

Introduction to String Theory

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Course Information:

PHY 372, Fall 2015

Time: Wednesdays 7pm-9:30 pm

Location: Room 512, Physics Building

Website: <https://coursesite.lehigh.edu/>

Course Description

This course is an introduction to string theory for upper-level undergraduates and beginning graduate students. Building on concepts from Einstein's theory of general relativity and quantum theory, the course will expose students to the fundamentals of string theory and to some of the latest developments in the field. Advanced topics such as D-branes, non-perturbative dualities and holography will also be covered. The material will be accessible to students who have a working knowledge of quantum mechanics and special relativity, and have had some exposure to general relativity.

Required Textbook

"A first course in string theory" by Barton Zwiebach.

Additional References (not required, of various levels)

- "The Little Book of String Theory" by Steven S. Gubser (introductory level)
- "String Theory For Dummies" by A. Z. Jones and D. Robbins (introductory level)
- "String Theory", Volumes I and II, by Joseph Polchinski (advanced, requires knowledge of QFT)
- "String Theory in a Nutshell" by Elias Kiritsis (advanced, requires knowledge of QFT)
- "Supersymmetry and String Theory: Beyond the Standard Model" by Michael Dine (advanced)
- Useful Websites:
 - <http://www.superstringtheory.com/>
 - <http://www.sukidog.com/jpierre/strings/>
 - <https://www.quantamagazine.org/20150803-physics-theories-map/>
 - <http://whystringtheory.com/>

Course Objectives:

- Gain an appreciation for the main concepts of quantum gravity and string theory, and how they relate to high energy physics, early universe cosmology and quantum field theories more generally.
- Learn the basic analytical and technical skills needed to approach simple problems in general relativity and string theory.

- Learn to perform literature searches and present your work to a wide audience, by preparing written and oral presentations, as well as writing up research-style papers.

Course Requirements:

- **Homework** will be assigned on a weekly basis.
- **Final Paper** to hand in on the last day of classes. Each student should choose a topic they find fascinating and inspiring, related to anything discussed in class, and write a review paper on the subject, appropriately citing background material. A list of possible topics will be provided by the instructor as a guide, but students are free to choose their own topic.
- **Presentation** (a poster for undergraduates, a talk for graduate students) on the topic chosen for the Final Paper. The purpose of the presentation is to help students think critically about how they would structure their final paper, and to learn to present material in front of a wide audience. This is a skill that they will find useful as they progress in their career. We will reserve two lectures around the middle of the semester for this purpose.

Grading:

Students will be graded on the basis of class participation, homework assignments, quality and depth of their presentation and writing assignment. The grades will be determined as follows:

- Homework 40%
- Mid-semester presentation 20%
- Final paper 30%
- Class participation 10%

Grading Scale

A = 88 – 100

B = 75 – 87

C = 60 – 74

D = 50 – 60

Feedback

Students in this class come from very different backgrounds and are at different stages of their career. For this reason, it is important for you to give me feedback about the level of the course, and whether you find specific concepts or homework problems difficult, and why. This can help me readjust the course throughout the semester, and also pinpoint specific areas that might not be familiar to you. *Come and talk to me about anything you may be struggling with and give me your honest feedback!*

Accommodations for Students with Disabilities:

If you have a disability for which you are or may be requesting accommodations, please contact both your instructor and the Office of Academic Support Services, University Center C212 (610-758-4152) as early as possible in the semester. You must have documentation from the Academic Support Services office before accommodations can be granted.

The Principles of Our Equitable Community:

Lehigh University endorses The Principles of Our Equitable Community

[http://www.lehigh.edu/~inprv/initiatives/PrinciplesEquity_Sheet_v2_032212.pdf]. We expect each member of this class to acknowledge and practice these Principles. Respect for each other and for differing viewpoints is a vital component of the learning environment inside and outside the classroom.

Summary of Topics

- **Historical Introduction**
- **Special relativity and extra dimensions**
- **Electromagnetism in various dimensions and relativistic electrodynamics**
- **The relativistic point particle**
- **The relativistic string**
- **Parametrizing the motion of a string and its physical interpretation**
- **Vibrational modes of a string and quantization**
- **The graviton from string theory**
- **D-branes**
- **Black holes and thermodynamics**
- **Counting microstates of a black hole**
- **Holography and the gauge/gravity correspondence**
- **Cosmological models from string theory**
- **Building models of particle physics and the role of supersymmetry**