THE PHYSICS BEHIND THE INTERNET

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Course Content and Philosophy:

Summary

How does it all work? How can electrons traveling on copper conductors tell machines what to do? How does email work? How does wireless work? What is the physics of information and information transport that drive the global internet? How can we make the Internet go faster? What are the larger societal consequences of this technology?

These are some of the questions we will explicitly engage this term.

This course will consist of a number of thematic pieces and we will spend approximately 2 weeks on each of the 5 themes below:

- Communication and Information
- Electricity, circuits, transistors and semi-conductors
- Lasers and Light
- Internet Routing and Chaos
- Social Issues with respect to the Internet

Course Intent

Communication has always been central to the advancement of civilization. This advancement occurs when humans are able to create and distribute new ideas in an efficient manner. The role that technology plays in this advancement is usually taken for granted. The role that physics plays is completely ignored. Currently the Internet is the major communication tool of our modern society. Its impact is phenomenal in nature and it clearly is spawning a cultural revolution. Hidden to all but a few, the development of the Internet has been the direct result of a protracted evolution driven by advances in fundamental and applied physics. This course will explore these advances, thereby exposing students to the physical underpinnings of Internet technology. Further, we will examine how this evolutionary process has ignited an unprecedented entrepreneurial spirit in high technology industries and, at the same time, has raised serious sociological issues. Students will be encouraged to understand the impact of technology and technological revolutions in modern society using the Internet as the most relevant example.

Physics Milestones

In this introduction we will first explore the necessary concepts of classical and modern physics, starting with the Photo-electric effect, first understood by Einstein in 1905, and which later won him the Nobel prize. We will then examine the process which occurred over the next 45 years that lead to the development of the first transistor. Advanced in materials research fueled the rise of the semi-conductor industry in the 50's and 60's and we will explore the physical principles that were the foundation for this rise.

After the revolution in electronics came the revolution in photonics (the use of optical photons instead of electrons to send coherent signals). The major piece of physics in this chapter is the development of the laser and the eventually development of thin optical fibers to carry these signals over long distances. We will explore, through lectures and student run simulations, why it is that the information density is much higher in a packet of photons than in a packet of electrons. This of course,
is the basis for the determination of bandwidth that everyone hears about these days but few actually understand.

Method of Instruction

The steps leading to development of the Internet provide a textbook example of a technological revolution for which there is, as yet, no textbook. This is precisely what makes the subject so interesting and timely. We will assume no prior knowledge of physics, and an important goal of the course will be science literacy in the context of an important modern technology. Relevant readings will be assigned and these readings are all available in digital form. This class will make heavy use of the provided wireless laptops in this space to engage students with various simulations and exercises related to the topic at hand.

Course Requirements and Grading

Consistent attendance of lectures is strongly encouraged.

Grading procedure:

- In class participation 15%
- Midterm 20%
- Homework assignments 40%
- Final 25%

Math Required:

This course will not be very technical, although some mathematical descriptions will be absolutely necessary. Grading techniques, however, will be designed so that people with weak math backgrounds or abilities will not be penalized.