Natural Science I: Einstein's Universe V55.0204
Summer 2014 Meyer 102

Tuesday and Thursday
2:00 – 5:00 p.m.
Dr. Burton Budick
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Office Phone: (212)-998-7683
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Office hours: Wednesday 2:15-3:15 pm
Or 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 posted in the Assignments folder. 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.

Course Examinations

There will be one midterm examination during the semester in addition to a cumulative final exam on Thursday July 3 from 3-5 pm. The examinations will be based on (a) lecture topics and (b) homework problems. Lectures will be based on the readings and on the handouts. Questions will be handed out each week in lecture 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 and a number 2 pencil to all exams.

Examination Schedule and Course Grade

First examination:	25%	**Thursday, June 12 3:45-5 pm**
Laboratory:	25%	
Final examination:	50%	Thursday **July 3 3:40-5:00 pm**

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 session* after the experiment has been performed. **The laboratory sessions will be held in Silver 203 and will begin on Wednesday, May 28.**
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	MW	10:00 – 12:00 a.m.	3	MW	1:30 –3:30 p.m.

The laboratory grade will be based on the following assignments:

Lab experiment and report	70%
Participation in homework/lecture question discussion sessions	30%
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
The 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

Ekta Patel Email: ep1091@nyu.edu Office: Meyer 537 Office hour Friday 10:00-11:30 am	

Homework

Homework problems will be assigned each week in lecture. The source of the homework will be course handouts. Homework assignments are to help you understand the material and to prepare you for course examinations. They will not be graded, but you will be asked to show your homework to your lab instructor each week to show that you are keeping up with the coursework.

Lecture Questions

The lectures are built on questions that scientists have pursued over the course of the history of physics. In order to help you organize the course material and to let you know what you are responsible for, question sheets will be handed out twice each week. Examinations will be built on these questions, and on the homework, so you should write out the answers to these questions each week. *You must bring your written answers to the lecture questions to laboratory sessions devoted to discussing this work.* You will be asked to discuss your answers in laboratory.

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%
Final examination (cumulative)	75%

Final Exam

Please avoid making travel plans before the date of the final exam. No alternative date for the final examination will be offered.

Class Web Site

A web site for this class exists and is accessible through your *NYUHome* account or by going to NYUClasses and logging on using your netID and the same password as that of your NYU email account. You must have an active NYU email account to access the site.
Aside from a copy of the syllabus you will find folders labeled, Resources, Assignments and Announcements.

Weekly Schedule of Topics, Readings and Laboratories

Note: Homework problems and due dates will be in the Assignments Folder.

Date	*Lecture Topic*	*Reading*	*Weekly Lab*
T May 27	Introduction of the Course/Syllabus Review Geocentric theories of the solar system	Singh:: 1-36 Wolfson: Ch. 1, 2	W 5/28 MATH Review
T May 27	Heliocentric theories, Kepler's Laws Newton's Laws Gravity	Singh : 37-84 Wolfson: Ch. 3	
R May 29	Wave motion and Interference Speed of light The wavelength of visible light	Wolfson: Ch. 4 Singh: 87-92,229-236	W 5/28 Kinematics
R May 29	Electric and magnetic fields Electromagnetic waves	Wolfson: Ch. 5 Singh: 85-98	
T June 3	The Ether Michelson-Morley and Relativity	Wolfson: Ch. 6 Singh: 99-112	M 6/2 Newton's Second Law
T June 3	The Postulates of Special Relativity Relativity of Simultaneity	Wolfson: Ch. 7, 10	
R June 5	Time Dilation Length Contraction	Wolfson: Ch. 8,9 Singh: 113-116	W 6/4 Young's Experiment
R June 5	Faster than Light? $E = mc^2$	Wolfson: Ch. 12	M 6/9 Michelson Interferometer
T June 10	Past, Present, Future and … Elsewhere	Wolfson:Ch. 11	W 6/11 Homework/Lecture Questions Discussion
T June 10	*Video: "Einstein Revealed" part 1*	Isaacson: Ch. 5	
R June 12	**REVIEW**		
R June 12	**☹ Exam 1 ☹ 3:45- 5 pm**		
T June 17	Radioactivity, mass to energy conversion, antimatter Nucleosynthesis, The curve of binding energy	Singh: 158-159, 216, 265-353,473*handouts*	M 6/16 Spectroscopic Analysis of Light
T June 17	A Problem of Gravity and the Principle of Equivalence General Relativity	Wolfson: Ch. 14 Isaacson: Ch. 9	
R June 19	Galaxies, The Great Debate Cosmic distances, Cepheid Variables	Singh: 116-163, 165-213,174-177,195-213	W 6/18 Principle of Equivalence
R June 19	*Video: "Einstein Revealed" part 2*	Wolfson: Ch. 14 Isaacson: Ch. 18, 19	
T June 24	The Cosmological Principle Velocities of Galaxies Hubble's Law	Singh: 237-263 Handouts	M 6/23 Hubble's Law
T June 24	Big Bang Cosmology Evidence for the Big Bang Cosmic Microwave background	Wolfson: Ch. 15 Singh: 357-401	
R June 26	Abundance of the elements	Handouts	W 6/25 Homework/Lecture Questions Discussion
R June 26	Early 20th century universes	Singh: 144-161 Handouts	
T July 1	*The size, shape and future of the Universe*	Singh: 401-465	M 6/30 Observing the Cosmological Redshift
T July 1	**Inflation, dark matter and dark energy** **REVIEW**	Wolfson:Ch. 16 Singh: 479-482 Singh: Epilogue	W 7/2 Homework/Lecture Questions Discussion
R July 3	**More Review FINAL Exam 3:40- 5:00 pm**		