Space, Time, and Matter[1]
PHYS 419/420 and PHIL 419/420[2]
Spring 2020
(Revised in light of recent events involving COVID-19)

Time: One lecture (which may be a series of videos) will be posted to compass2g by 11:59pm CENTRAL TIME on Tuesdays and Thursdays (one lecture per day).
Location: Distance learning (online)
Professor: Dr. Christopher Gregory Weaver, Assistant Professor of Philosophy at the University of Illinois at Urbana-Champaign
E-mail: wgceave9@illinois.edu (I prefer to be contacted through email. Please see my email correspondence policy below.)
Office Hours and Location: Every Tuesday during the Spring 2020 academic semester 2:00pm to 3:00pm CENTRAL TIME through Zoom. Students will need to use Zoom to discuss course material with me during office hours. Please see the links here and here for instructions on how to use Zoom. I will send a download link to the Office Hour session by way of a Compass announcement every Tuesday at 1:50pm CENTRAL TIME. Zoom should be free for all University of Illinois students.
Prerequisites: The prerequisites for either PHIL/PHYS 419 or PHIL/PHYS 420 are: PHIL 101 and (either PHYS 101 or PHYS 211).
Credits: PHYS/PHIL 419 is worth 3 credits, and PHYS/PHIL 420 is worth 2 credits.
Course Compass 2g Webpage: Go to https://compass2g.illinois.edu and sign in.
Course Website: https://courses.physics.illinois.edu/phys419/sp2020/
Teaching Assistant #1: Instructor Varsha Subramanyan
Email: varshas2@illinois.edu
Office Hours: Every Friday morning from 9:30am to 10:30am **via Zoom**
Teaching Assistant #2: Instructor Nick Louzon
Email: nlouzon2@illinois.edu
Office Hours: Every Thursday from 11:00am to 12:00pm (noon) **via Zoom**
Teaching Assistant #3: Instructor Charles A. Byrne[3]
Email: bcharles@illinois.edu

I. Course Description

Space, Time, and Matter is an advanced and intensive history and philosophy of physics course that aims to: (a) introduce students to the history of both theoretical and experimental physics (more specifically, we will travel from scientific thought before Aristotle all the way to the development of the standard model of particle physics), (b) briefly introduce students to the basic formulae and accompanying (sometimes

[1] The Instructor reserves the right to adjust the course schedule in section V of the course syllabus when he deems that a change is necessary. Revised versions of the schedule will appear on the course compass2g webpage if revisions are made.

[2] Graduate students taking the graduate version of the course should speak with Instructor Weaver outside of class regarding their responsibilities and assignments.

[3] Instructor Byrne is a non-local teaching assistant. He will therefore not have office hours although one can reach him via email.

competing) interpretations of classical Newtonian mechanics, classical electrodynamics (both three-vector and relativistic versions), early kinetic theory, thermodynamics, (classical) Boltzmannian statistical mechanics, special relativity, general relativity, the standard Λ-CDM cosmological model, and both non-relativistic and relativistic quantum mechanics, (c) introduce students to debates in the foundations of physics, and (d) give special attention to philosophical debates concerning scientific realism and anti-realism, the relationship between the manifest and scientific images, and the nature of matter, space, time, and spacetime.

II. Learning Objectives

1. All students will be introduced to the topics mentioned in the course description.
2. All students will acquire substantive knowledge of the history of physics and natural philosophy before the 20th century.
3. All students will acquire substantive knowledge of the development of *modern* physics and its philosophy.
4. Students will be provided with a preliminary—though still substantive—picture of the scientific images of matter, space, time, and spacetime supplied by our best physical theories. They will be introduced to debates about the ontologies and interpretations of those physical theories as well.
5. All students will develop the skill of analyzing and synthesizing scientific and philosophical information for the purposes of generating new insights about physics, and the history and philosophy of physics.
6. Students enrolled in PHYS/PHIL 419 will develop and further hone their skills for writing an argumentative research paper defending a specific thesis on a topic peculiar to physics *and* (the history of physics or the philosophy of physics).

III. General Approach

What were in-class quizzes will now be five-point quizzes administered online. All lectures will be recorded and posted to Compass. I will post two lectures *per* week. You are required to view these lectures (I can track views on Compass). The midterm, final papers, and mini-essays will remain as is or as they were before spring break. The final exam will now be open book and open note. It will resemble the midterm. Please view the lectures the same week they are posted. **Subsequent to spring break, lecture notes and slides will no longer be posted to Compass**. Students will, instead, have recordings of Professor Weaver teaching new material. Students can use these recordings to help facilitate learning.

IV. Textbooks

The required textbooks for this course are:

1. Bruce J. Hunt, *Pursuing Power and Light: Technology and Physics from James Watt to Albert Einstein*. (Baltimore, MD: Johns Hopkins University Press, 2010). ISBN: 978-0801893599
    a. This text is abbreviated '**Hunt**' in the course schedule.

2. Hanoch Gutfreund and Jürgen Renn, *The Formative Years of Relativity: The History and Meaning of Einstein's Princeton Lectures*. (Princeton, NJ: Princeton University Press, 2017). ISBN: 978-0691174631
    a. This text is abbreviated '**G&R**' in the course schedule.
3. Roger Penrose, *The Road to Reality: A Complete Guide to the Laws of the Universe*. (New York, NY: Vintage Books, 2007). ISBN: 978-0679776314
    a. This text is abbreviated '**Penrose**' in the course schedule.
4. Helge Kragh, *Quantum Generations: A History of Physics in the Twentieth Century*. (Princeton, NJ: Princeton University Press, 1999). 978-0-691-09552-3
    a. This text is abbreviated '**Kragh**' in the course schedule.

V. 7th REVISED (03/28/2020) Course Schedule

Many of the readings listed in the course schedule are not in your textbooks. These items are or will be made available on Compass.

= **The History of both Physics and Natural Philosophy before the 20th Century**

= **The Development of Modern Physics and its Philosophy**

19. Tuesday, March 31st:

	➢ **Newton (1643-1727) and Modern Newtonian Mechanics**
	➢ **The History of STR**

a. Homework
- I. Bernard Cohen, "Newton's Concepts of Force and Mass, with Notes on the Laws of Motion." In *The Cambridge Companion to Newton*. 2nd Edition, edited by Robert Iliffe and George E. Smith. (Cambridge: Cambridge University Press, 2016), 61-92.
- R.C. Bless, *Discovering the Cosmos*. 2nd Edition. (Nerndon, VA: University Science Books, 2013), 135-158.
- **G&R**, 366-376.
- **Penrose,** 399-408, 412-439.

20. Thursday, April 2nd:

	➢ **Evangelista Torricelli (1608-1647)** ➢ **Pascal (1623-1662)** ➢ **Otto von Guericke (1602-1686)**
	➢ **Einstein, Minkowski (1864-1909), and STR**

a. Homework
   - **Kragh**, 87-92.
   - Peter Dear, *Discipline and Experience: The Mathematical Way in the Scientific Revolution*. (Chicago, IL: University of Chicago Press, 1995), 180-209.

21. Tuesday, April 7th:

	➢ **The Caloric Theory (Laplace to Dalton (1766-1844)**
	➢ **Lorentz and STR**

a. Homework
   - Hasok Chang, "Thermal Physics and Thermodynamics." In *The Oxford Handbook of the History of Physics*, edited by Jed Z. Buchwald and Robert Fox. (New York: Oxford University Press, 2013), 473-507.
   - **Hunt**, 4-24.

22. Thursday, April 9th:

	➢ **The Early Kinetic Theory (Bernoulli (1700-1782) to Joule (1818-1889))**
	➢ **Experimental Confirmations of STR**

a. Homework
   - **Hunt,** 25-35**.**
   - Emilio Segrè, *From X-Rays to Quarks: Modern Physicists and Their Discoveries*. (New York: Dover Publications, 1980), 78-100.

23. Tuesday, April 14th:

	➢ **Thomson (1824-1907), Clausius (1822-1888), and Thermodynamics** ➢ **The Ten Tenets of Modern Kinetic Theory**
	➢ **The History of GTR**

a. Homework:
   - **Hunt**, 36-67.
   - **G&R**, 25-45, 377-386.
   - Emilio Segrè, *From X-Rays to Quarks: Modern Physicists and Their Discoveries*. (New York: Dover Publications, 1980), 78-100.

24. Thursday, April 16th:

	➢ **Maxwell (1831-1879), Boltzmann (1844-1906), Gibbs (1839-1903), and Statistical Mechanics** ➢ **Modern Boltzmannian Statistical Mechanics**
	➢ **(Ran out of time)**

a. Homework
   - Emilio Segrè, *From Falling Bodies to Radio Waves: Classical Physicists and Their Discoveries*. (New York: Dover Publications, 1984), 233-251.
   - Theodore M. Porter, "Statistics and Physical Theories." In *The Cambridge History of Science: Volume 5 The Modern Physical and Mathematical Sciences*, edited by Mary Jo Nye. (Cambridge: Cambridge University Press, 2003), 488-504.
   - **G&R**, 94-105.

25. Tuesday, April 21st:

	➢ **Ten Tenets of Modern Kinetic Theory** ➢ **Alessandro Volta (1745-1827)** ➢ **Benjamin Franklin (1706-1790)**
	➢ **GTR** ➢ **The Genesis of Relativistic Cosmology**

a. Homework
   - **Hunt**, 68-73.
   - **G&R**, 46-105.
   - **Kragh,** 349-365.
   - Helge Kragh, "Cosmologies and Cosmogonies of Space and Time." In *The Cambridge History of Science: Volume 5 The Modern Physical and*

Mathematical Sciences, edited by Mary Jo Nye. (Cambridge: Cambridge University Press, 2003), 522-537.

26. Thursday, April 23rd:

	➢ **Maxwell and Modern Electrodynamics**
	➢ **The Development of Quantum Electrodynamics**

a. Homework
   - Bruce J. Hunt, "Electrical Theory and Practice in the Nineteenth Century." In *The Cambridge History of Science: Volume 5 The Modern Physical and Mathematical Sciences*, edited by Mary Jo Nye. (Cambridge: Cambridge University Press, 2003), 317-324.
   - Robert D. Purrington, *The Heroic Age: The Creation of Quantum Mechanics, 1925-1940*. (New York: Oxford University Press, 2018), 193-207.
   - **Kragh**, 332-339.
   - **Penrose**, 440-455.

27. Tuesday, April 28th:

	➢ **Relativistic Electrodynamics**
	➢ **The Weak Interaction** ➢ **Electroweak Theory** ➢ **Pions and Muons** ➢ **Leptons** ➢ **The Quark Model**

a. Homework
   - John David Jackson, *Classical Electrodynamics*. Third Edition. (New York: John Wiley and Sons, 1999), 514-532. This is a graduate level textbook on electrodynamics. The text, in entirety, is difficult. However, the section you are asked to read is mostly historical with some introductory comments about experimental confirmations of STR plus details about relativistic electrodynamics.
   - **Kragh**, 312-331, 339-344.
   - **Penrose**, 440-455, 627-644.

28. Thursday, April 30th:

	➢ **Lorentz and Heaviside (1850-1925)**
	➢ **The Development of Quantum Chromodynamics**

a. Homework
   - **Kragh**, 344-348.
   - **Penrose,** 645-654.

29. Tuesday, May 5th: Last Day of Class: Review and Student Evaluations
   a. Please finish your final papers.

VI. Things to Do

1. Assignments – (For students enrolled in PHIL 419 or PHYS 419, the assignments portion of the course is worth 15% of your course grade. For students enrolled in PHIL 420 or PHYS 420, the assignments portion of the course is worth 30% of your course grade.)
   a) Students will need to complete five-point quizzes **on Compass**. These quizzes will be **posted every Tuesday by 6:00pm CENTRAL TIME**. Responses to questions should be provided **by the immediately following Thursday at 2:00pm CENTRAL TIME**. The weekly five-point quizzes will be supplemented with a weekly mini-essay question (worth five points). So, every week one has to complete a 10-point quiz, five points of which can be earned by responding correctly to the questions/problems/challenges provided on a separate five-point quiz posted on Compass, and another five points of which can be earned by responding accurately/correctly to a mini-essay question provided via Compass. All portions of the weekly quizzes will be open book and open note. Mini-essay questions will be made available on **Tuesdays by <u>6:00pm</u> CENTRAL TIME**. **Responses to the essay questions should be provided in Compass by the immediately following Thursday at 2:00pm CENTRAL TIME**. Be sure to follow the instructions provided. Students are not allowed to work with each other.
2. Midterm – 30% (For All Students)
   a) Students will be required to take a midterm exam that will consist of four essay questions. The midterm will be made available on Compass and will be open book and open note. Students are not allowed to work with each other. The midterm will be made available on **March 7th at 10:00pm CENTRAL TIME** and will be due on **March 13th at 10:00pm CENTRAL TIME**.
   b) Special instructions for the midterm will be provided on the midterm exam itself (*e.g.*, word limits, *etc.*).

3. Final Paper – 30% (For Students Enrolled in PHIL 419 or PHYS 419 **Only**)
    a) Directions
        - Your final paper should be on a topic covered in class or in one of the textbooks. Please have your final paper topic approved by Professor Weaver by **April 2nd**. To acquire approval of your topic, please email me with the subject heading "Final Paper Topic for Approval", then in the body of your email state the thesis you intend to argue for. Your thesis should be a completion of the following phrase: "I will argue that…".
        - The document should be single spaced, the text should be in a justified format, and in Times New Roman font, size 12, with one-inch margins. Please do not include a title page. Please do not include course information.
        - Please paginate your papers.
        - Please document your paper in the University of Chicago Manual of Style. It should include a bibliography.
        - All drafts of final papers are due in PDF format via Compass.
        - A late (required final draft) paper will receive a one-point reduction every hour it is late (*e.g.*, if your paper is 70 minutes late, your final paper will receive a one-point reduction).
    b) Drafts
        - Students enrolled in PHIL 419 or PHYS 419 are required to submit both a rough and final draft of their final paper assignment.
        - Rough drafts are due **April 23rd at 11:00am (morning) CENTRAL TIME**.
        - Comments on rough drafts will be returned via compass by **May 3rd**.
        - All students who submit a rough draft will receive comments on their rough drafts and will be expected to make revisions in light of those comments. The revised version of your paper constitutes the final draft.
        - Final drafts are due on **May 13th at 10:00pm CENTRAL TIME**.
        - The rough ***and*** final drafts of your paper should have a word count between 3,000 and 5,000 words.
        - Failing to turn in a rough draft can negatively affect the final draft grade.
4. Final Exam – (For students enrolled in PHIL 419 or PHYS 419, the final exam portion of the course is worth 15% of your course grade; For students enrolled in PHIL 420 or PHYS 420, the final exam portion of the course is worth 30% of your course grade.)
    a) Students will be required to take a final exam that will consist of four essay questions. The final exam will be made available on Compass and will be open book and open note. Students are not allowed to work with each other. The midterm will be made available on **May 7th at 10:00pm**

CENTRAL TIME and will be due on **Thursday, May 14th by 11:00am CENTRAL TIME.**

b) Special instructions for the final exam will be provided on the final exam itself (*e.g.*, word limits, *etc.*).

5. Class Participation – 10% (For all students)
   a) Class participation points include a possible 100 points in all. However, class participation grades are only worth 10% of your final grade. Class participation grades will be negatively affected if disrespect is shown to others. Also, class participation grades can be negatively affected by accumulating absences (see the table below):

Absence Amount	Penalty
3 unexcused absences	The student's class participation grade is reduced by half (50/100 points)
4 unexcused absences	The student's class participation grade is reduced by 75% (25/100 points)
5 unexcused absences	The student's class participation grade is reduced to a zero (0/100 points)
6 or more unexcused absences	Excessive unexcused absences numbering six or more in amount can result in further consequences as allowed by the Student Code and the appropriate UIUC administrative bodies
Between 6 and 8 excused absences	An incomplete grade and makeup work after the semester ends (pending UIUC administrative approval)
8 or more excused absences	Dr. Weaver seeks advice from the appropriate Dean's office to discuss how to proceed

Due to COVID-19 and the shift to distance learning subsequent to spring break, it no longer makes sense to continue or track in-class presence (obviously).

VII. Current Academic Integrity Policy

To view the current academic integrity policy, visit the following link here (http://www.las.illinois.edu/students/integrity/). That policy is binding for this course. Please be sure to avoid plagiarism. Plagiarism is discussed and defined in the current academic integrity policy linked above. There are significant and serious consequences for committing plagiarism in this course.

VIII. Food, Cell Phone, and Computer use Policies

I do not allow students to consume food in class. If you would like to use an electronic device to take good notes, and you would like to make use of electronic copies of your reading and/or lecture notes, you may use your computer, tablet, or smart phone. Class participation grades will be reduced if Professor Weaver discovers that you are

interacting with non-course related material during class. Prior to the start of class, please silence all electronic devices.

IX. Email Correspondence Policy

All email correspondence with your instructor must be done using your academic (usually the one provided for you by the University of Illinois at Urbana-Champaign) email address (that's an email address ending with .edu). Email correspondence received from non-academic email addresses will be ignored. Email correspondence sent to any other email address besides wgceave9@illinois.edu in an attempt to communicate with me will be ignored. All email correspondence with Professor Weaver should include one's first and last name.

Students can expect to receive a reply to their emails within 24 hours on weekdays. If your email is sent after 5pm on Friday, or during the weekend you can expect a reply by 3:00pm the following Monday.

X. Academic Accommodations

The Division of Disability Resources and Educational Services has a webpage here (http://www.disability.illinois.edu/academic-support/accommodations). If one has need of academic accommodations, please speak with me outside of class.

XI. Grades

The regulations and policies of the grading system for undergraduates of the University of Illinois at Urbana-Champaign are explicated here.

XII. Grading Scale

The grade scale for PHIL 419, PHYS 419, PHIL 420, and PHYS 420 is provided below:

A+	**97.0% to 100%**	**C+**	**77% to 79.9%**
A	**93% to 96.9%**	**C**	**73% to 76.9%**
A-	**90% to 92.9%**	**C-**	**70% to 72.9%**
B+	**87% to 89.9%**	**D+**	**67% to 69.9%**
B	**83% to 86.9%**	**D**	**63% to 66.9%**
B-	**80% to 82.9%**	**D-**	**60% to 62.9%**

Any grade percentage below 60% is an F.[4]

[4] Again, if you are a graduate student taking the graduate version of the course, please speak with Professor Weaver outside of class regarding your assignments and duties. Thank you.