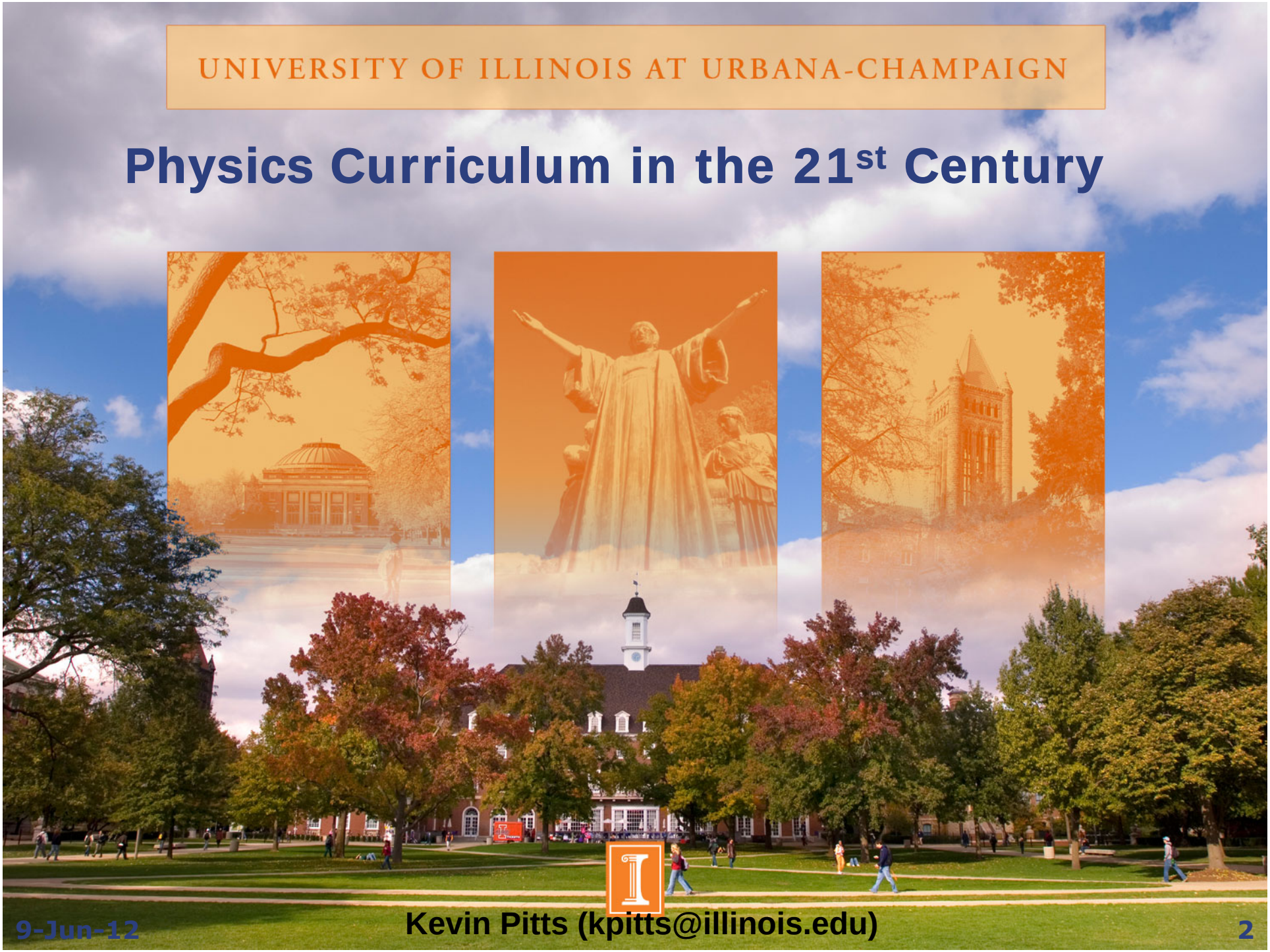
Conference on Women in Physics

- January 18-20, 2013
- Sites:
  - Cornell
  - University of Central Florida
  - University of Illinois
  - Colorado School of Mines
  - Texas
  - Caltech

- Careers, networking, research, grad school

- Participation fully subsidized. Please send your students!!



Physics Curriculum in the 21st Century

Kevin Pitts (kpitts@illinois.edu)

Introduction/Disclaimer

- Our curriculum modifications have happened over the course of a decade.
- I'm presenting this as a "single story", but we implemented these changes piecemeal and never attempted to address all issues at once.
  - It took us many years to even recognize the issues.
- This effort was carried out by many people with different goals and interests. It was never a single strategy carried out by a single person or group.
- Things I won't discuss
  - Our curricula in two different colleges (LAS/Engineering)
  - Our high school teacher prep program (with College of Education)
  - Progress in Intro Physics (iClickers, SmartPhysics)
  - Development of courses for non-scientists

2002 Demographics

- Graduating class ≈ ½ incoming class
  - Losing about ½ of students to engineering and other disciplines
  - Some change interests, others say, "physics isn't what I thought it was"

- About 70% of degree recipients going to graduate school.
  - Didn't know much about the other 30%.

- Diversity quite low. About 85-90% male. Few female and almost no Hispanic or African American students. International fraction also low (5%)

Our 2002 Physics Program

Physics:

- 3 semesters introductory physics
- 2 semesters mechanics (includes SR)
- 2 semesters E&M
- 2 semesters quantum mechanics
- 1 semester thermo/stat mech
- 1 semester classical lab
- 1 semester modern lab (or elect lab)
- Other undergrad courses available (not required)
  - Condensed matter, subatomic, optics

Supporting Courses:

- Math: 3 semesters of calculus + diffeq + linear algebra
- 1 semester of CS, Chemistry

Questions/Concerns

- How can we "ease" the transition from introductory to advanced physics?
- Can we improve our retention rate?
- Can we make our program more relevant to students who don't want graduate school?
- How can we better prepare students for graduate school?
- How can we improve diversity?
- Can we improve the success rate of transfer students?

Improvements

- **Elective option curriculum**

- **New courses**
  - **"Bridge" course**
  - **Physics relevance**
  - **Senior Thesis sequence**
  - **Other new courses**

Broadening the appeal

- **Introduce flexibility in curriculum, allow students to tailor program to their interest.**

- **Format**
  - **All students take same base physics courses (fixed core)**
  - **Students must choose from additional physics courses (flexible core) including a lab class**
  - **Student must choose an "elective option"**
    - ***Option course might not be in physics, but they count as part of the physics major.***

Elective options

- **Students who want to pursue grad school and a research career choose the "Professional Option" which is basically our old curriculum.**

- **Students who want to do something else choose a different option.**
  - **They are basically "trading" 4-5 advanced physics courses for courses in another area.**

New Curriculum "Cores"

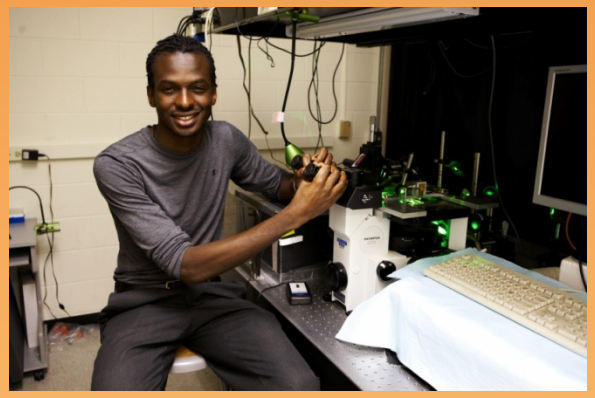
- **Fixed core:**
  - 3 sem intro
  - 1 sem mechanics
  - 1 sem E&M
  - 1 sem quantum

This forced us to move material around in 2-semester courses. Could no longer assume all students get both semesters. All "must know" material goes into 1st semester.

- **Flexible core choose 3 from:**
  - 2nd sem mechanics
  - 2nd sem E&M
  - 2nd sem quantum
  - Stat/thermo
  - Must choose at least one lab course

Elective Options

- **Allows students to tailor curriculum to their needs and interests.**
- **Examples:**
  - **Professional Physics *(this is the grad school track)***
  - **Astrophysics**
  - **Biophysics**
  - **Bioengineering**
  - **Computational Physics**
  - **Materials Science**
  - **Physical Electronics**
  - **Earth Science**
  - **Science Writing**
  - **Pre-law**
  - **Pre-med**
  - **User defined**



New options coming:

- ***Nuclear physics***
- ***Energy/sustainability***
- ***Management***
- ***Atmospheric science***
- ***…***

Recent user defined options

- Electrical Engineering Technical Option
- Geology/Geophysics
- Pre-Optometry
- Mathematical Physics
- Prep for Grad School in Library Science
- Economics
- Acoustic Engineering
- Atmospheric Sciences
- Acoustics
- Biomedical Engineering
- Nuclear Physics
- Sustainable Technology Commercialization

Example options

- **Physical Electronics**
  - ECE 110 Intro to Electrical & Computer Engineering
  - ECE 210 Analog Signal Processing
  - PHYS 404 Electronic Circuits Lab
  - ECE 4xx **or** PHYS 460 Condensed Matter Physics

- **Computational Physics**
  - CS 225 Data Structures and Software Principles
  - CS 357 Numerical Methods
  - MATH 415 Linear Algebra
  - Choose two other 400 level CS courses

Class of 2011

- 50% grad school in physics
- 20% grad school in other fields
  - CS, Nucl Eng, MatSE, EE, Math
- 20% industry
  - Software engineer (CISCO Systems), manufacturing systems (Intel), information technology (Simplex Investments, Accenture Consulting), finance (Belvedere Trading Company), public policy.
- 5% teaching
- few% military

Class of 2012

- 40% grad school in physics
- 17% grad school in other fields
  - Economics, law, neuroscience, biomedical engineering, architectural acoustics, materials science
- 17% industry
  - Software engineer (eKta, HRL Labs, Google), process integration (IBM), information technology (DOD)
- 6% teaching
- 13% looking for jobs
- few% military
- few% other

Comments on new curriculum

- 60-70% in "professional" option.
  - Want to go to grad school
  - Or have enough room in schedule to do the full physics program and still get benefits of subject matter courses.
- Other 30% are students we would have (mostly) lost.
  - Students reporting that option courses are helping them get jobs.
- I didn't expect the number of students going to grad school in other fields.

Operational Experience

- **Students like the flexibility.**
  - **But they tend to put off decisions.**
- **This system requires more proactive academic advising**
  - **For course selection**
  - **To help tie course selection to career path or graduate school**
  - **For custom option construction.**
- **Also requires oversight and updating.**
  - **Including non-physics courses in physics major.**

Improvements

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Easing the transition from introductory to advanced courses.

Introductory Courses

- **Introductory sequence (3 semesters)**
  - PHYS 211 -- Mechanics
  - PHYS 212 -- Electricity and Magnetism
  - PHYS 213/14 -- Thermal Physics /Waves and Quantum

Take Intermediate Mechanics concurrently with 3rd semester.

- **Course format:**
  - Lecture, discussion (interactive problem-solving), labs
  - Lectures are highly interactive using iClickers
  - Physics majors in with Engineers. These are BIG classes
- **Tried honors sections for physics majors. This didn't work so well.**
- **Recent improvement:**

  Physics major-only discussion sections
  - Help to build a sense of community with our majors
  - Cover additional material when appropriate

PHYS 225: Easing the transition

- **We introduced a "bridge" course:**
  - **PHYS 225 Relativity and Math Applications**
  - **2 credit hours, take concurrently with 2nd semester of intro sequence (E&M) and Calc III**

- **Syllabus:**
  - **Spend 7 weeks on special relativity.**
    - ***It's fun, interesting and connects students to "modern" physics sooner.***
  - **Spend 7 weeks on math methods.**
    - ***Vector calculus and Diff EQ as applied to physics problems in mechanics and E&M.***
    - ***Serves as a warm up and transition into advanced courses.***

Relativity and Math Applications

- One hour lecture per week.
- Learning mostly through "guided discovery" done in group work in a 2 hour discussion session.

  http://online.physics.uiuc.edu/courses/phys225/spring12/

- Course now an integral part of program.
  - This is now an "imprint" course
  - Important to have the right instructor
- Removed SR from intermediate mechanics, freed up time for fluids, stress tensors and in some cases GR.

Improvements

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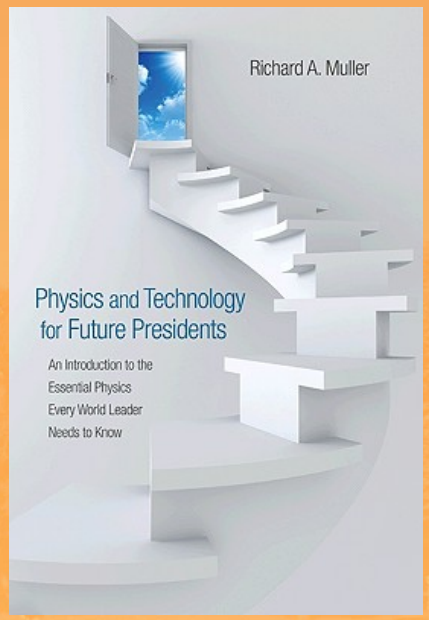
Allowing students to learn about applications early.

Also helping them learn to communicate.

PHYS 199REL The Relevance of Physics

- **New course spring 2012**
- **For Physics majors only**
- **Discuss the societal relevance of physics…**
  - **Energy, space travel, nuclear power, weapons, electricity, light, radiation, climate**

  …and the relevance to physics majors
  - **Careers, funding, education**
- **Project-based**
  - **Career project, poster project, position papers, videos.**
- **In class discussion & debate**



PHYS 199REL The Relevance of Physics

Projects

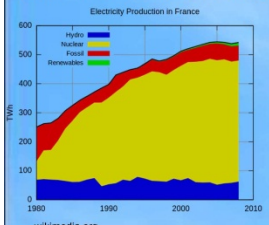
- Careers in physics (not research, faculty)
  - In class presentation
- Team poster project
- Position paper on some alternative energy technology
- Interview a faculty member and report on research in physics (team)
  - In class presentation
- Video (team)

Nuclear Waste: Reusable?

Lingyi Kong (lkong5@illinois.edu), Robert Osiol (osiol2@illinois.edu)

Case Study: France

The French Nuclear program rose out of the 1973 oil crisis and the Messmer plan which dedicated France to producing much of its energy from nuclear power. Today France produces more than 75% of its domestic energy from Nuclear power. (7)

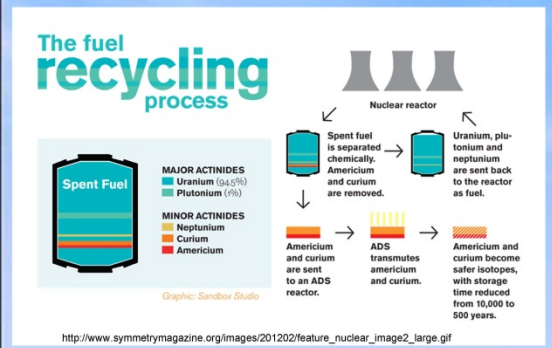


wikimedia.org

globalsecurity.org

Nuclear Reprocessing

France has opted for a waste management system based on Nuclear reprocessing. Reprocessing serves to take spent waste and enrich it back to fissionable material. While not 100% recyclable, reprocessing can reduce the waste associated with a family of four over a twenty year period to the size of a cigarette lighter (8). Reprocessing follows the PUREX method. First, waste is dissolved in Nitric Acid. The dissolved waste/acid mixture is then mixed in a process of organic solvent extraction to retrieve the Uranium and plutonium. After plutonium and uranium are extracted in the organic mixture the two can be separated (9). 96% of used fuel can be recycled, 95% Uranium and 1% Plutonium (10).The remaining 4% of waste still needs to be stored in a repository. Disadvantages to the reprocessing method are the higher costs of recycled Uranium compared to mined Uranium in the once through cycle as well as plutonium which could be used in a nuclear weapon.



http://www.symmetrymagazine.org/images/201202/feature_nuclear_image2_large.gif

What Is Nuclear Waste?

Nuclear waste is the left over material from nuclear power plants. This can be from ore-mining, various processing and refinery to spent nuclear fuel. There are two types of nuclear waste-low level radioactive waste (LLW) and high level radioactive waste (HLW). HLW consists mostly of spent nuclear fuel, and LLW is often found in other forms (6). More than 99% of radioactivity is found in HLW, whereas LLW takes up 85% of entire nuclear waste generated (3).

The Danger of Nuclear Waste

The danger of nuclear waste is radioactivity. Radiation exposure is measured in **rems** (roentgen equivalent in man). The bigger the number, the more radiation a person receives, which means a more hazardous effect. Exposure of 25 rems will have detectable effect on humans(2), 100 rems will cause short-term illness, and above 300 rems will be lethal (1). Spent fuel emits millions of rems when removed from reactors. The danger of nuclear waste makes nuclear waste disposal an important issue.

What's the situation?

"The global volume of spent fuel was 220,000 tonnes in the year 2000, and is growing by approximately 10,000 tonnes annually." (Greenpeace.org) (5).

Geological disposal has been the most favorable solution for dealing with nuclear waste (6). HLW is often buried in deep underground in leak-proof lead-lined container, as it can take hundred of thousands of years to give off all its radioactivity (6). LLW, on the other hand, is often stored in near-surface burial (6).

Warning Symbol for Radiation Danger(www.iaea.org)

http://media.treehugger.com/assets/images/2011/10/nuclear-waste-storage-US-urgent.jpg

Future Waste Strategy

Mankind's evolving energy needs demand a unified strategy to deal with nuclear waste. An effective strategy must include ways of addressing existing waste and future energy production. Investments in reprocessing would enable countries on the once through fuel cycle, like the US, to reduce their current stockpiles of nuclear waste. In the long term, power generation needs to minimize waste produced. Advances in thorium reactors show great promise in meeting future energy demands while producing much less waste. The lack of alternative base load, carbon neutral, energy sources almost guarantees Nuclear energy a place in humanity's future.

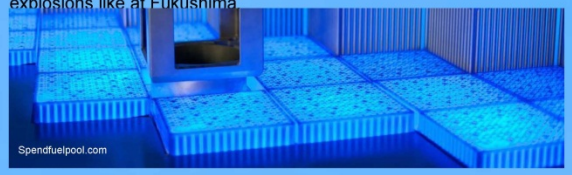
Beaver Valley Power Station nuclear power plant (pictured) Photo: United States Nuclear Regulatory Commission via Wikimedia Commons

Case Study the US

The US produces 19.6% of its electricity from Nuclear power but is the world's largest producer. (11) United States nuclear power runs exclusively on the once through fuel cycle.

Nuclear Waste Storage

Since the United States doesn't reprocess waste it must store all Nuclear waste after use. One form of storage involves the use spent fuel pools. Nuclear waste is submerged in 20 feet of water or more which shields workers from radiation.(12) Pools provide several risks of operation. One stems from the high temperatures associated with the spent fuel. Pools need to be cooled to prevent the water from boiling off and releasing radiation into the atmosphere. The other major risk involved with storage pools is Radiolysis, the disassociation of molecules via radiation. Water molecules exposed to the waste can produce hydrogen which if left unmonitored and uncontrolled could cause explosions like at Fukushima.



Spendfuelpool.com

Space in spent fuel pools is limited and during the 70's and 80's a need developed for an alternative storage option. To fill this need the industry started investing in Dry Cask Storage. Dry Cask Storage takes spent fuel already cooled in fuel pools and surrounds them with an inert gas. This space is then enclosed in a steel cylinder surrounded by more steel, concrete, and other materials (12). It is estimated that the United States now has 65,000 tons of nuclear waste in temporary storage(13). Plans for a national Nuclear waste repository at Yuca Mountain Nevada have been suspended amid controversy and much legal action. Without a national repository, waste sits on sight at the plants where it was generated. Limited space has forced some plants to shut down to accommodate storage of their waste (14).

References:
1. Muller, R. A. *Physics and Technology for Future Presidents: An Introduction to the Essential Physics Every World Leader Needs to Know*. Princeton, NJ: Princeton UP, 2010. Print.
2. http://library.thinkquest.org/3471/radiation_effects_body.htm
3. http://www.tms.org/pubs/journals/JOM/0009/Yim-0009.html#ref1
4. Whatisnuclear.com
5. http://www.greenpeace.org/international/en/campaigns/nuclear/waste/
6. http://library.thinkquest.org/3471/nuclear_waste_body.html
7. World Nuclear Association (Web)
8. Frontline: Why the French like Nuclear Power (Web)
9. European Nuclear Society (Web)
10. AREVA (Web)
11. US Energy Information Administration (Web
12. US Nuclear Regulatory commission (Web)
13 Time: Bury our Nuclear Waste before it Buries Us (Web)
14. New York Times: Wanted: Parking Space for Nuclear Waste (Web)

Spring 2012 PHYS 199REL Poster Project

29-Feb-2012

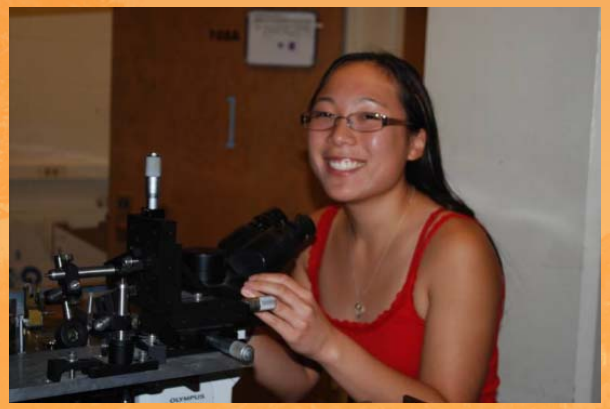
Example video from PHYS 199REL

http://online.physics.uiuc.edu/courses/phys199rel/spring12/project5team1final2.wmv

Improvements

- **Elective option curriculum**
- **New courses**
  - **"Bridge" course**
  - **Physics relevance**
  - **Senior Thesis sequence**
  - **Other new courses**

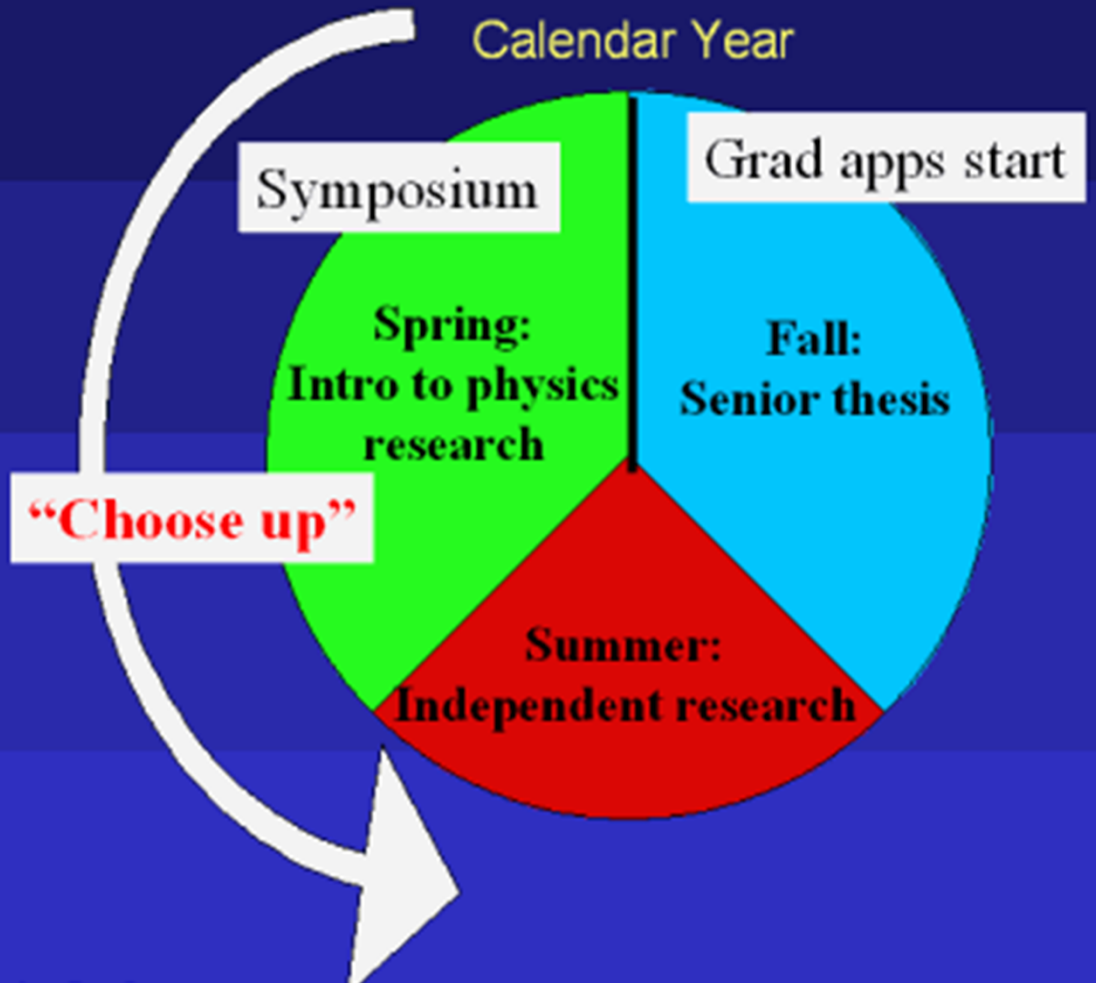
Preparing students for research, teaching them to communicate.



Did you learn this in a class?

- In what class did you learn the following?
  - How to write a research paper.
  - How to document your research.
  - How to "approach" research.
  - How to put together a good talk.
  - How to make and present a poster.
  - How to write a grant proposal.
  - How to apply to grad school.
- And how much practice did you get??

PHYS 496/499 "Senior Thesis"



Emphasis on research and communication (speaking/writing)

Physics 496 Introduction to Physics Research Spring 2012

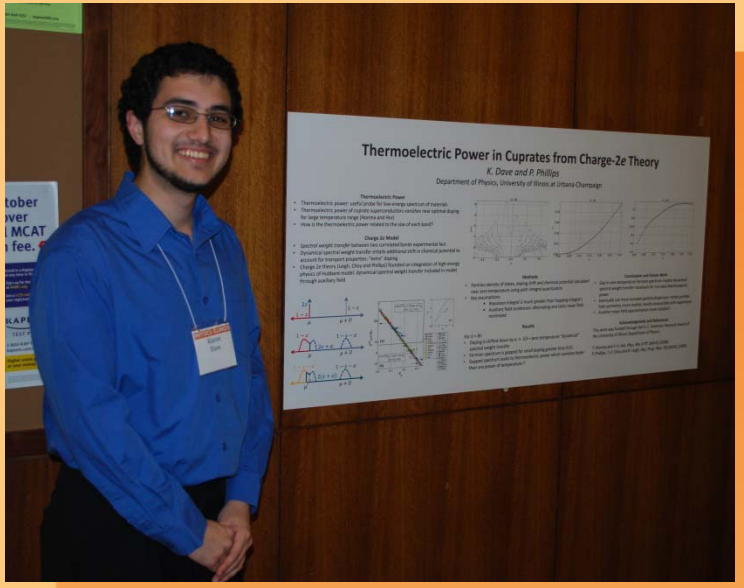
Syllabus and Homework Assignments

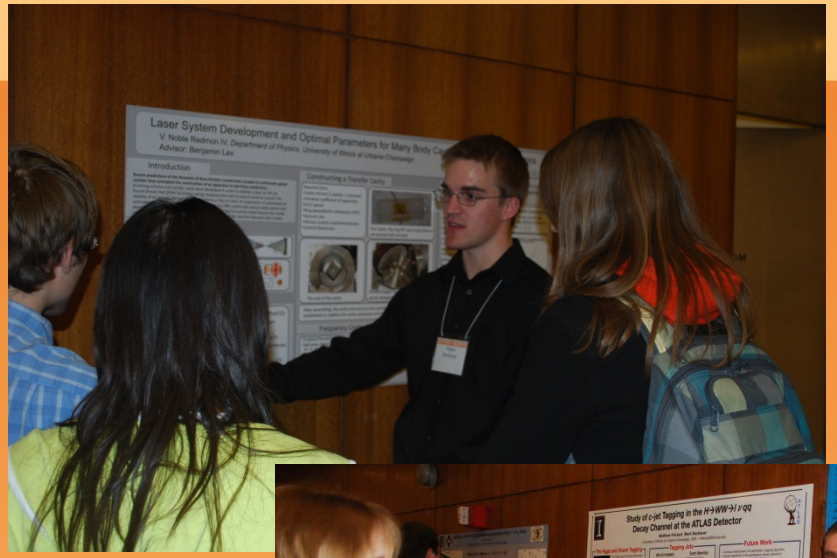
Laura H. Greene, Swanlund and Center for Advanced Study Professor of Physics
Celia M. Elliott, Director, External Affairs and Special Projects

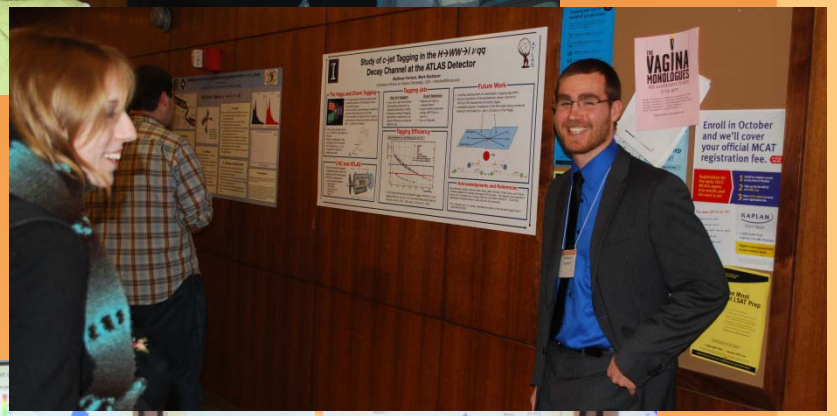
Revised 04/03/2012

Homework assignments are to be deposited in your Dropbox file by 5 p.m. on the due date.

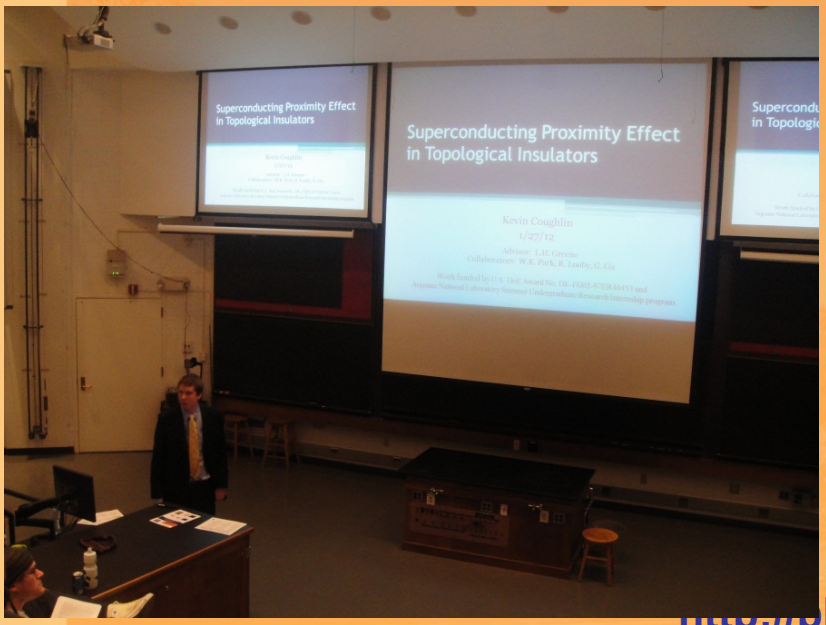
Wk	Date Fridays	**Writing Workshop** (257 LLP) (Usually 2:00–2:50 p.m., unless noted otherwise)	**In Class Activities** (322 LLP) (Usually 3:00-4:50 p.m. unless noted otherwise)	**Homework Due Today**
1	Jan 20	Intro to Writing Workshop—goals and rationale WW #1—Getting *something* written down	Course introduction and expectations (lhg) The "hows" and "whys" of research (lhg) Technical communications in science (cme) Evaluating a science talk (cme)	None
2	Jan 27	**11th Undergraduate Research Symposium** 2:00–6:00 p.m., 141 LLP; attend the talks in lieu of class—no Writing Workshop today; no homework due today		
3	Feb 3	WW #2—Using the right word	Using persuasion in scientific communications (cme) Tools for the scientific skeptic (lhg) Abstracts and titles (cme)	#1—Evaluating Scientific Presentations
4	Feb 10	WW #3—Them thar	Using online resources for research (lhg) Writing effective paragraphs (cme) Documenting research (lhg)	#2—Abstract
5	Feb 17	WW—Literature search (team exercise)	Creating good figures (lhg) Effective figure captions (cme) Using analogies to explain science (lhg)	#3—Paragraphs
6	Feb 24	WW #4—Getting *only* in the right place	Giving a talk (cme) Effective slide titles (cme) Presenting information in tables (cme)	
7	Mar 2	**No WW—go directly to Room 322**	Professional ethics for physicists (lhg/cme) Ethics case studies (group activity)	#4—Analogies

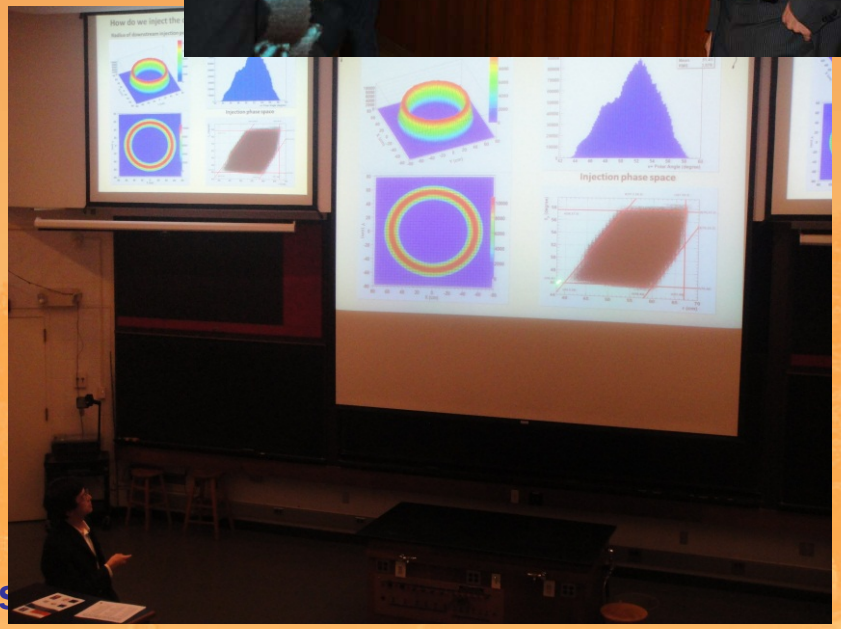






Undergrad Poster Session (Nov ’11)
Undergrad Research Symposium (Jan ’12)





http://phys

Senior Thesis Sequence

- **Feedback from students is incredibly positive.**
  - **Most cite it as their best course.**
  - **They report back from grad school that they are far ahead of their peers when it comes to doing and reporting research**

- **Challenges/limitations**
  - **Finding research spots (and funding) for all students in the class.**
  - **Course limited to ~20 students per cycle.**
  - **We are fortunate to have a writing guru.**
  - **Course is aimed at grad school bound students.**

REU

- We've propagated aspects of Senior Thesis to our REU program

- Seminars on:
  - Doing research
  - Ethics
  - Poster presentations
  - Giving talks
  - Science Writing
  - Grad school
- Students make lots of presentations.

Other new/improved courses

- **PHYS 100 pre-intro sequence**
  - **Followed by enrichment supplemental courses**
- **Significant upgrade of our modern physics laboratory course**
- **Physics of music laboratory course**
- **Senior level Biophysics course**
- **Senior level Atomic Scale Simulations course**

What's missing?

- We still haven't gotten numerical methods integrated into our curriculum
- Broadening participation in our senior thesis sequence.
  - Students not going to grad school could benefit from some aspects of the course.
- Increasing undergrad research opportunities.
  - 100 students doing undergrad research this summer does not growing meet demand.
- Increasing corporate internship opportunities.

Summary

- **We've made some significant course and programmatic improvements**
  - **Not every experiment worked.**
- **Enrollments are up and retention improving.**
- **We still have lots to do.**
  - **More curriculum development, student support, internships, research opportunities.**
- **Must make young people aware of the potential that physics offers.**

Career Awareness

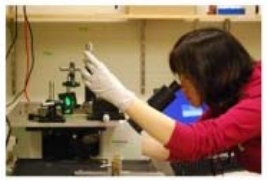
- **Challenge to communicate the diversity of career opportunities to students.**

- **We're trying multiple approaches:**
  - **Send them to career fairs**
  - **Blog**
  - **Town Hall meetings**
  - **"What can you do with a physics degree" talks**

ILLINOIS
UNIVERSITY OF ILLINOIS AT URBANA-CHAMPAIGN

Skill set of Physics majors at the University of Illinois at Urbana-Champaign

Our physics majors have a strong background in mathematics and fundamental science. We feature degree programs that can be tailored to emphasize knowledge in topics such as computation, electronics, biophysics, acoustics and sustainability. Our program is highly ranked and includes a strong laboratory component. In addition, students trained in physics are highly motivated and possess the following skills:



Critical thinking and problem-solving

Collaborative approaches and teamwork

Agility and adaptability

Effective oral & written communication

Accessing and analyzing information

Processing and synthesizing large data volumes

Curiosity and Imagination

For more information contact:
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http://www.physics.illinois.edu/education/undergrad/

http://physics.illinois.edu/undergrad/posts.asp