Philosophy of Space and Time

Syllabus

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OFFICE DATA

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Office Hours: MWF 12:00 - 1:00 p.m. and by appointment.
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EXAMS AND GRADING

- **Midterm Quiz:** Approximately after the first six weeks of lecturing. One hour in-class closed-book test, preceded by a review session;
- **Final Exam:** Standard 2hr closed-book class exam or a final term paper (essay on a course-related topic, determined after the Midtem Quiz) — exactly one of these two alternatives. (Class exam is preceded by a final review session.)
- **Contributions to Class Discussion:** Students are expected to discuss and analyze the concepts/theses presented during the lectures. Relative to class size, this may apply only partially.

Each of these performance inputs will contribute, in respective proportions of ca. 40%, 55%, and 5% to the final grade.

COURSE OUTLINE

I. Relativity and its Roots:

1. A world created by God: Pythagoras, Philolaus, Aristotle and Plato. The Pythagoras-Philolaus cosmological model of the Universe. Relationships between numbers, music and the world. Aristotle's Philosophy of Science.
2. A world seeking itself: Ptolemy, St. Augustine, and Aquinas. Ptolemaic geocentric system of cosmology. Roots of positivist philosophy of science.

3. A world subordinate to the Sun: Copernican revolution. Heliocentric cosmological models. Roots of relativism; what do Ptolemy and Copernicus really see—a sunrise or earth's motion?
4. A world subject to laws: Kepler's principles. Why Kepler's 'Fourth Law' is actually not a law?
5. Attack on Aristotelian Philosophy. Galileo's and Tycho Brahe's cosmological systems. Does modern science begin with Galileo?
6. A world subject to one universal law: Newtonian synthesis. Newton vs. Descartes: One calculates and the other explains. Newton vs. Leibniz: who was first?

II. Newtonian Physics:

1. The nature of matter, gravitational force and fields. What are matter and force according to Aristotle and Newton? Newton's axiomatic method.
2. Newton's metaphysics: Absolute space and absolute time. Leibnizean relationist metaphysics of space and time.
3. Philosophy behind the basic concepts of Newtonian physics.
4. Newton's laws of motion and their empirical interpretation.

III. Einstein's Special Relativity:

1. Minkowski geometry of space-time. Comparisons with Euclidean geometries of space and time.
2. The special principles of relativity and their consequences.
3. Newtonian and relativistic simultaneity.
4. The twin paradox and the problem of space-time intuition.
5. Empirical confirmation of special relativity.
6. Relativistic puzzles of space-time.

IV. Einstein's General Relativity:

1. The principle of equivalence.
2. Curved space-time: a new interpretation of gravitational and inertial forces. Einstein's field equations: The Final Theory.
3. Consequences and limitations of general relativity. Is general relativity complete?
4. Empirical confirmation of general relativity.

5. Comparison with Newtonian theory. Philosophical puzzles of general relativity.

V. Relativistic Cosmologies:

1. Definitions and botany of cosmological models.
2. The Big Bang Model, its alternatives and testing.
3. Gravitational collapse and black holes. Species of black holes.
4. Stellar structure and evolution.
5. Possible solutions to gravitational equations: elliptical, hyperbolic and Euclidean. What to believe: The accepted solution.
6. The Origin and Fate of the Universe.
7. The Universe as a whole and relativistic time travel.

VI. Unified Field Theories:

1. Four known species of forces and fields.
2. The essence of quantum theory: Principles and classification of elementary particles.
3. The principal claims of unified and grand unified field theories.
4. Superstrings and the theory of everything.
5. Where do we go from here: has the universe a destiny, beginning and end? Can there be a complete theory of 'everything'?

READINGS

- **Pre-relativistic cosmological and space-time models:**
  Durham F. and Purrington, R. D. : *Frame of the Universe*, Columbia University Press, New York 1983 or more recent, pbk.

- **Relativistic and post-relativistic cosmological and space-time models:**

  Hawking, S. : *A Brief History of Time*, From the Big Bang to Black Holes, Bantam Books, New York, 1990, pbk.

  Ferreira, P. G.: *The State of the Universe: A Primer in Modern Cosmology*, Weidenfeld & Nicolson, New York 2006, pbk.

These textbooks are available in the textbook section at Penn's B & N bookstore.