

Program

Workshop

Friday, October 23

4.30 - 6.30 PM

Improving the Teaching Laboratory through DIY Apparatus Development

Oxendine Science Building, ***Room 3260***

William D. Brandon, UNCP

There are many key benefits to being actively engaged in apparatus development for the teaching labs that are synergistic in promoting and maintaining a healthy physics department. Some of the concrete benefits include: 1) Cost savings 2) Increased knowledge (students and instructor) 3) Stimulating more interest in research 4) Staying abreast of the latest cost effective technology 5) Forcing innovation 6) It's Fun!

We will demonstrate and discuss several different approaches to apparatus development ranging from significant modifications of existing instruments to complete design and building of new ones and how to exploit various resources in carrying out such endeavors. Below is a list of apparatus we have used over the past two years in our introductory labs at UNCP.

Computer software

Wavedrivers: driver, amplifier and function generator for less than \$50.00)

Soundtubes: speaker, tube, function generator and scope/spectrum analyzer (less than \$20.00)

Simple mechanically driven oscillator to introduce the Lorentzian model (let it run while you lecture)

Interface boxes (very simple and very useful)

Exploiting light sources to upgrade Pasco optics benches

Laser modulator (simplest): direct and indirect methods

Cheap high current power supply

Workshop

Saturday, October 24

8:00 - 8:45 AM (Part 1) & 11:15 – Noon (Part 2)

Oxendine Science Building *Room 3235*

Renewable Energy Education Workshop: Enhancing Your Physics Courses and Your Recruitment Efforts with Renewable Energy: Part 1

Robert Ehrlich, George Mason University

Oxendine Science Building, Room *TBA*

Purpose and intended audience: This workshop will help people interested in teaching about renewable energy at the college or high school levels find resources to assist them in preparing their courses. No specific knowledge of renewable energy is assumed.

Workshop schedule:

30 min: Why physics teachers should get involved in R.E.; “Renewable Energy 101”; Student interest in the subject; Using renewable energy to enhance your physics teaching and recruitment efforts; Trends in renewable energy education nationally; Obstacles to developing renewable energy programs in colleges and universities; Career opportunities & future employment projections

30 min: Description of the rev-up project

60 min: The “work” part of the workshop which will feature a contest with a **cash prize** awarded to one workshop member subject to certain rules described below.

Contest rules: The prize goes to the person who adds the largest number of new items to any of the eleven resource categories (books, media, etc) in the rev-up database during a 60 min period. Items added to the under-populated categories of “simulations” and “course notes” count double. In addition I will also double count evaluations submitted under the “evaluate & improve this site” link provided you make a substantive suggestion.

General restrictions on entered items:

Duplicates. Items added must not duplicate items already there, and they can be in any of eleven resource categories. In order to check for duplicates before you enter an item, just do an alphabetic sort of all items in a given category.

Level. Items added must be appropriate to high school or college level, and relevant to renewable energy. (Climate change is slightly off-topic, for example, but energy conservation is OK, but not energy conservation in the “physics sense.”)

Restrictions on entries for specific resource categories:

Speakers. In the speakers category only add people whom you know for a fact are willing and able to talk to school or other groups on renewable energy topics – you may include yourself if this describes you & you may add a “review” of yourself along the lines of the “review” I added for myself

Student Projects. For the student projects category, only add actual “how to” descriptions of projects, not reports on projects various groups have done.

Simulations. For the simulations category, only add simulations that are suitable to use in a class or as a project, not for example some commercial energy simulations for the actual detailed design of a building. On the other hand, simple calculators that can be used, say, to calculate your roof’s solar potential are fine.

Internships. These must be actual opportunities open to students anywhere, not a specific institution, and they must be descriptions of the opportunity, not a news report about the work done by earlier students.

8:45 – 9:00 AM Break

Oxendine Science Building *Room 3202*

Papers

9:00 – 9:15 AM

Oxendine Science Building *Room 3256*

Fifty Years of Teaching Physics

Aaron McAlexander, MSC 1251, Queens University of Charlotte, 1900 Selwyn Avenue, Charlotte, NC 28274, (707)365-4795, mcalexaa@queens.edu

It goes without saying that much has changed in the almost half century that I have been teaching physics, but perhaps less change than one might expect. This is a presentation of some humorous and poignant observations about changes in the physics curriculum and pedagogy, and how I have coped (and failed to cope) with those changes. A few suggestions of how one might prepare for future changes are also included.

9:15 – 9:30

Oxendine Science Building Room 3256
Interactive Lecture Models

Wolfgang Christian, Davidson College, Davidson, NC wochristian@davidson.edu

Computer models combined with theory and lecture demonstration engage students through a cycle of Predict → Observe → Explain → Refine. This talk describes two such models. The Falling Cup with Ball model shows a mass attached to the inside of a cup with a light spring. The cup is held upside down, with the mass hanging out of the cup, and then released. The Falling Slinky approximates a slinky using twenty masses connected with light springs. The slinky is suspended from one end and released. What happens when these objects begin to fall? I will present Easy Java Simulation (EJS) models of these lecture demonstrations. Additional Open Source Physics curricular materials and EJS models suitable for interactive lectures are available at: <http://www.compadre.org/osp/index.cfm>

Partial funding was provided by NSF grant DUE-0442581.

9:30 – 9:45 AM

Oxendine Science Building Room 3256
Undergraduate Computational Projects Using the Open Source Physics Library

Larry Engelhardt, Francis Marion University, PO Box 100547, Florence, SC 29502, (843)661-1452, Fax: (843)661-4616, lengelhardt@fmarion.edu, <http://swampfox.fmarion.edu/engelhardt>

We present the results of recent computational physics projects that have been undertaken by undergraduates at Francis Marion University. One of these projects involves the simulation of systems of interacting quantum spins. Various aspects of this project could be of relevance to students taking modern physics, statistical physics, quantum physics, or condensed matter physics. Other projects include the simulation of the H_2^+ molecule (the simplest “real” quantum system after the hydrogen atom), and the simulation of combinations of finite capacitors (which lack the symmetry that is necessary for an analytic solution). In all cases, the use of the Open Source Physics Library has allowed the students to create sophisticated simulations, with easy-to-use interfaces, in a reasonable amount of time.

9:45 - 10:00 AM

Oxendine Science Building Room 3256
The Elon Physics Phenomena Photography Project

Claudine R. Moreau, Elon University, 2625 Campus Box, Elon, NC 27244, (703)999-5223, cmoreau@elon.edu

For the past three years, Elon University has sponsored a physics phenomena photography contest for students enrolled in algebra-based physics courses. This project is modeled after the AAPT High School Physics Photo Contest. In this talk, I will discuss details of this

contest/project, including a submission process using Flickr (www.flickr.com), its scoring rubric, and the production of a final multimedia show. I will also review the most frequently submitted physics phenomena, common misconceptions students have about their photos, and the perceived benefits for this project.

10:00 – 10:15 AM

Oxendine Science Building *Room 3256*

What You Can Learn From A Discarded Microwave Oven

William W McNairy, Duke University, Dept. of Physics Box 90305 Durham, NC 27708,
(919)660-2689, Fax: 919-660-2525, mcnairy@phy.duke.edu

In my walks about town I often come across discarded microwave ovens lying by the curb-- most are surprisingly in good working order. From several past discussion threads on TAP-L, I have found that a number of interesting demonstrations can be created using either the microwave oven or its separate components. My presentation of some of my favorites will include: relative motion, thermal expansion, wavelengths of EM waves, plasmas, the sparkling glow of everyday objects, and energy stored in a capacitor.

10:15 – 10:30 AM

Oxendine Science Building *Room 3202*

BREAK

10:30 – 10:45 AM

Oxendine Science Building *Room 3256*

Imagine the possibilities: A new perspective on physics student reasoning

Jon D. H. Gaffney (graduate student), Ruth W. Chabay, North Carolina State University,
(Graduate Student), Riddick Hall, Room 224A, Box 8202, Raleigh, NC 27695-8202
(Office): (919) 513-7214, jon_gaffney@ncsu.edu

In the preliminary paper "Is Clicking Thinking?" presented at the fall 2007 NCS-AAPT meeting at High Point by Shawn Weatherford, we reported that students often have difficulty following and utilizing chains of deductive reasoning. I present a follow-up with further research in understanding student reasoning. Instead of looking for evidence of "formal logic," I have utilized a framework for reasoning based on the search and elimination of possibilities (based on work by P. N. Johnson-Laird). This has shed some light upon the actual reasoning processes that students use and provides a foundation for future investigation. In this research update, I will present a brief overview of some of the results and implications from this new perspective.

10:45 – 11:00 AM

Oxendine Science Building *Room 3256*

The role of theory and experiment in the introductory course

Aaron Titus, Department of Chemistry and Physics, High Point University, 833 Montlieu Ave, High Point, NC 27262, (336)841-4668, titus@mailaps.org

In the introductory physics course, the list of objectives is quite long. We teach problem solving skills, conceptual understanding, lab skills, and math skills across an expansive list of topics. Yet, it is imperative that within this framework, students gain insight into the nature of science. Today, computational physics plays an essential role in applying theory, testing models, explaining observations, and making predictions. To help students learn about the nature of science, especially the interplay of theory and experiment, I teach students to develop computational models, to compare results of these models to experimental results, and to make predictions. In this talk, I'll present some ideas and course materials that I use to teach computational physics in the introductory mechanics course.

11:00 – 11:15 AM

Oxendine Science Building *Room 3256*

What are Matter Waves?

Bill Brandon, UNCP Dept of Chemistry & Physics, (910)775-4289 William.Brandon@uncp.edu

A simple description of matter waves lending itself quite naturally to further development in introductory modern physics pedagogy follows from the notion that inertial mass originates from the special relativistic effects of a resonant coupling between the zero point field and charge. Using basic algebra to investigate the energy dispersion of the free electron it appears that matter waves might be attributed to a modulated wave formed by superimposing the intrinsic set of randomly phased, Lorentz transformed, Doppler shifted electromagnetic waves. In particular, matter waves are the result of zero-point-field driven resonances modulated at deBroglie frequencies. This is a very simple version of an interpretation rigorously described earlier by researchers in the field of stochastic electrodynamics. The attraction to such an approach, for those so inclined, is the simplicity afforded in returning to an old fashioned mechanistic understanding of the universe and an effort to break from established Copenhagen doctrine.

Workshop (Part 2)

11:15 - Noon

Oxendine Science Building *Room 3235*

Renewable Energy Education Workshop: Enhancing Your Physics Courses and Your Recruitment Efforts with Renewable Energy: Part 2

Robert Ehrlich, George Mason University

Concurrent Papers

11:15 – 11:30 AM

Oxendine Science Building *Room 3256*

Demo on Standing Waves

Gabriela Stefan, North Carolina School of Science and Mathematics
1219 Broad Street Durham, NC 27705 Bryan (919)416-2756, (919)416-2600.
Stefan@ncssm.edu

The goal of this demo is for the students to figure out what are the factors affecting the speed of a standing wave. By varying tension and seeking different number of specific antinodes, knowing/reading the frequency of the source of forced oscillations observing the relationship between the wavelength and the length of the string the speed of the wave is calculated. Is the speed of a wave dependent on the properties characteristics of a wave, or rather the speed is dependent upon the properties of the medium?

11:30 – 11:45 AM

Oxendine Science Building *Room 3256*

Astronomy Resources You Can Use in Your Classroom

Ken Brandt*, NBCT, JPL/NASA Solar System Educator, Robeson Planetarium and Science Center, UNC-Pembroke, (910)735-2147, Fax (910)671-6017, brandt@uncp.edu

We will quickly survey a smattering of the online resources available to the Physics and Astronomy Teacher for use in the High School and College classroom. I will also show you simple ways to tie into appropriate mission websites and outreach efforts to pique student interest in astronomy and physics. You will leave this session with at least one bulletin board's worth of posters, and other materials suitable for use in your teaching situation.

*Sponsored by Jose D'Arruda, UNCP

11:45 – Noon

Oxendine Science Building *Room 3256*

Determine Longitude Using the Moons of Jupiter as Part of a Global Effort with Tomsk State Pedagogical University in Siberia Russia to Celebrate the International Year of Astronomy 2009

Michael Everhart (undergraduate student), Jason York (undergraduate student), Nathan H. Stewart and Jose D'Arruda, Department of Chemistry and Physics, UNCP, Pembroke, NC, T.S. Boronenko., Department of Astronomy, TSPU, Tomsk, Russia

We report on a joint on-going project of two universities, UNCP and TSPU, to record the ephemeris of the moons of Jupiter and from that data, the longitude of our two locations. With

an ephemeris for Jupiter satellite transits and occultation that is accurate for the time at the Royal Greenwich Observatory, you can synchronize your clock to the observatories by watching the scheduled event. The difference between your local time and Greenwich local time reveals your longitude. We will present both of our data and from that data determine our respective longitudes.

Noon – 1:30 PM

Chavis University Center

Lunch and Business Meeting

1:30 – 1:45 PM

Oxendine Science Building *Room 3256*

Stereo (3D) Visualization

Thomas A. Dooling, Department of Chemistry and Physics, UNCP, (910)521-6595

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Stereo visualization is becoming more common place as technologies improve the process for generating three dimensional images. Students are exposed to it routinely in the movie theater and TV manufacturers are rushing to bring different 3D designs to the home. With a simple digital camera and freely available software, anyone can present stereo visualizations using the anaglyph (red/cyan glasses) method. A quick explanation of how to produce a stereo image will be provided along with scientifically themed stereo pictures. It will also be shown how to make stereo simulations in Easy Java Script. The red/cyan glasses will be provided .

1:45 – 2:00 PM

Oxendine Science Building *Room 3256*

Microspectrophotometry Laboratory Projects for Undergraduate Instrumental Analysis

Paul A. Flowers*, Department of Chemistry & Physics, University of North Carolina at Pembroke, Pembroke, North Carolina 28372-1510, (910)521-6424, Fax: (910)521-6638

paul.flowers@uncp.edu

Recent surveys have shown several disparities between the expectations of chemical industry and the laboratory curricula of undergraduate chemistry programs in regard to student experience with various instrumental techniques. This disparity is particularly notable for optical microscopy, a technique routinely used in many industrial settings, but rarely encountered in the undergraduate chemistry lab. Rather than add a new lab project to an already full curriculum, an existing spectrophotometry project for undergraduate instrumental analysis has been revised to incorporate the use of optical microscopy. Attaching a miniature CCD spectrometer to the camera port of a standard compound microscope yields a simple microspectrophotometer suitable for student investigation of the usual photometric concepts (signal-to-noise ratio, Beer's law, etc.) and concepts of optical microscopy (magnification, illumination schemes, etc.).

Several such investigations, including student data and ideas for additional applications, will be described in this presentation.

*Sponsored by Jose J. D'Arruda

2:00 – 2:15 PM

**Oxendine Science Building *Room 3256*
A Flexible Platform for Teaching Astronomy**

Mario Belloni, Physics Department, Davidson College, PO Box 6910, Davidson, NC 28035-6910, (704)894-2320, Fax: (704)894-2894, mabelloni@davidson.edu
<http://webphysics.davidson.edu/mjb>
<http://webphysics.davidson.edu/physletprob/>

Todd Timberlake, Department of Physics, Astronomy & Geology, Berry College, PO Box 5004, Mount Berry, GA 30149-5004, (706)368-5622 Fax: (706)238-7855, timberlake@berry.edu

One of the most popular courses in physics is astronomy. However, the topics taught require visualizations that are not familiar to the typical students in these courses. To address this issue, we have created a set of flexible resources for the teaching of introductory astronomy based on two- and three-dimensional simulations. These simulations are created with Easy Java Simulations, EJS, which is a free and open source tool for creating Java simulations. Because EJS allows teachers to easily change simulations, existing simulations can be customized to the type of astronomy course one is teaching. This talk will show astronomy examples including the celestial sphere, Ptolemaic and Copernican models, Keplerian orbits, and solar and lunar eclipses. All of these materials are available on the OSP Collection on the ComPADRE digital library.

The Open Source Physics Project is supported by the National Science Foundation (DUE-0442581).

2:15 – 2:30 PM

**Oxendine Science Building *Room 3256*
NASA's University Student Launch Initiative (USLI), a Community College Perspective**

Doug Knight, Mitchell Community College, 500 West Broad Street, Statesville, NC 28677, (704)978-5432/w (336)909-1711/c FAX (704)878-0872 dougchar001@gmail.com

Marshall Space Flight Center sponsors a university level rocket contest where teams of students must build and fly a rocket to an altitude of one mile while carrying a scientific payload. In 2008, Mitchell Community College was the first community college accepted into this program. A synopsis of the USLI project along with results from the rocket's flight and scientific payload will be presented. Challenges, rewards and lessons learned with respect to a community college rocket team will be highlighted.

Workshop

2:30 - 3:30 PM

Oxendine Science Building *Room 1246*

PARI Digital Resources

Michael Castelaz, Pisgah Astronomical research Institute

Oxendine Science Building, Room *TBA*

Via the Internet, remotely access the School of Galactic Radio Astronomy (SGRA; <http://www.pari.edu/programs/teachers/smiley/>) 4.6-meter radio telescope located at the Pisgah Astronomical Research Institute (PARI). The radio telescope receiver is designed for detection of 21-cm radiation emitted by the center of our galaxy and its spiral arms, supernova remnants, regions of star formation and other celestial sources. Real-time control includes scheduling observing time, source selection, pointing the telescope, and taking the measurements. Several labs have been developed and include "Doppler Shift" and "Mapping Radio Sources". The labs and hands-on experience increase students' information and technology skills while promoting student-directed critical thinking and problem solving. This is accomplished by encountering real-world data and tools and putting them to work for the student.

A citizen science project called Stellar Classification Online - Public Exploration (SCOPE) (<http://scope.pari.edu>) will be presented. With SCOPE, learners, as citizen scientists, explore the visible stellar sky. Digitized images of archived astronomical photographic data taken over three decades are available through a user-friendly web interface and designed for classification of stars. The data is real, and was used originally used to compile the Michigan Spectral Survey based on several hundred thousand stars. However, nearly a million stars remain unclassified in the archive. This is a perfect scenario for a citizen science project which teaches stellar evolution.

SGRA and SCOPE will be expanded for national use through the NSDL infrastructure, contributing a new, real-life interactive component to current NSDL digital educational resources.

Concurrent Papers

2:30 – 2:45 PM

Oxendine Science Building *Room 3256*

Creating a Regional Partnership to Address Honey Bee Colony Collapse Disorder

Len Holmes, Sartorius Stedim Biotechnology Laboratory, UNCP Biotechnology Research Center, Len.Holmes@uncp.edu

The worldwide economic value of the pollination service provided by insect pollinators, honey bees, is estimated to exceed \$300B for the main food crops. This figure is approximately 9.5% of the total value of the world agricultural food production. The honey bee (*Apis mellifera*), is undoubtedly the most important pollinator of food crops for humans and probably of food for wildlife in North Carolina. Recently bee keepers across the country have witnessed wide-spread honey bee die off, threatening to wipe out crops that depend on them for pollination. The affliction is called Colony Collapse Disorder (CCD). Without a solution, 80% of fruits and vegetables that require pollination may not make it to market. The cause of CCD is not yet clear and may be related to pesticides, parasites, disease, urbanization or harmful insects. It is being proposed to establish a regional bee keeper support service to provide technical assistance and information to local farmers. The UNCP Bee Center will work under the guidance of national, state and regional bee keeping and agricultural organizations. Collaborations with community colleges and North Carolina State University will train students and build funding streams.

2:45 – 3:00 PM

Oxendine Science Building Room 3256

Determination of Isoelectric Point [pI] for Amino Acids and Peptides: A Teaching Tool

Joseph Lemanski, Bradley Eidschun and Siva Mandjiny, (students), Department of Chemistry & Physics, The University of North Carolina at Pembroke, Pembroke, NC 28372-1510

This program was designed to calculate the isoelectric point [pI] of amino acids and peptides, as well as simulate their movement in a solution of a user-defined pH. The user is also able to view the titration curve of single amino acid. This page also allows the user to view the pKa values of amino group, the carboxyl group, and the side chain wherever it is applicable. The isoelectric point is also graphically displayed on the titration curve screen along with the pKa values, in addition to being displayed numerically on the solution screen above the solution. When a user enters a string for the peptide, the program will estimate the peptide's isoelectric point.

3:00 – 3:15 PM

Oxendine Science Building Room 3256

Visualizing the Initial Stages of Amorphous Organic Semiconductor Growth

Zhengang Wang (graduate student), Alex Pronschinske, and Daniel B. Dougherty*, Department of Physics, NCSU, Rm. 446 Riddick Hall, 2401 Stinson Dr., Raleigh, NC 27695-8202, (919)513-2610, Fax: (919)513-0670 zwang6@ncsu.edu, dbdoughe@ncsu.edu

The organic semiconductor Alq₃ was grown on a Cu (110) surface by vapor deposition in an Ultra High Vacuum environment. The surface topography has been characterized using Scanning Tunneling Microscopy at room temperature as a function of coverage in the first monolayer. At the lowest surface coverages, Alq₃ molecules are highly mobile on the Cu(110) surface and cannot be imaged. However, with increasing coverage, stable pairs of Alq₃ have been observed that gradually grown into extended disordered chain structures. The formation of pairs and disordered chains is attributed to electrostatic dipolar interactions between the adsorbed

molecules. This interpretation is compared with statistical characterizations of other physical systems with structure driven by dipolar interactions.

*Department of Physics,
North Carolina State University

3:15 – 3:30 PM

Break

Oxendine Science Building *Room 3202*

Papers Continued

3:30 – 3:45 PM

Oxendine Science Building *Room 3256*

Fabrication of Ferroelastomeric Microparticles

Daniel Glass (undergraduate student), Department of Physics, Elon University, Elon NC, 27244, (484)639-1683, Dglass2@elon.edu

Magnetic microspheres are used in a wide variety of applications within the scientific community; they are pertinent to the medical field to transport drugs throughout the body, in chemistry to cleanse a solution of radical particles and in physics to apply torques and forces to materials on the microscale. However, current production methods lead to a gap in the size range of commercially available magnetic microspheres in a critical range between 0.5 and 1 micron. We have produced a novel magnetic polymer composite material that may be crosslinked, and have begun to produce magnetic microspheres by creating a colloidal suspension of this material and crosslinking the resulting particles. My research aims to fill the current size gap with highly-magnetic microspheres and to explore the factors that affect the size of magnetic microspheres fabricated by this technique.

3:45 – 4:00 PM

Oxendine Science Building *Room 3256*

Incorporating science into study abroad through outreach

Martin Kamela, Physics Department, Elon University, <http://www.elon.edu/mkamela>

The recent trend in higher education promoting internationalization and global citizenship begs the question of how science faculty can be involved in such efforts. In particular, how can science faculty use their expertise in the context of a study abroad program? In this presentation I will explore outreach as a basis for a short-term study abroad course. Our “Traveling Science Center” brings interactive exhibits to middle schools in Kerala state, India. We reach about 3000 children in the three-week January term and evaluate our efforts. Elon students receive science credit for preparing exhibit posters and for monitoring the science center activities. Through close interactions with local partners, and through contacts with school children and teachers,

Elon students develop an appreciation for the lifestyle in Kerala and for the concerns and aspirations of their Indian peers thus becoming wiser global citizens.

Posters

Oxendine Science Building *Room 3231*

A Method for Studying Non-planar String Motion

Brayam Pinilla (Poster), (senior student), Mentor: Dr. Thomas A. Dooling, Dr. William Brandon UNCP, bep003@bravemail.uncp.edu

When a string is driven by a mechanical oscillator it can experience non-planar “Jump rope like” motion near its resonance frequency. Our approach to study this phenomenon is to drive a copper wire under tension over a strong magnet. The magnet induces an alternating emf in the wire, which is measured with a Pasco interface. When the wire vibrates in a plane, the induced emf forms a sinusoidal wave. However when the wire makes circular motions, then the positive and negative parts of the sinusoidal envelope becomes asymmetric. This asymmetry characterizes the degree to which the motion is out of plane. This method was used to study a 0.24mm copper wire with a length of approximately one meter. The wire was driven by a mechanical oscillator through a range of frequencies that took it through its first resonance. This process was done for wire tensions from five to six Newtons. Data will be displayed that demonstrates the planar and non-planar motion of the copper wire as it passes through resonance.

An Automated Faraday Rotation Apparatus for Investigating Band Parameters

Samantha Hutcheson (undergraduate student at UNCP) (Poster)

An automated and highly accurate Faraday rotation apparatus was developed to measure Verdet constants, the dispersion of which gives insight into the band gap parameters of transparent materials. All known data for the most commonly measured substance, water, was combined to confirm the precision and accuracy of the apparatus. The design of the instrument in conjunction with the methodology, by which all previous band parameters for water were calculated, including those from our measurements, will be addressed.

The Creation of a Plasmid Vector for the Genomic Integration of the Gene for GFP into *Salmonella enteritidis*

Floyd Inman

Preliminary study on the use of bioluminescent transformed *Escherichia coli* MM294Lux+ to study shear forces under simulated hypergravity

Johnathan Locklear

Micropropagation of ornamental plants

Brittany Locklear

Mass Production of Entomopathogenic Nematodes

Heather Taylor, Fayetteville Technical Community College

(Len Holmes will be presenting this poster in the absence of the student.)