Relativity of Space and Time in Popular Science

Astron 9 Summer 2017
Jul 3 - Aug 11

Instructor:	Richard Anantua	**Time** (x^0) :	M,W,F 13:30 – 16:00
Email:	ranantua@berkeley.edu	**Place** (x^i) :	Campbell Hall: Rm 121

Course Pages:

1. http://richardanantua.com/teaching/

Required Materials:

- *Interstellar* movie: http://www.imdb.com/title/tt0816692/ (2014)
- Edwin Abbot, *Flatland: A Romance of Many Dimensions* : http://www.gutenberg.org/ebooks/201 (1884)
- H. G. Wells, *The Time Machine* : http://www.planetpublish.com/wp-content/uploads/2011/11/The_Time_Machine_NT.pdf (1895)
- *Predestination* movie : http://www.imdb.com/title/tt2397535/ (2014)

Objectives:

This course is primarily designed as an introductory survey course for undergraduate students– not necessarily physics or astronomy majors– with some background in classical mechanics and electromagnetism, to a pillar of modern physics: relativity. Popular science will be used to motivate and reinforce quantitative concepts by means of often vivid and engaging illustrations, often with a hint of social commentary. Throughout the course, we will also appreciate primary sources such as Einstein's *Electrodynamics of Moving Bodies* as well as seminal historical developments such as Hubble's measurement of the expansion rate of the Universe and discovery of the accelerating expansion of the Universe through observations of distant supernovae (2011 Nobel Prize). Collaboration in groups is encouraged for classwork and homework (provided students write up individualized solutions).

Prerequisites:

Some understanding of undergraduate-level concepts in classical mechanics, electromagnetism, differential equations and linear algebra is assumed (course exams and projects will not require semester-long course background in these subjects). A brief introduction of these subjects and some of the requisite mathematics will be provided for the uninitiated when such tools are required to enhance our understanding of relativity.

More informally, do you know what is a vector? If not, you probably do not have the background to be comfortable with the material in this course. Do you know what a vector is– *in the context of relativity*– (Hint: (ct,x,y,z) but not (x,y,z))? If so, you might be slightly advanced. Do you never mix up covariant and contravariant indices? If so, you will probably be bored here.

Tentative Course Outline:

Week 1: July 3-7
Group Jeopardy; Review of Math Methods (Linear Algebra, Differential Equations), Classical Mechanics and Electromagnetism; Intro to Special Relativity (Postulates, Lorentz Transformations, Time Dilation); *Interstellar*

Week 2: July 10-14
Special Relativity (Length Contraction, Relativity of Simultaneity); Intro to General Relativity (Black Holes, Equivalence Principle, Gravitational Time Dilation); *Flatland : A Romance of Many Dimensions*; Relativity vs. Common Sense: Editing the Manuscript of an Einstein Denier; **PSet 1** (Review, Falling into a Black Hole, *Interstellar*)

Week 3: July 17-21
Special Relativity (Spacetime Diagrams); General Relativity (Geometry of Spacetime); Tensor Analysis; *The Time Machine*; **PSet 2** (Spacetime Interval, Geodesics, Twins Paradox, *Flatland*, *The Time Machine Chs. 1-4*)

Week 4: July 24-28
Experimental Verification of: Time Dilation (Flying Atomic Clocks, μ-Decay), Einsteinian Gravity (Light Bending Around Stars, LIGO); **Midterm Project** (12-Min PowerPoint Presentations and 3-4 p. Create Your Own Popular Science or Science Fiction Article)

Week 5: July 31-Aug 4
Predestination; General Relativity (Einstein Field Equation Solutions, Closed Timelike Curves); Experimental Verification of: Expanding Universe (Hubble's Law, Reiss, Schmidt & Perlmutter); **PSet 3** (Spacetime Curvature, Causal Loops, *The Time Machine*, *Predestination*)

Week 6: Aug 7-Aug 11
Course Review; Future of Science (Worldmapper: Research Output Across Earth; Representation of Women and URM); **In-Class Final Exam**

Grading Policy: Homework (30%), Midterm (30%) (15% Presentation, 15% Paper), Final Exam (30%), Class Participation (10%).

Important Dates:

PSet#1 ..... F 17:00 Jul 14
PSet#2 ..... F 17:00 Jul 21
Midterm Presentation ..... W Jul 26
Midterm Paper ..... F 17:00 Jul 28
PSet#3 ..... F 17:00 Aug 4
Final Exam ..... W Aug 9

Class Policy:

- Regular attendance is essential and expected.
- Late homework will be penalized 50% pts/wk without instructor permission in advance of the deadline.

Academic Honesty: https://asuc.org/honorcode/index.php