "General Relativity and the Conceivability of Time Travel," *Philosophy of Science* 46(2): 328–332.