NORTH CAROLINA SECTION OF THE AMERICAN ASSOCIATION OF PHYSICS TEACHERS

Southern Atlantic Coast Section American Association of Physics Teachers

11th Annual Spring Meeting March 24-25, 2006

A Joint Meeting with the South Atlantic Coast Section of AAPT and the Society of Physics Students
Belmont Abbey College, Belmont, NC

Secondary Teachers Only
Complimentary Registration
Special Door Prize Drawing for Classroom Equipment

Invited Speakers:

FRIDAY NIGHT BANQUET SPEAKER 8:00-9:00pm Haid Ballroom

Paul Hewitt

author of **Conceptual Physics** and column editor for The Physics Teacher. http://www.conceptualphysics.com/pghewitt.shtml

Conceptual Problem Solving

Many of us are frustrated with students when at the earliest moment of solving a problem they plug in numerical values. There is a simple remedy: Eliminate numbers from problems. Let mass be m instead of 4.8 kg; let speed be v rather then 10.2 m/s; let force be F rather than 480.0 N. Write your exam problems in three parts. In part (a) the problem solution in part is expressed in letters, each of which represents a concept. In part (b) supply numerical values for a numerical solution. In part (c) ask a related conceptual question. Samples of this procedure and a way of helping students do the most difficult part—knowing how to start a solution—will be discussed.

SATURDAY MORNING PLENARY SPEAKER

Dewey Dykstra

Professor of Physics, Boise State University and Research and Teaching Column Editor for the Journal of College Science Teaching.
http://www.boisestate.edu/physics/dykstra/Dyks.html

8:00-8:50 am Tibetan Buddhist Monks, Emptiness, Inquiry and Physics. Dewey Dykstra; William Gaston Science Auditorium

For the last five years we have been giving inquiry workshops in physics as part of the Science for Monks (SfM) Project. The SfM project is conducted at the request of His Holiness the 14th Dalai Lama and is funded by the Sager Foundation. Members of the physics education research community have conducted these workshops: Stamatis Vokos, Mel Sabella, Randall Harrington, Hunter Close, Dewey Dykstra, and Andy Johnson. The purpose of the project is to eventually have exposure to western science as part of the standard monastic experience for all monks. Currently about 50 monks are regular participants in a month long SfM gathering held at various locations in India during our Christmas break. Typically each gathering includes an inquiry workshop in physics, an activity based session in mathematics and several lecture series. The lecture series topics have included modern physics, physics surveys, cognitive science, neuroscience, and genetics. A combination of slides and short video clips will be shared in this presentation to give a feel for the experience. One can link to the Science for Monks web page at: http://www.scienceformonks.org/index.html. (Reference to what is meant by "emptiness" in Buddhism will be made.)

11:10 am -12:10 pm What are we doing and how long have we known? Dewey Dykstra: WGS Auditorium

Many changes have been happening recently in education that impact science education and more specifically physics education. Times of change are dangerous times, but they are also times of opportunity. Changes these days are driven by multiple factors: the No Child Left Behind Act, changes in criteria for accreditation for schools and teacher education programs both by the states and national bodies such as the National Council for the Accreditation of Teacher Education (NCATE). So, how are we doing at teaching physics? How long have we known how we are doing teaching physics? How are we doing at preparing teachers to teach topics in physics? How can we take advantage of the opportunities in the times of change to make large advances in how we teach physics? What are the challenges we are likely to encounter?

FRIDAY

3:00-7:00 pm Registration at the William Gaston Science Building (WGS Entry Hall)
4:00-6:00 pm WORKSHOP: Low Cost/No Cost Classroom Demos: William McNairy (WGS 103)
7:00-9:00 pm BANQUET/ Conceptual Problem Solving: Paul Hewitt (Haid Ballroom)
10:00-11:30 pm WORKSHOP: Photographing the Night Sky: Mary Creason (WGS 103)

SATURDAY

7:30-11:00 am Registration, Vendor (WGS 107 & 110)
8:00-8:50 am Tibetan Buddhist Monks, Emptiness, Inquiry and Physics. Dewey Dykstra (Auditorium)
9:00-9:30 am SPS Poster Session (WGS 107 & 110)
9:30-11:00 am Contributed Papers
11:10-12:10 am What are we doing and how long have we known? Dewey Dykstra (WGS Auditorium)
12:15-1:00 pm LUNCH (Haid Ballroom)
1:00-2:00 pm Business Meeting NCS: Auditorium
Business Meeting SACS: Haid Ballroom
2:00-4:00 pm WORKSHOP: Remote Sensing as a tool for Environmental Physics: J. B. Sharma (WGS 111)
WORKSHOP: On Drawing: Paul Hewitt (WGS Auditorium)

WORKSHOP ABSTRACTS

FRIDAY 4:00-6:00 pm $2.00 William Gaston Science Building Room 103

Low Cost / No Cost Classroom Demonstrations: **Bill McNairy;** A make and take workshop that will provide materials, instructions, and supply sources for demonstrations appropriate for secondary and post-secondary classrooms.

FRIDAY 10:00 -11:30 pm $2.00 William Gaston Science Building Room 103

Photographing the Night Sky: Mary Creason; An introduction to photographing the night sky using both digital and film techniques, including effects of film speed, exposure times, camera mounting systems, and other techniques. A setup will be available for you to take pictures. It is recommended you bring your own camera and film for photographing the night sky during the workshop. Digital Cameras should have a minimum exposure time of 30 seconds. Film Cameras should have a minimum exposure time of 60 seconds and use film speed of 400 ASA or greater. Tripod and cable release are optional, but recommended.

SATURDAY 2:00-4:00 pm $2.00 William Gaston Science Building Room 111

Remote Sensing as a tool for Environmental Physics: J. B. Sharma

This workshop will be a hands-on introduction to the remote sensing of the environment using the shareware image processing program 'Multispec'. Multispectral satellite imagery can be processed to identify and map earth surface features based on reflectance spectral signatures. Participants will get a copy of the 'Multispec' software and some satellite imagery. Image data sources on the Web will also be discussed. This workshop is suitable for both high school and college faculty.

SATURDAY 2:00-4:00 pm $2.00 William Gaston Science Building Auditorium

On Drawing: Paul Hewitt ; Participants will have the opportunity to improve their classroom “chalkboard skills” under Dr. Hewitt’s direction. Each participant will practice drawing on the boards during the workshop.

Local Organizer

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Directions

From the North:
Take I-85 South to Exit 26, the Belmont Abbey College exit. When you exit, you will see the campus in front of you. Turn left at the stop light, then turn right into the first entrance of the college. Turn right at the stop sign, and follow signs to the meeting. "Campus parking restrictions have been suspended for the meeting. So, you can park wherever a space is available."
From the South:
Take I-85 North to Exit 26, the Belmont Abbey College exit. Turn left at the stop sign, and left again at the stop light. You will see Belmont Abbey College to your right as you pass over I-85. Turn right into the first entrance of the college. Turn right at the stop sign, and follow signs to the meeting.

"Campus parking restrictions have been suspended for the meeting. So, you can park wherever a space is available."

Hotels

Holiday Inn, Charlotte 800.647.7829
Located off I-85 at Exit 32 (6 miles from campus)
$56 + tax for Belmont Abbey College guests
Holiday Inn Express, Belmont 704.812.2000
Located off I-85 at Exit 27 (5 miles from campus)
$79 + tax for Belmont Abbey College guests
Fairfield Inn, Gastonia 800.228.2800
704.867.5073
Located off I-85 at Exit 20 (8 miles from campus)
$59 + tax for Belmont Abbey College guests
Courtyard by Marriott, Gastonia 800.321.2211
704.852.4411
Located off I-85 at Exit 20 (8 miles from campus)
$69 + tax for Belmont Abbey College guests
Comfort Suites, Gastonia 704.865.6688
Located off I-85 at Exit 20 (8 miles for campus)
$65 + tax (hot breakfast included) for Belmont Abbey College guests

Some Radio Stations (as you drive in the Charlotte area)

90.7 FM	WFAE	NPR News and Talk
89.9 FM	WDAV	NPR Classical
88.9 FM	WNSC	NPR Jazz

SATURDAY

	Saturday	SPS Poster Session (Rooms 107 and 110) Moderator: William McNairy	
9:00-9:30	**An Analytic Study of Quantum Mechanical Asymmetric Infinite Square Wells** Laura P Gilbert, Mario Belloni (sponsor), Michael A Doncheski*, Richard W Robinett* Davidson College Physics Department, P.O. Box 7133 Davidson, NC 28036-7133 *Pennsylvania State University lagilbert@davidson.edu The infinite square well (ISW) is often used in quantum mechanics as the simplest starting point for the exploration of energy eigenstates and the superpositions of such states. The asymmetric infinite square well (AISW), an infinite well with a constant potential energy "hump" covering part of its base, takes the ISW problem a step further, adding a potential that complicates the wave functions and their corresponding energies. In this paper we examine a number of approaches to a particle in an AISW. We begin with the construction of position-space wave functions for the AISW, and show how we use a transcendental equation to find the allowed eigenenergies for a specific well. We demonstrate how we can use a Wigner distribution to compare classical and quantum phase space for the AISW. Finally, we construct wave packets, and present a preliminary study of the time evolution and revival behavior of these packets in the well.		**An Analysis of Particle Motion beneath Ocean Waves** Cyrus Buffum (Presenter), Chris Mack*, Laney Mills (sponsor) Department of Physics and Astronomy The College of Charleston millsl@cofc.edu cabuffum@edisto.cofc.edu *Applied Technology and Management, Inc. 260 W. Coleman Blvd., Suite A Mt. Pleasant, S.C. 29464 cmack@appliedem.com This talk describes the construction and operation of a wave tank for analyzing the movement of particles beneath propagating ocean waves. The tank is 3.05 m long, 61 cm wide, and 61 cm deep. At one end is a device for generating waves and manually altering their frequency and amplitude. The bottom of the tank can be altered to simulate various sloping shore lines. The objective is to gain insight regarding the detailed affect of ocean waves on beach morphology. This project is conceived as a stepping stone to a larger study of the direct relationship between ocean waves and beach erosion. Chris Mack, Senior Engineer, from Applied Technology and Management, a local firm, is assisting in the construction. The talk will show photos of the tank and its operation.
	Low Cost Optical Signal Transport Seth Henshaw , Sponsored by Mary Creason Physics Department, Duke University, Box 90305, Durham, NC 27710, henshaw@muscat.tunl.duke.edu This poster presents a modified concept of optical signal transport based on activities first developed by the MetroLogic Laser corporation. It uses a low cost device to provide wireless communication between electrical devices. This will focus specifically on transporting audio signals between the receiver and amplifier using a modulated laser beam, however the concept can be applied whenever wireless communication is needed. The entire setup is on the order of $5 in cost and takes roughly 30 minutes to assemble. It provides an excellent teaching forum to present concepts of AC circuits, lasers, how electrical devices communicate, and basics of audio equipment and sound.		**Learning how to do CCD Photography in a small college observatory** Jason York, Justin Hall and Bineyam Kassahun Sponsored by Dr. Jose' D'Arruda University of North Carolina Pembroke Pembroke NC 28372 jose@uncp.edu We will describe the early states of the systematic observation and photography of the night sky using our 16" Meade LX200 GPS telescope and several CCD cameras. We will describe several of the different software packages used and display some of our first pictures taken recently.

Contributed Papers

SATURDAY

	Room #108 Moderator: T. McMurray	Auditorium: W. Gaston Science Building Moderator: Mario Belloni	Room #109 Student Session 9:30-10:30 Moderator: Chris Cunningham
9:30	**My First Year of Teaching Physics Online: Strategies and Reflections** Loren Winters North Carolina School of Science and Mathematics 1219 Broad St., POB 2418, Durham, NC 27715 winters@ncssm.edu After more than 30 years of teaching physics in face-to-face settings, I'm now in my first year of teaching physics online. The course is an AP B course distributed by LEARN NC* and administered jointly by LEARN NC and the North Carolina Department of Public Instruction. Current enrollees include students at 7 high schools throughout North Carolina and a home school in New York. I'll describe some of the teaching strategies that I use, give examples of some of the content, comment on student motivation and performance, and reflect on some of my experiences. * LEARN NC is a program of the University of North Carolina-Chapel Hill	**Optical Observatory and CCD Photography** Jose D'Arruda University of North Carolina Pembroke Pembroke NC 28372 jose@uncp.edu A case study on the construction and implementation of a campus optical observatory and its educational programs. We discuss the issues in designing and building the physical facility along with selecting appropriate telescope hardware and the "learning curve" associated with the variety of hardware and software needed to effectively implement the educational programs. We will discuss the student program, community program and focus on CCD photography and present student example photography.	**The effectiveness of the DSI Pro camera for the determination of the relative ages of different star clusters** Hannah L. Barks[1] Warren Wilson College, WWC 7309 Asheville, NC 28815 hbarks@warren-wilson.edu The inexpensive Meade Deep Sky Imager Pro (DSI-Pro) camera was used to obtain multiple images of different star clusters. The monochrome camera comes with four separate filters: infrared (IR) block and the band-passes for red, green and blue. The images were processed via dark frame subtraction, flat fielding, alignment, and co-adding. The analysis of the images was conducted using a program written in Matlab. This program plots the luminosity derived from the green image versus the color index derived from the blue: green ratio (similar to a Hertzsprung-Russell diagram). The band-pass of the filters was obtained using a spectrophotometer. It was found that each filter transmitted IR light along with its designated color, which diluted the color index. With the corrections for the dilution or placing the IR block in series with the bandpass filters, the clusters were successfully observed at different stages of evolution. [1]Sponsor: Donald F. Collins, Warren Wilson College.
9:45	**Forgotten Fundamentals** Laney Mills Department of Physics and Astronomy College of Charleston, Charleston, SC 29424 millsl@cofc.edu Dr. Al Bartlett is widely known for his talk entitled "Forgotten Fundamentals of the Energy Crisis." in which he argues that there is a single fundamental issue at the root of the energy crisis. This present talk addresses what might be called a crisis involving use lecture format in teaching physics to undergraduate college students. In recent years, frustration with lack of success of the lecture format has led many to deprecate lecturing and to seek alternate methods in which the students are to discover for themselves the basic physics principles. This talk takes the point of view that the lecture format is imminently appropriate for teaching undergraduates and that the reason for its failure is due to forgotten fundamentals. Those fundamentals are spelled out in practical terms that can lead to immediate success in student response, enthusiasm, and learning.	**Variable Stars for Science Fairs and Undergraduate Research** Robert J. Dukes, Jr. Department of Physics and Astronomy The College of Charleston, Charleston, SC 29424 dukesr@cofc.edu The observation and analysis of variable star data provides projects for students at varying academic levels from middle school science fairs through senior theses. In this presentation I will describe some of the types of projects which can be done. These range from visual observation of the light curves of variable stars through sophisticated analyses of time series data of multiply periodic pulsating stars. I will describe a curriculum for high school students which has been produced by the American Association of Variable Star Observers and which and be adapted for use in a range of high school science and math courses as well as college courses. I will also describe sources of data which are available on-line and which are suitable for student projects involving original research. This work is supported in part by NSF grants #AST-0071260 and AST-0507551to the College of Charleston	**Dynamic Tunneling in a Quantum Mechanical System** Murugan Vinayagam[1] Warren Wilson College, WWC 7382 PO Box 9000 Asheville, NC 28815 muruguan@warren-wilson.edu Quantum tunneling is a phenomenon of a particle existing in classically forbidden regions. Tunneling of quantum particles plays a major role in Scanning Tunneling Microscopy, Quantum Dots, Tunnel Diodes, and Very Large Scale Integrated Systems. Solutions to the Schrödinger equation are studied for a particle-in-a-box with a finite barrier in the center. All the solutions to the Schrödinger equation must be continuous and must satisfy the boundary conditions of zero value at the hard walls. These conditions lead to quantization. We chose to approximate the solutions numerically in order to simplify the process of finding solutions for various types of barriers. A search algorithm was programmed in MATLAB to approximate numerical solutions for the wave functions. The numerical solutions obtained from the search algorithm represent various stationary states of a wave function. Dynamic tunneling is shown by the time-dependence of the superposition of two stationary states. An animation is produced. [1]Sponsor: Donald F. Collins, Warren Wilson College.

	Room #108 Moderator: T. McMurray	Auditorium: W. Gaston Science Building Moderator: Mario Belloni	Room #109 Student Session 9:30-10:30 Moderator: Chris Cunningham
10:00	**How Do You Measure a Physics Student? (A 2-meter Stick Isn't Enough.)** Denise M. Wetli Wake Technical Community College 9101 Fayetteville Rd, Raleigh, NC 27603. dmwetli@waketech.edu Increasing focus on assessment of student learning has extended far beyond the assignment of grades. Although grades are what students most focus on, instructors and departments need specific indicators of students' abilities and understanding of physics and ways to document how well students meet these. The assessment cycle is the model for improving course content and delivery methods on a continual basis. This paper will share some assessment strategies and seek your input as to what learning outcomes are essential for anyone taking physics.	**Inka Astronomy in the Liberal Arts Classroom** Elena Mendez Converse College 580 E. Main St.,Spartanburg, SC, 29302 elena.mendez@converse.edu An exercise based on the Inka ceque system of alignments was carried out as part of an introductory astronomy course for non-science majors at Converse College. This involved constructing observation poles at various sites around campus to record the direction of the rising sun and other celestial events. Students were introduced to the role astronomy played in Inka and Mesoamerican cultures. They were then asked to consider the factors involved in creating a calendar and to choose suitable events to observe and record from campus. Measurements of azimuth positions were taken and later compared to sky software predictions. A summary of our results, procedure and experiences will be presented.	**Marketing Physics in High School: Reaching Out to All Students** Shawn A. Weatherford North Carolina State University 201 Buck Jones Road Raleigh, NC 27606 saweathe@ncsu.edu AIP reports a trend of rising enrollment in high school senior level physics courses throughout the 90s and into this Century. Maintaining this trend through marketing physics to traditional and non-traditional students is an effective tool to increase enrollment in high school populations, regardless of student body size. Strategies and anecdotes are provided to help ensure this positive trend that are mindful of expense, student diversity, and effort. Using these strategies at Williams High School in Burlington, NC led to record-breaking enrollments in advanced physics courses and tripled the number of females registered for college-prep physics in one year. Graduate Student
10:15	**I.T.S Physics** Wayne Fisher Physics Teacher, NBCT Myers Park High School w.fisher@cms.k12.nc.us I.T.S. Physics is an innovative teaching strategy that gives students choices as to how they learn, allows them to assume ownership of their learning, and holds them accountable for what they learn. The role of the teacher is that of lesson designer, classroom consultant, and organizer of learning opportunities. Students are at the center of the learning experience, working individually or in small groups to complete a series of learning contracts. The end result is a student-centered classroom where students learn how to be self-reliant learners, producers of quality products, collaborative workers, and contributing members of a learning community.	**Interactive Color Photometry of Star Clusters using an Inexpensive CCD** Donald F. Collins Warren Wilson College, dcollins@warren-wilson.edu Hannah L. Barks, hbarks@warren-wilson.edu A highly engaging activity has been developed for students to examine color-enhanced telescope images of open stellar clusters. The images have been acquired using an inexpensive non-cooled Meade DSI Pro CCD camera. The camera comes with blue, green, and red filters as well as an IR block filter in order to obtain reasonably high quality blue, green, and red images. After alignment of the three-color images, users can “point and click” on each star in a cluster image on a computer screen. This program, written in Matlab, immediately plots each star’s measured luminosity as a function of measured color index, thus providing an interactive plotting of a Hertzsprung Russell diagram. The algorithm will be briefly described and demonstrated. Students have responded well to this application in general astronomy. Some student reports have shown surprising misconceptions about the nature of H-R diagrams, which will be addressed in future applications.	**Investigation and Evaluation of the UNC Charlotte Physics Resource Center** Kristin Walker University of North Carolina at Charlotte Department of Physics and Optical Sciences 9201 University City Blvd., Charlotte, NC 28262 knwalker@uncc.edu The University of North Carolina at Charlotte Physics Department offers the Physics Resource Center (PRC) to all physics students for supplemental instruction. Low attendance to the PRC raised questions about the effectiveness of this program. Introductory physics students were surveyed to investigate and evaluate this program’s effectiveness. Students who took the survey were placed into one of four tracks depending on their knowledge and use of the PRC. Survey results were categorized by student profile, evaluation, and improvements. These results create an understanding of what students are attending the PRC and why they are attending. This talk will discuss the evaluation of the PRC and suggested improvements made by the students. Graduate Student Sponsored by Melissa Dancy

	Room #108 Moderator: T. McMurray	Auditorium: W. Gaston Science Bldg Moderator: Mario Belloni	Room #109 Moderator: Mary Creason
10:30	**Implementing Multi-Dimensional Interaction in Physics Classroom Activity** Mikhail M. Agrest College of Charleston, Physics and Astronomy Dept 66 George Street, Charleston, SC, 29424 AgrestM@cofc.edu One-dimensional approach of lecturer-student interaction and flow of the information was replaced by mult-idimensional methodology and the tools were developed to implement the method [1-4]. Written in the genre of mathematical prose, the supplemental workbook for recording notes is engaging students into active work during the professor's presentation. Achieved objectives include engaging students in the classroom active learning process, completing lecture notes with all substantiations, derivations and correlation of concept, but without misprints, saving time for discussion qualitative issues, demonstrations, problem solving, etc.; reducing departmental expenses on handouts; raising the effectiveness of the teaching process. Designed for regular students, this tool is especially helpful for students with Learning Disability, particularly with Dyslexia 1-2. M. Agrest. Lectures on Introductory Physics I & II, Thomson Learning , 2004, ISBN 0759345120 & 075934583x 3-4. M. Agrest. Lectures on General Physics I & II. (Calculus Based Course). Thomson Learning. ISBN 0-759-35047-7 & 0-759-36060-X, 2005.	**Learning Astronomy Online** Aaron Titus High Point University Department of Chemistry and Physical Science, 833 Montlieu Ave., High Point, NC 27262 atitus@highpoint.edu Online resources in astronomy--from telescope data to content to images--are abundant. But can an introductory astronomy course be taught effectively as an online course? The challenges seem obvious. As science teachers, we believe in the efficacy of hands-on experiences and classroom dialogue. For this first-time experiment in teaching astronomy online, a number of activities were developed that used VPython simulations and Physlets, and a number of technologies including instant messaging, WebAssign, and CLEA labs were employed. Some sample activites will be demonstrated. Results from the Astronomy Diagnostic Test, recording of student dialogue, and feedback from surveys will be shown in an effort to demonstrate both the successes and failures of teaching such a course. Course materials are available at http://linus.highpoint.edu/~atitus/ast121/.	**Geospatial Technology in the Introductory Physics Classroom** J.B. Sharma Gainesville State College, Gainesville, GA Geospatial technologies like the Global Positioning System (GPS) and Google Earth provide a novel basis for relating real-life motion to the mechanics concepts taught in the introductory physics classroom. Students can incur real-life motion and capture the time varying 3D position vector using a GPS unit. This contains all the kinematics of the moving object. If the mass of the moving object is known, the dynamics and energetics of the motion can be unfolded as well. Students can use geo-spatial tools that are readily available to analyze and visualize their own motion. This can serve as a capstone exercise in an introductory mechanics course, summarizing all the fundamental ideas in the context of motion incurred and experienced by the student's themselves.
10:45	**Hiroshima: When was the Decision to Use the Bomb Made?** Hugh Haskell NC School of Science & Mathematics P. O. Box 2418, Durham, NC 27715 haskell@ncssm.edu Last year was the 60th anniversary of the bombing of Hiroshima and Nagasaki, the only times that a nuclear weapon has been used "in anger." By now almost all of the information relating to the decision process that led to that event has been declassified, and so some insights about how and why the decision was made are now available that have not been available until recently (within the past 10 years or so). I will examine some of the evidence now available about the decision and speculate on the motivation of some of those involved, on both sides of the issue.	**Teaching Wave Function Shape in Introductory Physics with Physlets** Mario Belloni and Wolfgang Christian Davidson College Physics Department, BOX 6910, Davidson, NC 28036 mabelloni@davidson.edu The most fundamental construct of time-independent quantum mechanics is that of the wave function. A wave function is a solution to the Schrödinger equation and, when it represents a localized solution, has a probabilistic interpretation according to Born. One of the most important questions in quantum mechanics, therefore, is why does a wave function have the shape that it does? In this talk we will describe several simple, yet accurate, "rules" for determining wave function shape. Along the way, we shall see which concepts we can "borrow" from classical physics and which ones we must discard. To help accomplish this goal, we have created computer-based Physlet exercises which can be used as in-class, tutorial or laboratory exercises.	**An LED Activity for Introductory Electricity and Magnetism Lab** Michael Burns-Kaurin, Paul Camp, and Marta Dark McNeese Spelman College Campus Box 220, 350 Spelman Lane Atlanta, GA 30314 mburns-k@spelman.edu As the culminating activity in a series of activities on DC circuits, the students are asked to connect an LED to one or more 1.5 V batteries so that the current is 3 mA. As they proceed, students may ask for a specific resistor if they give a reason (trial-and-error not allowed). Students progress from simply connecting the LED across batteries to, ultimately, a graphical analysis that includes the current vs. voltage curve of the LED (fit by the Schottky equation).