

# PHIL 4605/5605: Space and Time (Fall 2020, 3 units)

August 11, 2020

**Instructor:** Prof. Samuel C. Fletcher (scfletch@umn.edu)

**Preferred Address:** Prof. Fletcher, he/him

**Class Meetings:** Tu/Th 2:30–3:45 in Blegen 5 through Thanksgiving, then via Zoom

**Office Hours:** Tu/Th 1:00–2:00 and by appointment via Zoom

**Course Website:** <https://canvas.umn.edu/courses/191129>. I will send class announcements via Canvas, so please enable Canvas notifications so that you can know of them in a timely manner.

**Timely Communication:** I prefer that you contact me via Canvas Inbox or email, and will respond within two business days. I expect the same of any email or Canvas queries to you.

## 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 through 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 a means to complete notes for your electronic learning journal (on which more below in the section “Basis for Evaluation”).

**Required Technology:** Every class meeting after Thanksgiving will require the use of a laptop, desktop, or tablet computer with reliable, high-speed internet access, a webcam, microphone, and a recommended web browser (Mozilla Firefox or Google Chrome) that will allow you to access our course’s Canvas site. During lecture you are not required to turn on your webcam, but you are strongly encouraged to do so when in Zoom breakout rooms with your peers. If you anticipate having technology issues, please consult the UMN Information Technology page, “Working and Learning Off Campus.”

## 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. Our study will be partly historical—that is, focused on the business of reconstructing the philosophical views of past thinkers—but also partly topical. For the latter purposes we will often 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 Learning Journal (25%)** You will be responsible for keeping an “electronic learning 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? The prompts for these will be in Canvas, with one per class and the associated reading for that class. There will be *twenty-five* such “journal entries,” each worth 1%, due one day after the beginning of each class period. 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). I will accept journal entries up to 24 hours late but with a reduction in 1 point.

**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 one of the last two class sessions (12%). There is no restriction on what media you must use to construct your spacetime model. Since you will present your project over Zoom, you may decide to record a video or present it live; in either case, your Q&A period will be live. 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 be open-book, take place during the normally scheduled class period on Tuesday, October 20, 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 be open-book, take place online via Canvas quiz from 4:00 p.m.–6:00 p.m. on Monday, December 20, 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

In past versions of this course, I have applied a curve to exams. If I plan to do so this semester, I will notify you via Canvas announcement with details concerning how.

### How to Compute Your Letter Grade

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

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 the UMN policy library.

## **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’ Student Conduct Code. 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.” 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 during in-person meetings 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](http://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. 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 the UMN policy library.

The Office for Student Conduct and Academic Integrity has compiled a useful list of Frequently Asked Questions. If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class, e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

## **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 verified illness (inclusive of dependents), medical conditions relating to pregnancy, participation in intercollegiate athletic events, subpoenas, jury duty, military service, bereavement, religious observances, and participation in formal University system governance. Such circumstances do not include voting in local, state, or national elections. For complete information, please see the UMN policy library.

Under such legitimate circumstances leading a student to be absent for any exam or assignment, including class participation, that student must contact me at least two weeks in advance of the exam or assignment, or as soon as possible if the circumstances are known later, to schedule a make-up exam or assignment or an extension on the assignment deadline, as I deem appropriate.

## **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 the UMN policy library.

## **Sexual harassment, Sexual Assault, Stalking and Relationship Violence**

The University prohibits sexual misconduct, and encourages anyone experiencing sexual misconduct to access resources for personal support and reporting. If you want to speak confidentially with someone about an experience of sexual misconduct, please contact your campus resources including the Aurora Center, Boynton Mental Health or Student Counseling Services. If you want to report sexual misconduct, or have questions about the University's policies and procedures related to sexual misconduct, please contact your campus Title IX office or relevant policy contacts.

Instructors are required to share information they 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 personal support resources and options for investigation. You may talk to instructors about concerns related to sexual misconduct, and they will provide support and keep the information you share private to the extent possible given their University role.

For additional information, please consult the Board of Regents' policy on the matter.

## **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.

## **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. Students with short-term disabilities, such as a broken arm, can often work with instructors to *minimize* classroom barriers. In situations where additional assistance is needed, students should contact the DRC as noted above. If you are registered with the DRC and have a disability accommodation letter dated for this semester or this year, please contact me as early in the semester as possible to review how the accommodations will be applied in

the course. If you are registered with the DRC and have questions or concerns about your accommodations, please contact your access consultant or disability specialist. For more information, please see the DRC website.

## 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.

## 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. Peter Hanks (pwhanks@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                              | Comments |
|---------|----------------------------|--------------------------------------|----------|
|         | <b>Aristotle to Newton</b> |                                      |          |
| Tu 9/8  | Introduction/Space-Time    | Course Syllabus,<br>GRAB 1, SZE 10.2 |          |
| Th 9/10 | Aristotelian Space-Time    | PPST pp. 1–4,<br>GRAB 2              |          |

| Date                                      | Topic                               | Reading  | Comments                     |
|---|-------------------------------------|--|------------------------------|
| Tu 9/15                                   | Aristotelian Tradition to Descartes | SZE 5, McGinnis,<br>SZE 6                        |                              |
| Th 9/17                                   | Newtonian Space-Time                | SZE 10.3, PPST pp.<br>4–16, 24–34                |                              |
| Tu 9/22                                   | Newton's Space-Time Ontology        | SZE: <i>De Grav</i> , 7.1–2,<br>Domski           |                              |
| <b>Newton to Mach</b>                     |                                     |  |                              |
| Th 9/24                                   | Buckets and Frames                  | SZE: <i>Principia</i> , 7.3–5,<br>PPST pp. 17–24 |                              |
| Tu 9/29                                   | Leibniz-Clarke Correspondence       | PPST pp. 34–46,<br>SZE 8                         |                              |
| Th 10/1                                   | Du Châtelet's Reconciliation        | Du Châtelet, HWPS<br>website                     |                              |
| Tu 10/6                                   | Cockburn on Substantivalism         | Berkeley, Thomas                                 |                              |
| Th 10/8                                   | Machian Space-Time?                 | SZE 9  |                              |
| <b>Kant to Einstein</b>                   |                                     |  |                              |
| Tu 10/13                                  | Kant: Incongruent Counterparts      | SZE 11, Sklar ('74)                              |                              |
| Th 10/15                                  | Galilean Space-Time                 | PPST pp. 54–66,<br>SZE 10.4, GRAB 3              |                              |
| Tu 10/20                                  | Midterm Exam                        |  | ←                            |
| Th 10/22                                  | Special Relativity I                | GRAB 4–5,<br>PPST pp. 67–87                      |                              |
| Tu 10/27                                  | Special Relativity II               | ↑  |                              |
| Th 10/29                                  | Special Relativity III              | PPST pp. 87–111,<br>124–5, GRAB 6                |                              |
| <b>Implications of Special Relativity</b> |                                     |  |                              |
| Tu 11/3                                   | Special Relativity IV               | ↑  |                              |
| Th 11/5                                   | Conventionality of Simultaneity     | Norton, Poincaré                                 | project group<br>assignments |
| Tu 11/10                                  | Temporal Passage Lost?              | Putnam, Stein,<br>Callender                      |                              |
| Th 11/12                                  | Temporal Passage Regained? I        | Zimmerman, Skow                                  |                              |
| Tu 11/17                                  | Temporal Passage Regained? II       | Ismael, Hartle                                   |                              |

| Date   | Topic                          | Reading                            | Comments                 |
|--|--------------------------------|------------------------------------|--------------------------|
| <b>General Relativity and World Geometry</b> |                                |                                    |                          |
| Th 11/19                                     | General Relativity             | GRAB 7,<br>PPST pp. 126–40         |                          |
| Tu 11/24                                     | Black Holes                    | PPST pp. 140–6<br>GRAB 8           | project meetings         |
| Th 11/26                                     |                                |                                    | Thanksgiving             |
| Tu 12/1                                      | Time Travel                    | PPST pp. 153–65<br>Lewis, Weingard |                          |
| Th 12/3                                      | Underdetermination of Geometry | Magnus, Luminet                    |                          |
| Tu 12/8                                      | Epistemology of Geometry       | SZE 13, Sklar ('92)                | due: project description |
| Th 12/10                                     | Final Project Presentations I  |                                    | ← (4605)                 |
| Tu 12/15                                     | Final Project Presentations II |                                    | ← (4605)                 |
| Mo 12/21                                     | Final Exam                     |                                    | ← 4–6pm                  |
| We 12/23                                     | Term Papers                    |                                    | ← (5605)                 |

## References

- [Berkeley] George Berkeley (1710), *A Treatise Concerning the Principles of Human Knowledge*, Aaron Rhames.  
[Read only sections 110–117.]
- [Callender] Craig Callender (2000), “Shedding Light on Time,” *Philosophy of Science* 67(Supplement): S587–S599.  
[Read only sections 1, 2, and 4.]
- [Domski] Mary Domski (2010), “Newton’s Empiricism and Metaphysics,” *Philosophy Compass* 5(7): 525–534.
- [Du Châtelet] Émilie du Châtelet (1742), *Institutions de Physique: Nouvelle édition*, Paris.  
[Read chapters 5 (trans. Katherine Brading) and 6 (trans. Isabelle Bour and Judith P. Zinsser).]
- [Hartle] James B. Hartle (2005), “The Physics of Now,” *American Journal of Physics* 73(2): 101–109.  
[Skip the appendix.]

- [HWPS Website] History of Women Philosophers and Scientists (2017), “Du Châtelet’s *Foundations of Physics*: Reading Guide.” Paderborn University, Germany. <https://historyofwomenphilosophers.org/project/du-chatelets-foundations-of-physics/>.
- [Read only the guide for chapters 5 and 6.]
- [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.
- [McGinnis] Jon McGinnis (2018), “Arabic and Islamic Natural Philosophy and Natural Science,” in *The Stanford Encyclopedia of Philosophy* (Winter 2018 Edition), Edward N. Zalta (ed.), <https://plato.stanford.edu/archives/win2018/entries/arabic-islamic-natural/>.
- [Read only sections 2.4 and 2.5.]
- [Norton] John D. Norton (2018), “Philosophical Significance of the Special Theory of Relativity, or, What does it all mean? The Conventionality of Simultaneity,” *Einstein for Everyone*, [http://www.pitt.edu/~jdnorton/teaching/HPS\\_0410/chapters/significance\\_conv\\_sim/index.html](http://www.pitt.edu/~jdnorton/teaching/HPS_0410/chapters/significance_conv_sim/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.
- [Skow] Bradford Skow (2009), “Relativity and the Moving Spotlight,” *The Journal of Philosophy* 106(12): 666–678.

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

[Skip section 1.]

[Thomas] Emily Thomas (2013), “Catherine Cockburn on Substantial 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.

[Zimmerman] Dean Zimmerman (2008), “The Privileged Present: Defending an ‘A-Theory’ of Time” in *Contemporary Debates in Metaphysics*, Theodore Sider, John Hawthorne, and Dean W. Zimmerman (eds.). Oxford: Blackwell, pp. 211–225.