"Physics Education and Student Cognition"

Spring Meeting of the Illinois Section of the AAPT

April 4-5, 2008

University of Illinois, Urbana, Illinois

Friday, April 4, 2008

9:30 - 5:30 **Registration**. **Loomis Lab foyer (outside of rooms 141 & 151), 1110 W. Green St. Urbana**. Please make out checks to "ISAAPT".

Please Recycle. When you leave the meeting to return home, please place your plastic name tag holder in the box which will be available in the Loomis Lab foyer. It will be used at the next meeting. Thanks.

10:00 - 12:00 **Workshop W1. "Increasing Student Engagement Using Personal Response Systems (Clickers) in Lecture"**, Mats Selen, Department of Physics, University of Illinois. Loomis 151.

10:00 - 12:00 **Workshop W2. "Inquiry-Based Teaching in High School Physics"**, Members of the 2008 graduating class of PTE majors at Illinois State University including Erik Brieger, Christopher Bush, Drew Sulski, Shane Hanson, Scott Kupiec, Mathew Herzau, John Metzler, Michael Turner and Ted Heyduck. Loomis 234.

11:00 - 12:00 **Workshop W3. Cracker Barrel: "Physics Teacher Candidate Preparation"**, Ad Hoc Committee for the Recruitment, Preparation, and Retention of High School Physics Teachers. Led by Carl Wenning, David Sykes, and Tom Foster. Loomis 158.

12:00 - 1:15 **Lunch** - on your own. See the list of restaurants on the Web site.

Here is a list of those who are doing contributed presentations.
Note that Sessions B, D, F and H are part of the Student Research Symposium.

Friday, 1:30 - 2:45			**Friday, 4:15 - 5:20**		
1:30 1:45 2:00 2:15	 A1. Tom Foster A2. Jeff Chamberlain	B1. Kara Lovelace and Michael Stachyra B2. James Kristoff and Ryan Linton B3. Ryan Tockstein B4. Ryan Lodes	4:15 4:30 4:45 5:00	C1. John Baier C2. Rebecca Lindell (AL) C3. Noella D'Cruz Take Fives	D1. Jacob Brown D2. Gabriel Caceres
Saturday, 8:15 - 9:15			**Saturday, 10:45 - 12:00**		
8:15 8:30 8:45 9:00	 E1. Lenore Horner (AL) E2. Lenore Horner (Demo)	F1. Thomas Traynor F2. David Wischhusen F3. Nic Chott F4. Matthew Norton	10:45 11.00 11:15 11:30 11:45	 G1. Tom Carter G2. Rebecca Lindell (Res) Take Fives WITHITs	H1. Daniel Rolando H2. Tim Garvin H3. Isaac Goodin H4. Sebastian Grobe H5. Sawyer Campbell

2:00 - 2:30 Session A (concurrent with Session B) - Loomis 151 - Chair: *Eugene Torigoe*

2:00 - 2:15 - A1 - Teaching Methods

Simple Design Problems for Physical Science. *Tom Foster and Susan Wiediger*, Southern Illinois University Edwardsville, Edwardsville, IL 62026. Illinois State Learning Goal 11a is all about design, yet it is the inquiry standard (11b) which gets all the attention! At SIUE we have created a physical science course with a design project as the capstone experience for the students. The students are elementary education majors who are generally science phobic, so we have created rubrics and other support mechanisms to help the students succeed. Because of this, we feel the projects should have applicability for grades9-12, if not younger. There is still more work to do, but we will give you an update of our progress.

2:15 - 2:30 - A2 - Other

Economy Robot using the SX Chip: The Programmable Acceleration Car. *Jeff Chamberlain*, Illinois College, Jacksonville, IL 62650. This project modified a radio-controlled car by replacing the motor control circuitry with a simple circuit using the SX microcontroller. Programs in BASIC control the motor allowing a wide variety of motion. LED indicators and pushbutton switches were added to the car's body to create a self-contained variable acceleration car. Potential experiments in basic mechanics and in robotics will be discussed.

1:30 - 2:30 Session B (concurrent with Session A) - Loomis 141 - Chair: *Jose Mestre*

1:30 - 1:45 - B1 - Student Research Symposium

Angular Dependence of the Efficiency of Polarizers. *Kara Lovelace, Michael Stachyra and Dr. Steve Daniels*, Eastern Illinois University, Charleston, IL 61920. The angular dependence on the efficiency of crossed polarizers was measured. Polarized light with axis perpendicular to the transmission axis of a polarizer was incident on that polarizer. Transmitted light was measured with lock in amplification. The efficiency of the polarizer was measured as a function of incidence angle for the light. Data will be presented indicating that the polarizer transmits less than 1 part in 10,000 of the incident light it but this efficiency can change by a factor of 4 over an angular incidence range of about 10°.

1:45 - 2:00 - B2 - Student Research Symposium

Turning Heat into Electricity: Making Better Thermoelectrics. *James Kristoff and Ryan Linton*, Illinois State University, Normal, IL 61761. For nearly two hundred years we've known about materials that could be used to convert heat into electricity. However, these thermoelectrics have been somewhat inefficient. The new field of nanoscience has re-opened the search for higher efficiency to enable the recovery of waste heat from factories and automobiles and to enable new high efficiency refrigerators. Our focus is on the study the properties of silicon and germanium when they are combined in atomic layers at the nano-scale. We have constructed a special deposition system to make these new materials and plan to measure their properties as a function of layer composition and thickness.

2:00 - 2:15 - B3 - Student Research Symposium

Effect Of Area Ratio Changes On Exit Pressure In A C-D Rocket Nozzle. *Ryan Tockstein*, Southern Illinois University Edwardsville, Edwardsville, IL 62026-1654. The research presented involves the pressure changes in a chemical rocket engine nozzle. Specifically, the research explains how changing the area ratio of a rocket nozzle affects the pressure of the exhaust gas at the exit of the nozzle. Equations involving the pressure, area ratio, and mach number were analyzed to show the relationship of the area ratio and exit pressure. Results of this project will be presented.

2:15 - 2:30 - B4 - Student Research Symposium

Modeling Correlated Gene Distributions Within a Strand of DNA. *Ryan Lodes*, Illinois State University, Normal, IL 61761. We model a set of DNA strands consisting of one hundred or more genes, and the genes code for one of twenty traits. In our model, traits one through ten have meaning, and eleven through twenty represent junk DNA. In order to be viable, a strand must have at least three genes for each of traits one through ten. Each DNA strand, which represents and individual of a population, is allowed to reproduce based on its calculated fitness. During reproduction, it may mutate and exchange a segment of its strand with another strand. After each reproduction cycle, the strand fitness is calculated. We report on the distribution of correlated genes within a DNA strand as the population evolves.

2:30 - 3:00 - Break - Loomis Lab Foyer (outside of rooms 141 and 151)

3:00 - 3:05	**Welcome - Loomis 151 - Prof. Dale Van Harlingen, Head, Department of Physics, UIUC**
3:05 - 3:30	***"Cognitive Science: Problem Solving and Learning for Physics Education"*** **Professor Brian Ross** Department of Psychology, University of Illinois at Urbana-Champaign **Loomis 151** Much research has been conducted in cognitive science that might be applicable to physics education. I will focus on some general principles of problem solving and learning, as well as a number of basic findings and their implications, including the improvement of problem solving. The areas of research to be discussed include specialized cognitive systems, the importance of content in thinking, and the use of categories and analogies.
3:30 - 4:00	***"Mental Models in Understanding Physics: Misconceptions and Learning"*** **Dr. David Brookes** Postdoctoral Research Associate Department of Physics University of Illinois at Urbana-Champaign **Loomis 151** I will present results of a reading study that shows the usefulness of probing physics students' cognitive processing by measuring reading time. According to contemporary discourse theory, people create a mental model while reading a text. If the reader encounters conflicting information, their construction of a coherent mental model is disrupted and reading times are prolonged. We used this effect to study how "non-Newtonian" and "Newtonian" students create mental models of conceptual systems in physics as they read texts related to the idea of Newton's third law. We found significant effects of prior knowledge state on patterns of reading time, suggesting that students attempt to actively integrate physics texts with their existing knowledge. Despite non-Newtonian students' attempts to integrate the new information, there is little evidence of a shift in their ideas after reading the text. I will discuss the implications of this result for what we want students to learn and how we want them to learn it.

4:00 - 4:15 - Break - Loomis Lab Foyer (outside of rooms 141 and 151)

4:15 - 5:20 Session C (concurrent with parts of Session D) - Loomis 151 - Chair: *Adam Feil*

4:15 - 4:30 - C1 - Active Learning

Inexpensive Equipment for Circuits and Resonance. *John Baier*, Glenbard South High School, Glen Ellyn, IL 61037. Covers for one and two inch diameter four foot long fluorescent tubes can be used to do resonance and the speed of sound. I will also show an inexpensive way of using a 4x6 inch board with nails to do series, parallel, and other simple circuits.

4:30 - 4:45 - C2 - Active Learning

Promoting Active Learning in the Introductory Astronomy Classroom. *Rebecca Lindell and Tom Foster*, Southern Illinois University Edwardsville, Edwardsville, IL 62026. At Southern Illinois University Edwardsville, we have restructured our introductory astronomy course to include hands-on inquiry-based in-class group activities. These activities utilize a modified learning cycle approach to cover specific astronomical concepts that traditionally resist conceptual change, such as phases of the moon and seasons, or that students have difficulty mastering, such as Hubble's law and the Hertzsprung-Russell diagram. Each group activity is designed to be completed during one 50-minute class period and utilize hands-on equipment whenever possible. In this workshop we will discuss the design and implementation of these group activities into our introductory astronomy course, as well as results of evaluation of the successfulness of these activities at promoting conceptual understanding and reasoning skills.

4:45 - 5:00 - C3 - Teaching Methods

Group Work in the Introductory Astronomy Class. *Noella D'Cruz*, Joliet Junior College, Joliet, IL 60431. Research has shown that one of the ways students learn is through social interactions. This semester I have incorporated a substantial amount of group work in my introductory astronomy class to enable my non-science major students to learn the material more deeply through interactions with each other. I will discuss group projects, group tests, and other activities that my students are involved in.

5:00 - 5:20 - Take Fives - Loomis 151

1. *Zachary Metzger*, "Spicing Up a Circuits Unit"
2. *Cliff Parker*,"A Pun is its Own Reword"
3. *Dave Sykes,*"The Enigmatic Heat Turbine"
4. *Eugene Torigoe*, "Circular Polarization Demonstrated Using a Box of Cereal"
5. *Jake Wietting,* "Augustana Physics Outreach Program - Reaching Out to the Community"
   Announcements

4:15 - 4:45 Session D (concurrent with Session C) - Loomis 141 - Chair: *David Brookes*

4:15 - 4:30 - D1 - Student Research Symposium

The Mass-Radius Relationship of Neutron Stars. *Jacob Brown*, Western Illinois University, Macomb, IL 61455. I will start off by explaining the different principles that are important to finding the mass-radius relationship. This will include the Pauli principle for compact stars vs. gravity, the Tolman-Oppenheimer-Volkov equation, and the many different equations of state. Next I will go into the project that I have been working on to create a flexible program that will allow us to take different equations of state and compare them to find the ultimate equation of state. The final part of my presentation is to go into the goals for the future that I want to attempt to do in getting this program up and running.

4:30 - 4:45 - D1 - Student Research Symposium

CDMS Veto Stability Study and Calibration. *Gabriel Caceres*, Augustana College, Rock Island, IL 61201. Most experiments searching for dark matter particles have been led deep underground to minimize the background produced by cosmic rays. The Cryogenic Dark Matter Search (CDMS) lies 1/2 mile underground in the Soudan Mine in Minnesota. Even though the muon rate is lowered by a factor of 10^5, the rate is still high enough to produce background signals. To solve this problem, scintillator panels have been placed around the detector to veto cosmic induced events. This work studies the behavior over time of the scintillator veto panels. By analyzing and tracking the response to a LED pulser system, the stability was determined to be within 3%. The absolute energy scale of the spectrum was then calibrated using radioactive sources, as well as the muon distribution. Knowing the absolute energy scale and where the veto trigger threshold lies provides useful information for calculating the amount of background that can be rejected.

5:20 - 6:30 - Free Time

6:30 - 7:00 - Social time - cash bar open on the third floor of the Levis Faculty Center, located on Illinois Street (across the street to the east from Krannert Center for the Performing Arts), approximately two blocks southeast of Loomis Laboratory of Physics.

7:00 - 8:15 - Banquet - third floor of the Levis Faculty Center. Presentation of the *Outstanding High School Physics Teacher Award* to John Baier, Glenbard South High School, Glen Ellyn.

8:15 - 9:15	***"The Ultra-Cold Frontier"*** **Dr. Brian DeMarco** Department of Physics, University of Illinois at Urbana-Champaign **Third floor of the Levis Faculty Center** Physicists around the world routinely cool atom gases to temperatures colder than the farthest regions of inter-stellar space. Atomic motion cannot escape its quantum mechanical nature at these ultra-cold temperatures, where thermal deBrogile wavelengths can approach a tenth of the diameter of a human hair. I'll explain how atom gases can be cooled to nano-Kelvin temperatures on a tabletop without using equipment colder than room temperature. I'll also show how atom gases, when trapped in a crystal formed from light, are now being used to resolve decade old questions about models of solid materials.

Saturday, April 5, 2008

7:00 - 8:15 - ISAAPT Council meeting - Presiding: *Deborah Lojkutz*, President. Loomis 322
8:00 - 9:30 - Registration. Loomis Foyer. Please make out your checks to "ISAAPT".

8:45 - 9:15 Session E (concurrent with Session F) - Loomis 151 - Chair: *Eugene Torigoe*

8:45 - 9:00 - E1 - Active Learning

Make Your Own Helmholz Resonator. *Lenore Horner*, SIUE, Edwardsville, IL 62026. Most people have blown across the top of a bottle to produce a pitch and in general taller bottles produce lower pitches. Introductory physics classes inadvertently perpetuate this over simplification by teaching about pitch in cylindrical wind instruments where longer instruments produce lower pitches. I present a relatively cheap and simple in-class activity where students can discover for themselves that the pitch of a bottle is more complicated than that of a cylindrical instrument.

9:00 - 9:15 - E2 - Demonstrations

Using the Wiimote to teach Mechanics. *Lenore Horner*, SIUE, Edwardsville, IL 62026. The remote for Nintendo's Wii gaming system has a built-in 3-axis accelerometer and some position capability. I will illustrate the possibilities and pitfalls of using the remote to teach elementary kinematics.

8:15 - 9:15 Session F (concurrent with Session E) - Loomis 141 - Chair: *Adam Feil*

8:15 - 8:30 - F1 - Student Research Symposium

Investigation into Factors Affecting the Operating Deflection Shapes of a Mandolin. *Thomas Traynor*, Illinois Wesleyan, Bloomington Il, IL 61701. Like any vibrating object the front and back plate of a mandolin will have mode shapes and operating deflection shapes when vibrated. The goal of this project was to test whether or not shaking the front plate, a common practice by luthiers during construction, changes the operating deflection shapes that occur during the vibration of the front plate. Some luthiers claim that shaking the front plate during construction will actually break down some of the cellular structure in the wood causing the instrument to have a better sound, like a well played mandolin. Using speckle pattern interferometry, the front plate of a mandolin was characterized during construction before and after it had been shaken. This data will also be compared to the analysis of the front and back plate of a student mandolin.

8:30 - 8:45 - F2 - Student Research Symposium

Role of External Forces in Pair-Creation. *David Wischhusen, Q. Su, R. Grobe*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790. Relativistic quantum electrodynamics describes the complicated quantum field theoretical nature of electrons and positions during the interesting process of their creations. Theoretical studies to date about these interactions are limited by our ability to obtain and analyze the solutions for the complicated systems. The newly developed computational quantum field theory has opened the field to answering many fundamental questions. Many famous mysteries such as the Klein paradox and the Zitterbewegung have been revisited and could be resolved. The validity of some models, on the other hand, has been questioned concerning important issues regarding locality and causality during these processes. I am proposing a set of computer simulations to investigate the effects due to a scalar potential versus a vector potential to model an external force. This work will help us to understand the fundamental nature of locality and causality.

8:45 - 9:00 - F3 - Student Research Symposium

Classical Phase Space Approach to Pair-Creation. *Nic Chott*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790. We explore the mutual coherence properties of electrons that are created by a sub-critical time-dependent force field. We compare the spatial evolution of the quantum field theoretical density with that of a relativistic classical mechanical ensemble. We find that portions of the electron cloud that were created sufficiently far from each other are not able to show interference patterns as they pass each other. The corresponding classical phase space density reveals interesting spiral shaped gaps, which have their manifestation in the corresponding quantum field theoretical data.

9:30 - 10:00	***"What Instructors Should Know About How Students Interpret Symbols in Physics"*** **Eugene Torigoe** Doctoral Student in Physics, Department of Physics, University of Illinois at Urbana-Champaign **Location** In studies involving nearly 1000 students we have found that numeric versions of certain questions have averages that are almost 50% higher than equivalent symbolic versions. Analysis of students' written work as well as student interviews suggests that this effect is related to confusion about the meaning of symbols. I will begin by describing how the structure of numeric solutions aids students in correctly answering physics questions and then discuss the ways in which symbolic questions impose greater cognitive demands on students than do numeric questions. I will conclude by discussing connections between student performance on numeric and symbolic questions, and overall success in physics.
10:00 - 10:30	***"Do Problem-Solvers Notice Changes Made to a Physics Problem while They are Reading and Explaining It?"*** **Adam Feil** Doctoral Student in Educational Psychology, Department of Physics, University of Illinois at Urbana-Champaign **Location** Human attention is quite limited, and even in situations where students are "paying attention", they may not be attending to relevant aspects of the problem or example in front of them. Using methods from visual cognition, we set up an experiment where features of physics problems were changed while students were reasoning about and explaining the problems. We found that a student's initial understanding of a problem has a significant effect on whether or not a given change will be noticed. Examples will be shown and discussed, and implications for physics teaching will be explored.

10:30 - 10:45 - Break - Loomis Lab Foyer

11:00 - 11:55 Session G (concurrent with Session H) - Loomis 151 - Chair: *David Brookes*

11:00 -11:15 - G1 - Research

Initial Results of Using a PER Based Text and Online Tutoring System at a Community College. *Tom Carter*, College of DuPage, Glen Elynn, IL 60137. I will compare indicators of student knowledge and performance from a class using the newer PER based textbook by Knight and the associated MasteringPhysics online tutoring system to a class using the more standard text by Halliday, Resnik and Walker and a less complex online tutoring system, TYCHO. Indicators of student performance will include average normalized gain on the FCI, performance on a locally produced standardized exam and fraction of students successfully retained in the class.

11:15 -11:30 - G2 - Research

The Evolving Nature of Terminal Physics Masters Programs. *Rebecca Lindell, Kimberly Shaw and Lenore Horner*, Southern Illinois University Edwardsville, Edwardsville, IL 62026. Like many terminal masters programs, SIUE faces a shortage of qualified graduate students and thus risks elimination during funding crises. To better understand this problem, we undertook a research study investigating why students pursue terminal masters degrees in physics. As part of this research we collected survey data from nearly half of the identified terminal master's programs in the US. In addition, we conducted site visits at three institutions to determine why they produced nearly twice the national average of master's degrees in year. Results of this research will be presented.

11:30 - 12:00 - Take Fives - Location

1. *Ann Brandon,*"A Sticky Situation"
2. *Teresa Craft,*"Review Bee"
3. *Rebecca Wenning-Vieyra,*"Speed of Light with Butter"
4. *Thomas Withee,*"Is Online Homework Effective?"
5. *Gary Wolber,* "Conservation of Energy"

WITHITs
Announcements

10:45 - 12:00 Session H (concurrent with Session G) - Loomis 141 - Chair: *Eugene Torigoe*

10:45 - 11:00 - H1 - Student Research Symposium

Application of Molecular Dynamics to the Simulation and Visualization of the Motions of Gas Atoms. *Daniel Rolando, Jie Zou*, Eastern Illinois University, Charleston, IL 61920. This project applies a computational method, Molecular Dynamics, to the study and simulation of the microscopic interactions and the resulting motions of gas atoms. The current study is carried out for a simulation cell of fifty Argon atoms based on the approach in Ref. [1]. Future study will be performed for other materials, such as silicon. The force between atoms is modeled by the Lennard-Jones pair potential. The atomic positions and velocities are computed as functions of time by numerically integrating Newton's Equations of Motion based on the finite-difference method. A computer program is written in MATLAB to implement the numerical algorithm. The obtained atomic trajectories are presented in both still images and animations. The animations will help students visualize the motions in a many-particle system. Equilibration and equilibrium properties, such as the velocity distribution, are also studied. [1] N. Giordano and H. Nakanishi, Computational Physics (Addison-Wesley, 2006), 2nd ed.

11:00 - 11:15 - H2 - Student Research Symposium

Laser Beam Widening Mechanisms in Turbid Media. *Tim Garvin*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790. We examine theoretically and experimentally the transverse intensity profile of a laser beam as it traverses through a turbid medium. By increasing the concentrations of milk in an aqueous solution we examine the transition from the weakly scattering to the diffusive regime. The experimental data of the transverse beam profiles are inferred in a non-contact geometry from photos of the exit surface of the medium for various scattering strengths. The intensity distributions are compared with theoretical data are obtained from Monte Carlo simulations.

11:15 - 11:30 - H3 - Student Research Symposium

Using Shadows in Imaging in Highly Scattering Systems. *Isaac Goodin*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790. We suggest that the concept of the point-spread function traditionally used to predict the blurred image pattern of various light sources embedded inside turbid media can be generalized under certain conditions to predict also the presence and location of spatially localized absorbing inhomogeneities based on shadow point spread functions associated with each localized absorber in the medium. The combined image obtained from several absorbers can then be decomposed approximately into the arithmetic sums of these individual shadow point spread functions with suitable weights that can be obtained from multiple regression analysis. This technique permits the reconstruction of the location of absorbers.

11:30 - 11:45 - H4 - Student Research Symposium

Limitations of Decomposition Based Imaging. *Sebastian Grobe*, University High School and ILP, Illinois State University, Normal, IL 61790. We examine theoretically and experimentally an imaging scheme that uses the scattered light intensity profile to reconstruct the locations of absorbers embedded in a turbid medium. This method is based on an a priori knowledge of the scattered light patterns associated with a single absorber that is located at various positions inside the medium. We discuss the range of validity of this method, its sensitivity with regard to noise and propose an algorithm to improve its accuracy.

11:45 - 12:00 - H5 - Student Research Symposium

Calibration of Webcams for Imaging. *Sawyer Campbell*, Intense Laser Physics Theory Unit, Illinois State University, Normal, IL 61790. We generalize a previously proposed imaging scheme to situations for which the set of hidden objects embedded in the highly scattering medium can take arbitrary shapes. We compare the accuracy of images obtained from optical detection fibers with those from a CCD camera. The latter approach is more efficient and can be applied to non-contact geometries, but it requires an a priori linearization of the obtained digitized images. We discuss some details of this calibration for the camera and establish its potential as a new tool for decomposition based imaging.

12:00 - 12:45 - Lunch - *It must be ordered with Registration.* **Loomis Lab Foyer**

12:30 Meeting of the Program Committee for the Fall 2008 meeting at Illinois State University in Normal

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