

**SYLLABUS FOR THE COURSE
EINSTEIN AND HIS THEORY OF RELATIVITY
Carol Crowley and Sam Ventres, Coordinators**

OCTOBER 19

SESSION 1: Carol Crowley

Introductions, Administrative details, Introduction to the Course

Why are we doing this?? Do I really want to know this stuff??

What is “modernism”? How does it relate to Einstein?

SESSION 2: Sam Ventres

Classical Reality: The State of Physical Science at the Turn of the Century

There were fundamental problems with what were considered well-established classical laws and theories from earlier centuries (the concepts of Newton, Faraday, and Maxwell). What were they?

Why did it take centuries to appreciate the problems with Newton’s Laws of Motion and Gravitation?

What are electromagnetic waves? Is visible light only one type of electromagnetic wave? Do they all travel at the same speed, c ?

Discuss the Principles of Conservation of Mass and Energy, which were considered fundamental before 1905.

What was known about the composition of matter at the turn of the century?

OCTOBER 26

SESSION 1: Jeffrey Newman

Einstein’s early life; his personality and psychology

What was going on in the world when Einstein grew up in Germany, Italy, and Switzerland before 1905?

What aspects of Einstein’s personality and psychology enabled him to produce such revolutionary work?

Music had a special significance in Einstein’s life – how so?

Discuss Einstein's relationships with his professors, sister, wives, children, step-daughters, friends, and colleagues.

Why did he become, not only the most famous scientist of the 20th century, but also a celebrity with "rock star" status in America?

SESSION 2: Don Harper

Relativistic Reality: Einstein's early interest in theoretical physics

Why did Einstein become a theorist rather than an experimentalist?

Who were some of the great theoretical physicists of the day who inspired Einstein?

Einstein did not get good grades at the Zurich Polytechnic and he had no luck getting an academic job when he graduated. He became a patent clerk. Why did this actually turn out to be a positive turn of events for Einstein?

Einstein's first major achievements came in 1905, when he published four papers. The last two of these are the special theory of relativity and the equation $E=mc^2$, which is a consequence of special relativity. What were the first two papers about and why are they important?

NOVEMBER 2

SESSION 1: Baruch Kirschenbaum

Einstein's Politics

Einstein's political sentiments formed early in his life. Discuss this fact.

How did Einstein acquire his disdain for nationalism and his belief in pacifism?

Einstein was only 17 when he renounced his German citizenship and became "stateless". Why did he do this?

SESSION 2: Rich Rudert

Relativistic Reality: The Special Theory of Relativity

What is "special" about the Special Theory of Relativity? What is "special" about constant velocity motion?

Why is the speed of light the same for all observers? Isn't this inconsistent with the laws of classical physics (Newton)?

Why can nothing go as fast as (or faster than) the speed of light?

Newton believed that distance (space) and time are fixed and absolute. Einstein reasoned that distance and time are different for observers who are in motion relative to one another. Explain.

The passage of time is slower for moving clocks relative to stationary clocks and this is true for biological clocks, mechanical clocks, and atomic clocks. The faster an object moves through space, the slower it moves through time. How so??

Why is all this so hard for us earthlings to understand?!

NOVEMBER 9

SESSION 1: Francine Robbins Einstein, Anti-Semitism, and Zionism

Einstein's feelings about religion were distinct and developed separately from his identification as a Jew. Discuss the resurgence of Anti-Semitism in Europe after WWI and how it affected Einstein.

Discuss the Zionist movement and its appeal to Einstein. Wasn't this totally opposite to his disdain for nationalism?

What happened in Germany, in general and to him personally, in the early thirties to convince Einstein that he needed to leave Germany in 1932?

The Nazis denigrated Einstein's theory by calling it "Jewish science". Is there any sense in which this might actually be true, that Einstein was, in fact, influenced by Talmudic philosophy?

SESSION 2: Relativistic Reality: The General Theory of Relativity

Einstein was confident of the veracity of special relativity, which tells us that NOTHING – no object, no information, no signal, no influence of any kind – can be transmitted faster than the speed of light. That created a problem for our understanding of gravity. How so and how did Einstein resolve this problem?

Einstein's recognition of the equivalence between accelerating motion and gravity was pivotal in the development of the General Theory. How so?

Why do a marble, a baseball, and a cannonball all fall vertically at the same rate when those same objects, if set into motion horizontally by an equal force, would all move at different velocities and go different distances?

The shortest distance between two points in a region of space where gravity exists is not a straight line – What!?!?

How did the total eclipse of the sun in 1919 confirm Einstein's General Theory?

What predictions followed from Einstein's General Theory and how did they wind up proving the theory?

How did Einstein's General Theory solve a problem concerning the orbit of the planet Mercury?

NOVEMBER 16

SESSION 1: Edith Kur Einstein and Religion

Did Einstein believe in God? What was his conception of God?

Why did Einstein characterize himself a “deeply religious nonbeliever”?

Einstein said, “I believe in Spinoza's God, who reveals himself in the lawful harmony of the world, not in a God who concerns himself with the fate and the doings of mankind.”

SESSION 2: Martha Cussler Quantum Reality

What are atoms made of?

What forces hold subatomic particles together?

What is the Uncertainty Principle? Why did it disturb Einstein so much?

How does Quantum Mechanics once again introduce the possibility of influence at a distance?

Discuss the Einstein-Podolsky-Rosen paper (1935) and its challenge to Quantum Mechanics. What was the response of the supporters of QM?

NOVEMBER 23

SESSION 1: Einstein and the Public/The Nobel Prize – George Champlin

Why did Einstein achieve rock-star celebrity? How did he feel about this status? Did other scientists become celebrities?

Discuss the political and personal factors that prevented Einstein from winning the Nobel Prize until 1921.

SESSION 2:

The Search for Unified Reality; Einstein in Princeton – Marilyn Kaplan

Why did Einstein choose The Institute for Advanced Studies in Princeton as his final academic home?

Why was Einstein so concerned about finding a “unified theory” or “theory of everything”?

Under what circumstances does the conflict between quantum mechanics and relativity become relevant?

Are we any closer to a unified theory today? Describe some of the candidates.

NOVEMBER 30

SESSION 1: Linda Guccione

Einstein and The Atomic Bomb

What role did Einstein play in the development of the Atomic Bomb?

Why was he not selected to work with others on the Manhattan Project to develop the bomb in the USA? How did Einstein feel about this? Who was selected? What event kick-started this project in the USA? What role did Neils Bohr play in the development of the atomic bomb in the USA?

Discuss the German program to develop the atomic bomb under the direction of Werner Heisenberg. Where did Germany get the uranium? What was the importance of heavy water in the atomic bomb and how did the Germans plan to obtain it? How did politics play a role?

Discuss the play, *Copenhagen*, by Michael Frayn, in which physics and politics interact as the terrible consequences of Einstein’s equation become clear. (This was also a TV movie produced by the BBC and aired on PBS. YouTube videos are available, as is a DVD.)

How do the physics underlying the atomic bomb directly use the equation $E=mc^2$?

How was the decision to use the bomb against Japan made? How did the scientists feel about the decision?

Our sun and all the other stars explode the equivalent of many million atomic bombs every second. $E=mc^2$ applies throughout the universe. Explain how stars convert mass into energy. How will the sun burn out and - yikes!! – when?

SESSION 2: Cosmological Reality

How old is the Universe? How did it begin? What contribution did Einstein make to our current thinking about this? What contribution did the astronomer, Edwin Hubble, make to our understanding of the origin of the Universe?

What is the evidence to support this theory of the origin of the Universe?

What did Einstein consider his greatest blunder concerning the nature of the Universe? Is it still considered a blunder?

What are the differences between inflationary cosmology, the current preferred theory about the origin of the universe, and the standard big bang theory? What facts does the former address that makes it the favored theory at the present time?

What are the theories about how the Universe will end?

What are black holes? What are worm holes?

What is “dark matter”? Why is it important to theories about the end of the Universe?

How does the “arrow of time”, our sense that time proceeds from past to present to future, derive from inflationary cosmology.

Several years ago much was made of the discovery of the “god particle”, the Higgs boson, in the Large Hadron Collider in Geneva. What is this particle and why is it called “the god particle”?

DECEMBER 7

SESSION 1: The Entire Class Einstein’s Bon Mots

“A foolish faith in authority is the worst enemy of truth”. (1901)

“Anything truly novel is invented only during one’s youth. Later one becomes more experienced, more famous – and more blockheaded.” (1919)

“To punish me for my contempt of authority, Fate has made me an authority myself.” (1919)

“Two things are infinite: the universe and human stupidity; and I'm not sure about the the universe.”

“The value of a college education is not the learning of many facts, but the training of the mind to think.”

“Science without religion is lame; religion without science is blind.”

“Imagination is more important than knowledge. Knowledge is limited. Imagination encircles the world.”

The most beautiful experience we can have is the mysterious. It is the fundamental emotion which stands at the cradle of true art and true science. Whoever does not know it and can no longer wonder, no longer marvel is as good as dead....”

“If my theory of relativity is proven successful, Germany will claim me as a German and France will declare that I am a citizen of the world. Should my theory prove untrue, France will say that I am a German and Germany will declare that I am a Jew.” (1922)

“Life is like riding a bicycle. To keep your balance, you must keep moving.” (1927)

“The eternal mystery of the world is its comprehensibility. The fact that it is comprehensible is a miracle.” (1936)

“Then there are the fanatical atheists whose intolerance is the same as that of the religious fanatics, and it springs from the same source.” (1941)

“I hold that mankind is approaching an era in which peace treaties will not only be recorded on paper, but will also become inscribed in the hearts of men.” (1946)

SESSION 2: The Entire Class

Einstein’s Legacy

What are some of the legacies of Einstein’s work that are familiar to us today? (Hint: GPS, smoke detectors, non-electric Exit signs, PET scanners. radiation therapy for cancer, carbon dating, lasers)

One of Einstein's most important legacies, gravitational lensing, results from a "little calculation" that he was reluctant to even publish because he felt it was so minor. What is gravitational lensing and why is a useful tool for cosmologists working today?

There are those, even today, who would discredit the theory of relativity. Among them are creation scientists and others in the right wing of the American conservative movement. What are their arguments?