Natural Science I: Einstein's Universe V55.0204
Fall 2018 Meyer 121

Tuesday and Thursday
11:00 – 12:15 p.m.
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Office hours: By appointment

A photograph of Einstein taken in 1912.

"The distinction between past, present, and future is only an illusion, even if a stubborn one." – Albert Einstein

"What I'm really interested in is whether God could have made the world in a different way; that is, whether the necessity of logical simplicity leaves any freedom at all." – Albert Einstein

"There is no better illustration of the unpredictable payback of fundamental science than the story of Albert Einstein and the Global Positioning System… the next time your plane approaches an airport in bad weather, and you just happen to be wondering "what good is basic science," think about Einstein and the GPS tracker in the cockpit, guiding you to a safe landing." – Clifford Will

The laws of physics are the same regardless of your motion. That's the theory of relativity. Though the statement of the relativity principle is simple, the implications of it will challenge your notions of space, time, energy, mass and gravity. This course is a historical presentation of relativity including its applications to astrophysics and cosmology. Some of the topics we will study are:

- Our place in the Universe
- Geocentric or heliocentric solar system
- The roots of special relativity in electromagnetism
- My now is not your now: the relativity of simultaneity
- Time and space intervals are relative
- What's not relative about relativity
- $E=mc^2$
- What is the universe made of?
- Radioactivity and nucleosynthesis
- General relativity
- Expansion of the Universe
- Cosmology: the Big Bang
- The size and shape of the Universe
- The future of the Universe
- Dark matter and Dark Energy

We will also discuss the life of Einstein, who, unlike most scientists, became a very public figure. Your lab manual contains a chronology of the life of Einstein and in lecture we will see a documentary called *Einstein Revealed* that was made in 1996 and first shown on public television.

The course will consist of lectures, laboratory projects and homework problems. Homework is excellent preparation for all examinations. Homework assignments will be announced in class. The homework will be checked to see if everyone is keeping pace with the work, but they will not be graded.

Course texts

1. *Simply Einstein: Relativity Demystified* by Richard Wolfson, W.W. Norton and Co. This recently published volume gives a historical development of relativity before Einstein and sets the stage for Einstein's work and his special and general theories of relativity, along with the famous $E = mc^2$ formula.
2. *Big Bang* by Simon Singh, HarperCollins. Singh captures the excitement of both ancient and current cosmologies. The personalities of the scientists who have contributed to the Big Bang, as well as their efforts and insights, make for fascinating learning.
3. Recommended*: Einstein* by Walter Isaacson, Simon & Schuster This excellent biography intended for the general reader captures the many facets of the iconic Einstein: his politics, his religious beliefs, his personality, as well as his scientific achievements.
4. *Einstein's Universe Laboratory Manual.*

The video *Einstein Revealed* is also available on the second floor of Bobst Library in the Avery Fisher Center. The video will be presented in lecture (see lecture schedule.)

Mathematics

Galileo sought an understanding of nature on an empirical and mathematical description of physical reality. Natural science has followed his lead, so you will be required to use mathematics commonly treated in high school or middle school courses such as algebra, geometry, fractions, powers of numbers, the square root, and scientific notation.
The skills you will need; algebra, trigonometry, and quantitative reasoning, are described in a Math Review that is in the Course Documents folder on NYUClasses.

Course Examinations

There will be two examinations during the semester in addition to a cumulative final exam on Tuesday, December ?, from 10 to 11:50 am. The examination will be based on (a) lecture topics and (b) homework problems. Lectures will be based on the readings. Questions will be assigned each week and will form the basis of what you are responsible for from our twice-weekly meetings. Many of the questions are answered in the course readings. The exams will be in the multiple-choice format. You will need to bring a calculator to all exams.

Examination Schedule and Course Grade

First examination:	15%	**Thursday, October 16**
Second examination:	15%	**Thursday, November 15**
Laboratory:	25%	
Final examination:	35%	**Tuesday, December ?**
Homework	10 %	

The final exam period for the University runs from December 17 to 21. While there will be no make-up exams for those offered on October 16 and November 15, under exceptional circumstances a make-up final exam will be offered at the beginning of the Spring 2019 semester.

Laboratory Sessions

These weekly sessions are an important part of the course. You must be registered for one lab section. You will have to submit a lab report for each experiment performed. The lab report has to include answers to all questions and any data you may have collected. The lab report will be due in lab *one week* after the experiment has been performed. **The laboratory sessions will be held in Meyer 161 and begin on Monday, September 10.**

The laboratory sessions will be devoted to

1. Doing experiments
2. Discussing the homework problems.
3. Discussing the lecture questions.

Laboratory Schedule					
Section	**Day**	**Time**	**Section**	**Day**	**Time**
2	Monday	9:00 – 10:40 a.m.	6	Monday	5:00 – 6:40 p.m.
3	Monday	11:00 – 12:40p.m.	7	Tuesday	9:00 – 10:40 a.m.
4	Monday	1:00 – 2:40 p.m.			
5	Monday	3:00 – 4:40 p.m.			

The laboratory grade will be based on the following assignments:

Lab experiment and report	50%
Participation in homework/lecture question discussion sessions	50%
Total	100%

You must bring your written answers to the lecture questions to laboratory sessions devoted to discussing this work.

Attendance

If you arrive at least 10 minutes late for the lab session you will lose the participation credit for that lab session.

Absence Policy

Excused absences will only be given in the case of illness (with a doctor's note) or observation of a religious holiday. You must notify your lab instructor in advance in writing if you miss a lab due to religious reasons. All other absences will be considered unexcused and will result in a lab grade of zero. **You cannot make up a lab by attending a laboratory session that you are not registered for.**

Late Assignments

Late assignments will be penalized five points for each day late (excluding weekends). If you wish to submit a late lab report you must do so only at your laboratory instructor's office.

Lab Instructors

Each lab instructor will hold a weekly office hour where you can discuss lecture and laboratory material. Office locations and office hour time and day will be announced during the first

laboratory session.

Contact Information

Xingchen Xu sections 2,3 xx352@nyu.edu	Shiyan Hu sections 4,5 726 Broadway room 1043 xh837@nyu.edu
Christopher William Tiede sections 6,7 726 Broadway room 801 cwt271@nyu.edu	

Homework

Homework problems will be assigned each week on NYUClasses. Check the Assignments folder. You will submit the solutions to me via NYUClasses. The source of the homework will be text and lecture. Homework assignments are to help you understand the material and to prepare you for course examinations. Solutions to the HW problems will be posted.

Missed Exams

There are no make-up exams for students who miss one or both of the exams given during the semester. If you miss an exam because of illness, you must contact Dr. Budick by phone or email **before** the start of the exam and follow up with a doctor's note. If you miss an examination, for a valid reason (illness, injury or family emergency), your grade will be based on the following allocations:

Laboratory	25%
1 Midterm +	
Final examination (cumulative)	75%

Final Exam

A make-up for the final examination will be given under exceptional circumstances, which must be discussed with Dr. Budick before the examination. A doctor's note must be provided in the case of illness. In this case a grade of incomplete will be assigned and **the make-up will be scheduled for the beginning of the Spring 2019 semester**. Please avoid making travel plans before the date of the final exam. No alternative date for the final examination will be offered before the end of the Fall 2018 semester.

Religious Holidays

If you will be absent from lab for a religious holiday during the semester, you must inform your lab instructor *in advance*.

Class Web Site

A web site for this class exists and is accessible through your *NYUClasses* account.

- Email access to the lecturer, lab instructors and all students.
- Links to other web sites with information about topics discussed in the course.

Any questions on lecture topics, readings from the texts, homework problems or laboratory experiments can be submitted here at any time on any day (except when you are in class or lab of

course).

Weekly Schedule of Topics, Readings and Laboratories

Note: Homework problems will be assigned in lecture each week.

Date	***Lecture Topic***	***Reading***	***Weekly Lab***
T Sep 4	Introduction of the Course/Syllabus Review Geocentric theories of the solar system	Singh:Ch: 1 Wolfson: Ch. 1, 2	No lab
R Sep 6	Heliocentric theories, Kepler's Laws Newton's Laws Gravity	Singh Ch: 1, 2 Wolfson: Ch. 3	
R Sep 13	Wave motion and Interference Speed of light	Wolfson: Ch. 4 Singh: Ch. 2	M 9/10, T 9/11 Math Review
T Sep 18	The wavelength of visible light The Electromagnetic spectrum	Wolfson: Ch. 4 Singh: Ch. 3	
T Sep 25	Electric and magnetic fields The Ether	Wolfson: Ch. 5	M,T Kinematics
R Sep 27	Michelson-Morley and Relativity	Wolfson: Ch. 6 Singh: Ch. 2	
T Oct 2	The Postulates of Special Relativity	Wolfson: Ch. 7	M,T Newton's Second Law
R Oct 4	Relativity of Simultaneity Time Dilation Length Contraction	Wolfson: Ch. 8, 9,10 Singh:113-116	
T Oct 9	Lab, No lecture		Interference and Diffraction of Light
R Oct 11	*Review*		
T Oct 16	☹ **Exam 1** ☹		M,T Speed of Sound
R Oct 18	*Video: "Einstein Revealed" part 1*	Isaacson: Ch. 5	
T Oct 23	Past, Present, Future and … Elsewhere	Wolfson: Ch. 11	M,T Michelson Interferometer
R Oct 25	Faster than Light? $E = mc^2$ Everything is not relative Space-Time Interval	Wolfson: Ch. 12 Wolfson: Ch. 14	
T Oct 30	Radioactivity, mass to energy conversion, antimatter	Singh:158-159, 216 265-233, 373	M,T Special Relativity
R Nov 1	Nucleosynthesis, The curve of binding energy	handouts	
T Nov 6	A Problem of Gravity and the Principle of Equivalence General Relativity	Wolfson:Ch. 14 Isaacson: Ch. 9	M,T Photoelectric Effect
R Nov 8	Galaxies, The Great Debate	Singh: 116-163, 165-213,174-177	
T Nov 13	Cosmic distances, Cepheid Variables	Singh: 195-213	M,T Exam Review
R Nov 15	☹ **Exam 2** ☹		
T Nov 20 R Nov 22	*Video: "Einstein Revealed" part 2* *No Lecture*	Wolfson: Ch. 14 Isaacson: Ch. 18, 19	M,T Principle of Equivalence
T Nov 27	The Cosmological Principle Velocities of Galaxies Hubble's Law	Singh: 237-263 Handouts	M,T Hubble's Law The Expanding Universe
R Nov 29	Early 20th century universes	Singh:141-161, handouts	
T Dec 4	The Big Bang Cosmology I	Wolfson: Ch. 15	M,T Observing the

	Cosmic Microwave Background	Singh: 357-401	Cosmo- Logical Redshift
R Dec 6	The Big Bang Cosmology II The size and shape of the universe	Singh: 401-465	M,T Exam Review
T Dec 11	Inflation, Abundance of the Elements	Singh: Epilogue Wolfson: Ch. 16	M, T Review
R Dec 13	Evidence for the Big Bang Dark matter and Dark Energy Review	Wolfson: Ch. 16 Singh: 479-482, Epilogue	
Dec 17-21	**Final Exam ?**		