APPH E4901 & E4903 Applied Physics Seminar

Fall 2015 Theme

Innovation and science to advance our national energy and climate goals

(a.k.a. "How can scientific and technical innovations help solve the world's energy-climate crisis?)

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General | Theme | Grading | Syllabus | GRE | Innovation Teams | Links

General

Welcome to the APPH E4901 & E4903 *Applied Physics Seminar* class information site. ***MW 11:40 - 12:55 Room 327 S. W. Mudd***

APPH E4901x *Applied Physics Seminar* 1 pt. Discussion of specific and self-contained problems in areas such as applied EM, physics of solids, and plasma physics. Topics change yearly. This course is usually reserved for third-year students majoring in Applied Physics.

APPH E4903x *Applied Physics Seminar* 2 pt. Involves students in all of the discussions that are part of **APPH E4901**, but also involves the preparation of a formal term paper or presentation on a research topic of the student's choice. This course is usually reserved for graduating seniors majoring in Applied Physics.

Topics change every year and are designed to introduce students in to current research in applied physics.

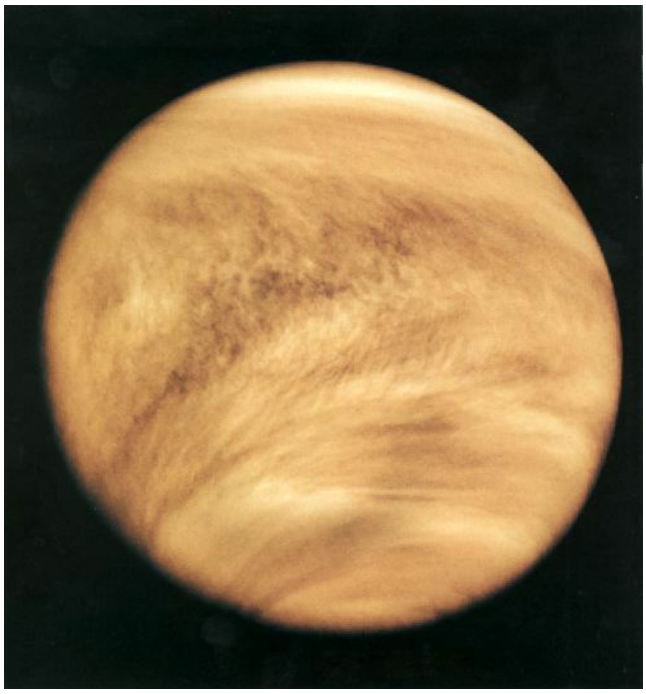
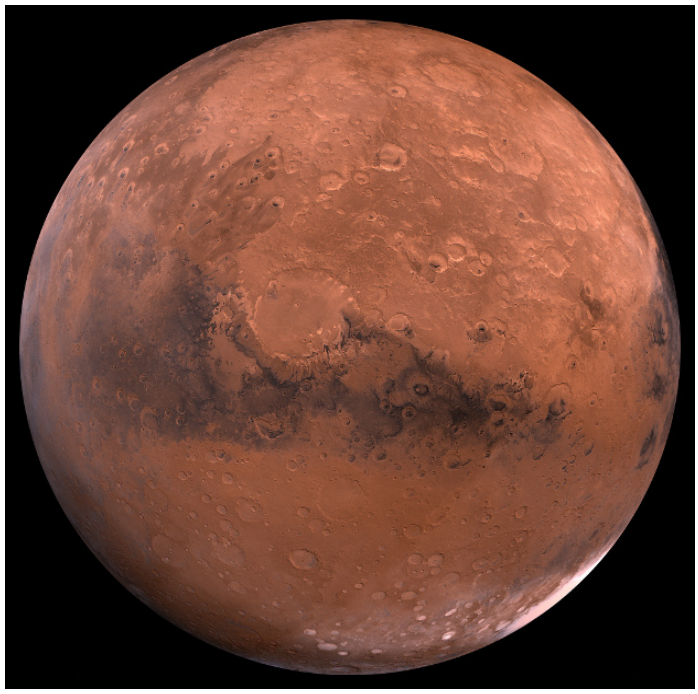
Theme

This year's theme is innovation and science for energy and climate. We will discuss the science of climate, the technology of energy, and the wide ranging policies discussed to bring about a sustainable future. To understand climate and energy is to understand one of the most important issues of our time.

Planetary exploration has shown how a planet's atmosphere effects climate. Compare Venus and Mars.

Venus is a closes twin of Earth. Both Venus and Earth have nearly equal size and composition is largely the same as Earth's. The orbit of Venus is close to Earth's. Both worlds have relatively young surfaces thick atmospheres with clouds. But the atmosphere of Venus is very dense (very high pressure) and made of carbon dioxide. Because Vensus has an extreme greenhouse effect, the surface of Venu can reach a 870 degrees Fahrenheit (470 degrees Celsius).

Mars is at the opposite extreme from Venus. Mars atmosphere is about 100 times less dense than Earth's (and nearly 9,000 times less dense than Venus). Being further from the Sun and without any greenhouse effect at all, Mars is a cold, about - 80 degrees Fahrenheit.)

The relationship between climate and greenhouse gases was first explained by Swedish scientist Svante Arrhenius in 1896. Since then, the modern science of climate has developed, and international organizations, like the Intergovernmental Panel on Climate Change (IPCC), bring together hundreds of scientists to inform policy makers about the implications of the science of climate and energy.

Climate and energy are "big issues". For example, look at Climate and Energy policies and actions at the White House, the United Nations, and ExxonMobile. Columbia University has the Earth Institute, the Climate Center, the Lenfest Center for Sustainable Energy, the Center on Global Energy Policy, and makes an institutional committment to sustainable energy and climate issues. There are several excellentopportunities for students to engage in important energy and climate research at Columbia University.

The motivation for this year's theme came from my own experiences as an applied physicists, from exposure to national science policy in plasma physics and magnetic fusion energy, and from my year as a Jefferson Science Fellow working in the Office of International Energy Policy (now the Bureau of Energy Resources) in the State Department. (The State Department has a role in science policy for several reasons. For one, science has become international, especially with mega projects like the ITER fusion energy experiment in France, the world's most complicated energy project, and the high-energy particle colliders used to understand the fundamental constituents of matter. Others include: science as diplomacy, the international efforts to keep the world safe from misuse of nuclear weapons technology, and the promoting international trade and development based on global advancements in science and technology. The involvement of Secretary of Energy Ernest Moniz, former professor of nuclear physics at MIT, in the negotiation of the Joint Comprehensive Plan of Action (JCPOA), a.k.a. the "Iranian nuclear deal", demonstrates an essentual role of the physicist in pressing international issues.)

- What are the energy and climate issues driving science and technology investments today?
- What are the physics principles underlying energy options and long term climate science?
- How should applied physicists contribute to environmental sustainability and economic growth?
- What are the attractive options for energy innovation and discovery?

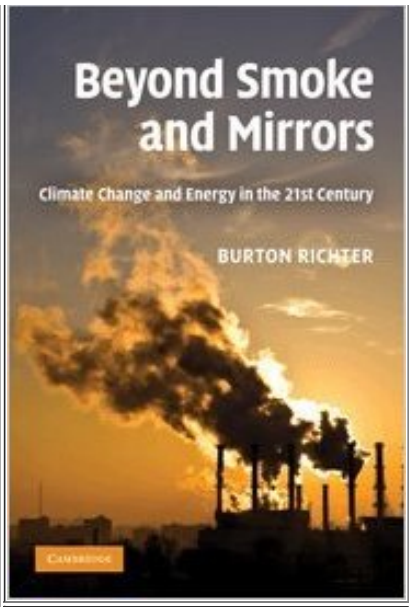
These are terrific (and complex) questions, with no single answer.

This semester, our approach will be to (*i*) introduce some basics, and, then, (*ii*) select one or two energy and climate topics and analyze the scientific and technical basis needed to arrive at something like a research and development plan, or a science policy recommendation.

Textbooks and References

There are ***no required textbooks in this course***. I will provide links to PDF documents in the class schedule detailed below.

But, there are two ***very good*** books (available as Kindle ebooks) that I used in preparing for this course:



Beyond Smoke and Mirrors: Climate Change and Energy in the 21st Century

by Burton Richter, who was co-recipient of the 1976 Nobel Prize for Physics.

His first edition was published in 2006, and last year Richter published an updated version. Richter explains, "The public needs and deserves an honest science-based explanation of what we know, how we know it, what the uncertainties are, how long it will take to reduce those uncertainties, and what we can do to reduce the risk of long-term changes to the world climate that make the Earth less hospitable to society."

Energy: A beginner's guide

by Vaclav Smil, the forthright energy science and policy expert from the University of Manitoba.

Smil's book was published in 2006, and ends with a hopeful prediction for scientfic innovation, "The task ahead is daunting, because the expectations for energy futures are high. ... While our past record of ingenuity, invention, and innovation is no guarantee that another fairly smooth epochal energy transition will take place during the next few generations – it is a good foundation for betting that our chances are far better than even."

GRE Practice

This year the GRE Subject Test in Physics can be taken on Saturday, October 24. ***Registration is Friday, September 18.*** A very good score on your GRE Physics Exam will significantly improve your graduate school admission options.

We'll practice GRE Physics problems on [Date to be determined], 11:45 to 12:25, beginning in September. We'll discuss those high-leverage questions that have a relatively low percentage of correct answers.

Some past year exams include:

- 1986 GRE Physics Exam
- 1992 GRE Physics Exam
- 1996 GRE Physics Exam
- 2001 GRE Physics Exam
- 2008 GRE Physics Exam

Grading

This is a *lunch-time seminar*, and grading is based on participation.

For those taking **E4903x**, your grade will also be determined by your policy recommendation and your editorial

presentation.

Process:

- Every student enrolled in **E4901x** and **E4903x** must work in a six-person "innovation panel".
- Students in **E4903x** will take leadership of the panel and be responsible for all final documents and presentations. However, your panel must work together as a team
- Each "innovation panel" must define a clearly stated science or technology question. After in-class discussion, you will submit a **draft innovation plan**, which I will review, revise, and return for your use.
- Based on your **innovation plan** you must prepare an **interim report** (*no longer than three pages in 14 pt font*) and a four-page slide presentation. You must provide a summary, background, and technology plan (which will probably include research and development.)
- After feedback from the class, each innovation panel must complete their final report (*no longer than six pages in 14 pt font*) and prepare a slide presenation to the class.

Syllubus

This Web Site is a basic resource for **APPH E4901** & **E4903**.

Copies of lecture notes will be available for download in Adobe PDF formats.

A key resource will be *several invited lectures* (T.B.D.) from energy and climate experts at Columbia University.

A preliminary lecture plan is llisted below. I anticipate changes as we move along. Some topics may require more lecture time, and some will require less. Depending on your interests and comments, we may change some of the topics in the last third of the course.

Lecture Dates	***Topics***
Sept 9	Introduction to the 2015 Applied Physics Seminar. Energy balance and planetary climate. Question: what is the average power balance of the Earth's surface?
Sept 16	**What powers humanity?**
Sept 23	
Sept 30	
Oct 7	
Oct 14	
Oct 21	

Oct 28	
Nov 4	*Group discussion about policy team charges and team work*
Nov 9 & 11	*Monday*: **Red** and **White** Teams: *Wednesday*: **Blue** and **Green** Teams:
Nov 16-20	*No class: Annual Meeting of APS Divsion of Plasma Physics*
Nov 23-25	*Monday*: (***All Teams!***) Review of One-Page Innovation Plan *Wednesday*: (***All Teams!***) Draft One-Page Innovation Plan
Nov 30-Dec 2	
Dec 7-9	*Monday*: Final Innovation Plan Reprots Due *Wednesday*: ***End of year "science for policy" celebration and recap***

Student Innovation Panels

All students in APPH E4903 will make a presentation on the technical motivation for your policy recommendations and submit to your classmates the *Op-Ed* article promoting your recommendation to the general public.

Policy advisory teams are listed below:

Red Team		***Scientific Question or Technical Objective:***
White Team		***Scientific Question or Technical Objective:***
Blue Team		***Scientific Question or Technical Objective:***
Green Team		***Scientific Question or Technical Objective:***

Useful Links and References

- Wiki's Energy in the United States
- ExxonMobil's energy outlook
- US Dept of Energy's Energy Information Agency
- International Panel on Climate Change
- International Energy Agency
- Prof. Jim Callen's "How to make effective scientific talks"

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Go to Prof. Mauel's HomePage
