Philosophy of Space and Time

Syllabus

Zoltan Domotor

Department of Philosophy, University of Pennsylvania

Fall 2009

OFFICE DATA

Department of Philosophy, Cohen Hall 465, Ext: 8-6347 or 8-8564 or 8-8563.

Email: `zdomotor@sas.upenn.edu`

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

TA: Collin Anthony, collina@sas.upenn.edu

Department of Philosophy, 433 Cohen Hall, Ext 8-8564.

Office Hours: TBD

EXAMS AND GRADING

- **Midterm Quiz:** 1-hour, closed-book, in-class written exam, approximately after the first six weeks of lecturing (date and time will be announced later). Students will be required to answer five questions drawn from the lecture material and readings covered in class.
- **Final Exam:** Standard 2-hour closed-book in-class exam or a final 15+ pp. (double-spaced) term paper, exactly one of these two alternatives, chosen by the student seven days before the end of classes. In the in-class exam option, students will be asked to answer five questions drawn from the lecture material and readings covered in class after the midtem. Final-paper topic is chosen by the student, after consultation with the Instructor.
- **Contributions to Class Discussion:** Students are expected to discuss and analyze the concepts/theses presented during the lectures. Relative to class size, this may only apply partially.

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

COURSE OUTLINE

This self-contained course (presupposing no prior background in philosophy of science

nor any extensive knowledge of cosmology) provides an introduction to the chain of conceptually decisive paradigm shifts in theories of space and time, and cosmology, from ancient to modern periods.

A BRIEF GUIDE TO THE LECTURES

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 Concept of Space and Time. 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. Attack on Aristotelian Philosophy. Galileo's and Tycho Brahe's cosmological systems. Does modern science begin with Galileo?
5. A world subject to laws: Kepler's principles. Why Kepler's hoped-for 'Fourth Law' is actually not a law?
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. Newton's instantaneous action at a distance.
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 and gravitational field equations.
2. Curved space-time: a new interpretation of gravitational and inertial forces. Examination of 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.
6. Is substantivalism the correct metaphysics of relativistic spacetime?

V. Relativistic Cosmologies:

1. Definitions and the botany of cosmological models.
2. The Big Bang Model, its alternatives and modes of testing.
3. Gravitational collapse and black holes. Species of black holes.
4. Stellar structure and evolution. Hertzsprung-Russell diagram and nuclear burning cycles.
5. Possible solutions to gravitational field 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. Does relativity allow travel back in time?

VI. Relativistic Quantum Cosmologies:

1. Four known species of forces and fields.
2. The essence of quantum theory: Principles and classification of elementary particles. The standard model and its pros and cons.

3. 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? Do we need parallel universes? Can there be a complete theory of 'everything'?

REQUIRED READINGS

- **Pre-relativistic cosmological and space-time models:**

  Durham F. and Purrington, R. D. : *Frame of the Universe*, Columbia University Press, New York 1993, 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, 1998, pbk.

- **Philosophy of space and Time:**

  Dainton, Barry: *Time and Space*, McGill-Queens University Press, 2001, pbk.

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

SUPPLEMENTARY READINGS

Greene, B. : *The Elegant Universe*, 1999.

Greene, B. : *The Fabric of Cosmos*, Alfred A. Knopf, N.Y. 2004.

Singh, S. : *Big Bang: The Origin of the Universe*, Harper, N.Y. 2004.

Goldsmith, D. : *The Runaway Universe*, 2000.

Rohrlich, F. : *From Paradox to Reality*, Cambridge University Press, New York 1990, pbk, or more recent.

Holton, G. and Brush, S. G. :: *Physics, the Human Advanture*, Rutgers University Press, New Brunswick, New Jersey, 2001.

Friedman, M. : *Foundations of Space-Time Theories: Relativistic Physics and Philosophy of Science*, Princeton University Press, Princeton, New Jersey, 1983.

Some chapters from Supplementary Readings will be provided as handouts. A large body of philosophy-of-cosmology articles may be found at
`http://philsci-archive.pitt.edu`, `http://plato.stanford.edu` (alphabetic encyclopedia) and `http://www.scholar.google.com` These URL data may be particularly important to those students who plan to write a final paper.