PhysicsFocus

Winter 2010-2011
Editors Jack Houlton & Lauren Otto

Bethel University Physics & Engineering Newsletter

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Inside this issue:

Plasmonics and Biotechnology Arrive in Bethel Physics

The Bethel University Physics Department recently found a new member for their 2011-2012 fulltime faculty team: Dr. Nathan Lindquist.

Dr. Lindquist has been helping our department as an Adjunct Professor of Physics during 2010 – 2011. He completed his Ph.D. in electrical engineering (EE) at the University of Minnesota (UMN) in August 2010 [Metallic Nano-Structures and Surface Plasmon Resonance for Optical Biosensing; Adviser: Professor Sang-Hyun Oh] and also was appointed to a postdoctoral position at UMN.

During the fall semester, Dr. Lindquist worked with Dr. Beecken on the electronics course and also with Jack Netland on the concepts in physics course. In addition to this, he also agreed to assist with senior research projects. This spring, he has been be co-teaching the computer methods course with Dr. Stein and working with lab projects for this spring's "lasers" class. Lindquist followed a University of Minnesota M.S. in physics with his extremely successful EE thesis work on plasmonics and biosensors. His personal story of arriving at this eventual focus area is described at http://www.grad.umn.edu/DDF/SampleProposals/Electrical_Engineering.pdf

In January 2010, he presented a review talk for Bethel faculty and students about plasmonics and the wide array of applications that are envisioned, including highly efficient solar cells and biosensors. During 2009 – 2010 he was supported by a prestigious Doctorial Dissertation Fellowship at Minnesota and was co-author of a *Science* paper: "Ultrasmooth Patterned Metals for Plasmonics and Metamaterials," Prashant Nagpal, Nathan C. Lindquist, Sang-Hyun Oh, David J. Norris, 31 July 2009: Vol. 325. No. 5940, pp. 594 – 597.

Dr. Lindquist at Bethel in January 2010

LaserFest 2010 Demonstrations Continue in Area High Schools

During the summer of 2010, Dr. Peterson and Dr. Hoyt travelled to Portland and led workshops for science educators to demonstrate laser physics and applications. This was sponsored by a grant from *LaserFest* 2010. This grant continued into the fall of 2010, sponsoring demonstrations at area high schools.

Bethel Profs Enlighten Local Schools

In October and November eight one-hour demonstrations and lectures were given in physics classes at St. Paul Public Schools (St. Paul Central, Johnson, Highland Park, and Como Park Senior High Schools) by Richard Peterson and Chad Hoyt with support of a the 2010 Laser-

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Dr. Peterson talks about laser resonator feedback at Highlands Park Senior High

Dr. Hoyt talks about Jello brand edible lasers at Johnson Senior High School

Fest grant from the Society of Photo-Optical Instrumentation Engineers (SPIE). Opening presentations were on October 27, 28, & 29 and featured demonstrations introducing the fundamentals of laser physics. Final presentations on Nov. 29, 30, and Dec. 1 enticed participants with a few of the many applications of lasers in science and engineering today. Physics majors Sarah Kaiser, Lauren Otto, and Brandon Brunkow played an active role in helping with the presentations. About $900 in lasers and accessories were also presented to each of the departments and their teachers.

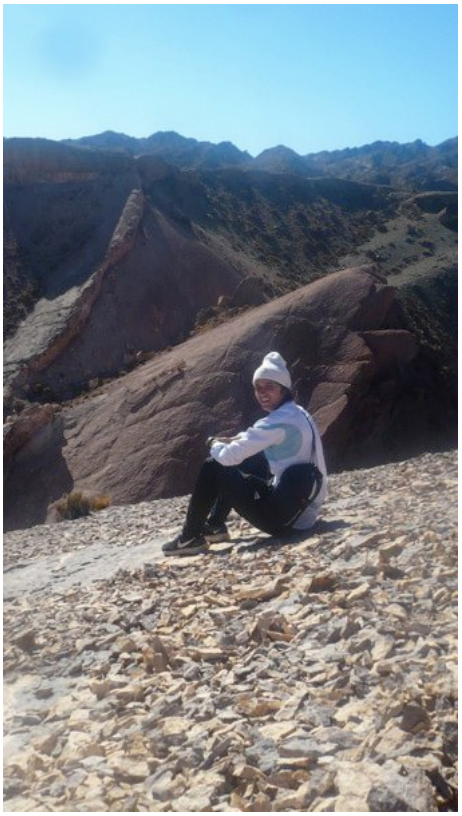
Senior Brandon Peplinski Studies Abroad in Argentina

There's nothing like spending a semester abroad! I left for Argentina in February with so many expectations—many of them were fulfilled, but in many cases things were different than I could've ever expected. All in all my experience was amazing.

I studied Castellano (Argentine Spanish) last spring and summer at La Universidad Nacional de Cuyo in the city of Mendoza, which lies in desert-like western Argentina in the foothills of the Andes. For my five months in Argentina, I lived with a host family, which consisted of two parents, two brothers in their twenties, a grandma, and a beagle. I studied things like sociology, economics, and classical guitar alongside Argentine college students and trained with the university fútsal team. I traveled the country, and roamed the wide streets and fountain-decorated plazas of a city whose population never seemed to sleep but rested often.

A typical Argentine's day starts with a cup of coffee around 7:00 for breakfast followed by work or school, a large lunch around 13:00 followed by a city-wide siesta (literally "rest") from 14:00-17:00 during which ALL stores close, back to work until 20:00, dinner at 22:00, and if it was the weekend, meet up to go out with friends at 24:00 (yes, that's midnight) for several hours. By the way, it is because Argentines sleep so little they use a 24-hour clock.

"By the way, it is because Argentines sleep so little they use a 24-hour clock." -Brandon Peplinski



Brandon enjoying the view in Uspallata, Argentina

While in Argentina, I was registered to take thermodynamics at my university, but the professor of the class lived 18 hours away in Bariloche, Argentina. The start date for the class kept getting pushed back because he was "traveling" and they didn't know how soon he would get there. This went on for too long, so I had to switch into a different class. It turned out that the professor never came and there was no thermo class! Needless to say, the academic system is quite different than ours, and

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much more laid back, although not lesser in quality. Dr. Greenlee apologizes vigorously if he runs a little behind and arrives 30 seconds late for class, but all of my Argentine professors casually and consistently showed up 10-15 minutes late, if they weren't on strike.

I was blessed with a few close Christ-seeking friends in my program and also attended a church where the congregation was youthful and on fire. Even so, five months alone and away from community and support made for my first challenge sustaining myself spiritually. I can say I learned and grew in new ways I could not have imagined. I left ready to expect the unexpected and God delivered. Five months alone in a foreign country, experiencing amazing things every day with equally amazing and different people made for the most unique and perspective-shaking time of my life.

Brandon enjoying the tranquility of the park while playing his acoustic guitar

Record Grads in 2010

Last year, the Bethel Physics Department graduated the largest class in its history: 24. Department Chair, Dr. Beecken, reflects on the achievement of the department in recent years, as well as our rising national rankings in average number of graduates.

Spring 2010 graduates and professors pictured from left to right: (back row) Dr. Greenlee, Derek Arens, Dr. Hoyt, Seth Anderson, Joe Larson, Brad DeJong, Pablo Jurpik, Dr. Peterson, Jeff Helget, Justin Watkins, Nicole Thom, Jimmy Thostenson, Dr. Beecken, (front row) Jessica Reynertson, Steve Chamberlain, Dan Slegh, Dr. Stein, Justin Knapp, David Steen, Peter Larson and Brandon Fosso. Not pictured: Carolyn Kan

Growing Numbers in the Physics Department

Bethel is a school focused on serving its students. Therefore, the most important measures of productivity necessarily involve students: the opportunities they have, the number of graduates, and their success. Most issues of the *PhysicsFocus* are devoted primarily to what current students are doing—usually with the descriptions in their own words. We do, however, want to give you a broader picture of the exciting increase in the number of physics and engineering graduates—a quantitative indicator of a thriving program.

The Bethel Physics Department offers five different degree and major combinations, including a Dual-Degree Program in Engineering (done primarily through collaboration with the University of Minnesota). The number of graduates from the department has dramatically increased as can be seen in the accompanying chart on the next page. During the last 20 years, while Bethel's undergraduate enrollment almost doubled, the number of graduates from the Physics Department has roughly quadrupled.

Of the 2010 graduates, many of whom are pictured in this issue, there were eight graduates with a Physics B.S. and 13 with a Physics B.A. Of the Physics B.A. graduates, nine also received a dual-degree in engineering. There was also one student with the Engineering

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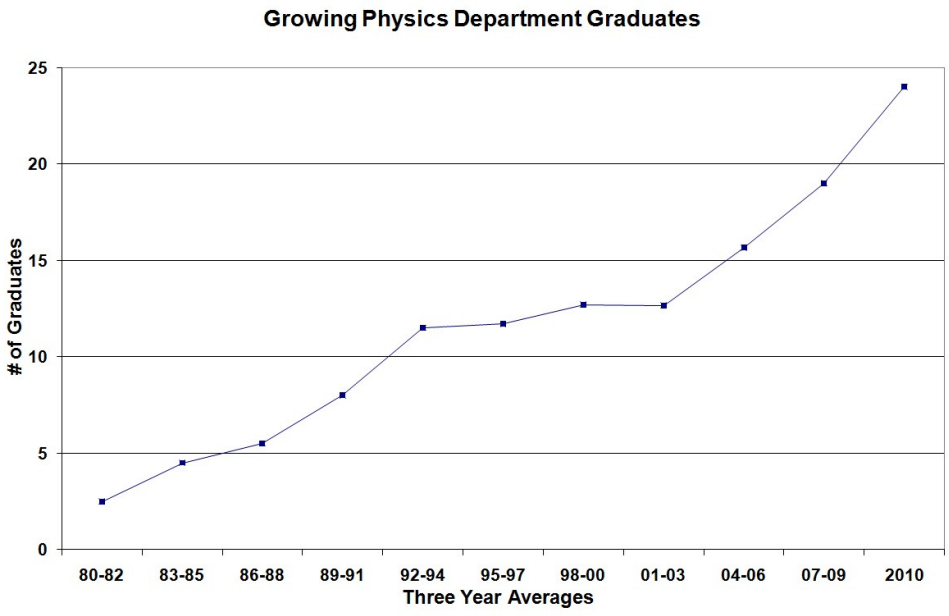
Fall 2010 graduates and professors pictured from left to right: Dr. Stein, Kent Underland, Dr. Greenlee, Dr. Hoyt, Andrew Reid, Brandon Brunkow

Most Physics Bachelor's Degrees

American Institute of Physics 2010 Statistical Report

Bachelor's-only departments averaging 10 or more physics bachelor's degrees per year, classes 2005 through 2007

School	Annual Average
CA Poly St U, San Luis Obispo	24
Harvey Mudd College (CA)	22
US Naval Academy (MD)	22
US Air Force Academy (CO)	21
SUNY College, Geneseo (NY)	20
Carleton College (MN)	18
Illinois State U	18
Loyola U of Chicago (IL)	17
Williams College (MA)	17
Bethel University (MN)	16
U of Wisconsin, La Crosse	16
James Madison U (VA)	15



Science B.A., one with an Applied Physics B.S., and one with an Education degree with a Physics emphasis. These 24 students constitute the largest graduating class from the Physics Department in the history of Bethel University.

For some perspective, it is important to note that these numbers are truly extraordinary. According to the table provided by the American Institute of Physics, our three-year average of physics graduates (not including the record setting 2010 class) currently ranks in the top ten out of the over 800 schools in the United States with strictly undergraduate programs in physics.

Funtastic Fall 2010 SPS Events

This fall, as in years past, the SPS hosted several events for physics students. Among the events of this fall were such traditions as the ice cream social and Halloween pumpkin carving in the electronics lab.

This year's nth annual ice cream social offered students (especially freshmen) an opportunity to interact with their classmates and professors in a non-academic setting. It also provided a legitimate dinner substitute for the less health conscious among us.

In October, many participated in the SPS Halloween pumpkin carving extravaganza, (materials provided by Kaiser Pumpkins Inc.) and many equations were preserved in that most lasting of media. A particularly beautiful relief of Dr. Peterson was created by our own Adam Banfield.

In November Jessica Doehrmann, a junior physics major, organized an SPS service event with about a dozen students packing food at a local Feed My Starving Children volunteer center.

December brought the annual physics Christmas party which was held at the Steins' home. Carols were sung, food was eaten, games were played, and merriment was made.

Truly fall 2010 was a great semester to be a physics or engineering major. Be sure to thank your SPS officers: Sarah Kaiser, Nathan Youngblood, Jack Houlton, and James Benhardus as well as their fearless leader, Dr. Greenlee, for their dedication and efforts.

Many physics students and professors can be seen enjoying food in the home of Dr. Stein during the annual Christmas party

Make sure you check out the additional pictures on the back page!

Adam Banfield holding his pumpkin bearing the likeness of Dr. Peterson after the Halloween pumpkin carving in October

David Juel, Robert Kohler and Jed Carlson enjoy being served by Jack Houlton, Nathan Youngblood and Dr. Greenlee at the 2010 ice cream social

Bethel Physics Expands: Student Research Beyond Campus pt. 2

The summer of 2010 was a busy summer of research for many Bethel Physics students. So busy, in fact, that we were only able to include some of their stories in the previous Focus . This issue includes Twitter, gamma rays, polarization, rockets, earthquakes, ultrasonic rat screams, sunny beaches and so much more within the stories of Andrew Reid, Jami Johnson, Jessica Doehrmann, Daniel (DJ) Arend, David Swenson and James Benhardus. Stories on pages 6, 7, 8 and 9.

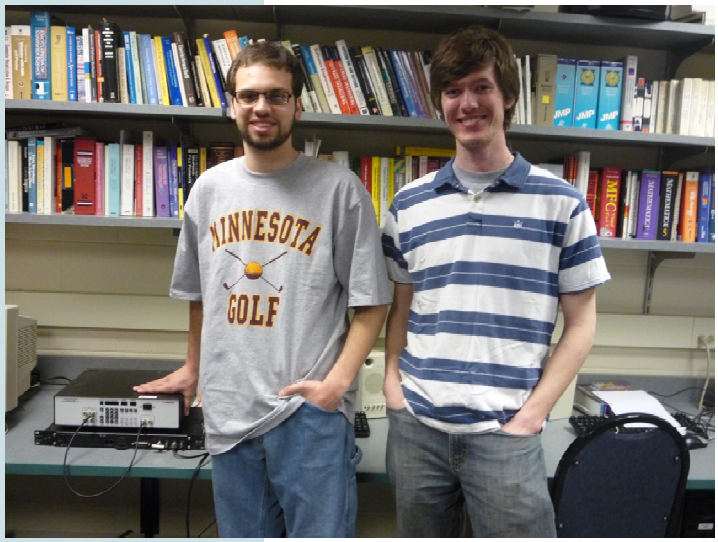
"...I left with a new window into signal analysis, as well as useful experience collaborating on scientific research in an applied math area."

-Andrew Reid

How Andrew Reid Measures a Rat Scream

"As a double major in physics and math, I've become interested in the mathematical tools often used in physics." Last summer Andrew Reid had the opportunity to venture into the wide world of signal analysis in a funded, ten-week Summer Research Experience (SRE) with the Bethel math department, specifically studying "wavelet transforms," which are akin to the Fourier transform (perhaps you'd call them cousins, ...once removed). The 2010 SRE had two student researchers: computer science major Rob Upcraft and Andrew, who worked with Bethel professor and applied mathematician Dr. Brian Turnquist on his continuing research and development of methods to quantify pain. The signals for their analysis were ultrasonic rat vocalizations (above the 20kHz frequency threshold of human hearing), recorded and sent by a collaborating medical group at Johns Hopkins University. Their goal was create a program to classify and group similar vocalizations. This tool could then be applied to, essentially, interpret rat 'language', by correlating sounds the rat makes with the kind of pain it is experiencing.

The first couple weeks, Andrew and his team hit the books to learn wavelet math and build their intuition. They then devised and implemented a method in MatLab to process and classify the audio waveforms, using wavelet techniques. "Essentially, we created ways to 'measure' several different features of a given vocalization, such as its spectral purity. This gave us a multi-dimensional 'feature space' in which each vocalization could be visualized as a point, and similar vocalizations grouped. In the last leg of the research – my favorite part – we sought to select a set of features 'most suitable' for effective categorizing." This involved crunching data on hundreds of vocalizations, observing the groupings, and then tweaking the feature-measuring techniques to push groups further apart. "All in all, the SRE was a rewarding experience: I left with a new window into signal analysis, as well as useful experience collaborating on scientific research in an applied math area."



Andrew Reid and co-researcher Robert Upcraft with their setup in the Happy Lab

Jami Johnson: Medical Physics at the U of MN

This summer Jami Johnson received a fellowship from the American Association of Physicists in Medicine to conduct research at the University of Minnesota Medical Center, Fairview. She worked with the medical physicist at the hospital doing research pertaining to the University's Gamma-Knife Radiation Therapy machine. The Gamma-Knife uses a ^{60}Co source to give a very high, precise dose of radiation to brain tumors of cancer patients. The treatment is so powerful that it is called stereotactic radiosurgery.

About 25-45% of cancer patients develop brain tumors when the cancer cells from another primary site, such as a lung or kidney, travel to the brain and develop lesions there. This occurrence is called metastasis. For her research, Jami looked only at Gamma-Knife cases that were due to metastatic brain tumors. She completed two projects, the first of which was a study of 'failed' Gamma-Knife treatments at the University. In about 20% of cases, a brain tumor that receives this treatment grows instead of shrinking. Her task was to collect the data of these patients and perform dosimetry analysis to determine if the local control of tumors was strongly correlated to the partial volume of the tumor receiving a dose less than the ideal amount. For the second project, Jami analyzed the data of all of the University's brain metastasis patients to see if there is a correlation between the location of the primary site of cancer and the lobe of the brain to which the cancer cells metastasized.

In reflection on her summer of research, Jami said that "This summer was a great opportunity and a fascinating learning experience. I enjoyed learning about an area of physics that is directly applicable to the medical field and getting first-hand experience with medical physicists."

"I enjoyed learning about an area of physics that is directly applicable to the medical field..."
-Jami Johnson

Polarized ^{3}He, Sunny Beaches and Jessica Doehrmann

This summer Jessica Doehrmann participated in the Triangle Universities Nuclear Laboratory (TUNL) REU at Duke University. TUNL is a collaboration between Duke University, North Carolina State University, and University of North Carolina Chapel Hill. There were 9 students participating in the REU this summer, and they all worked on different nuclear physics projects. Jessica worked with the Medium Energy Physics group on the polarized ^{3}He target project. The main goal of this project was to measure the asymmetries and spin polarizablities of the neutron in order to understand it better from the theory of quantum chromodynamics. This is done by using a polarized ^{3}He target as the effective neutron target, bombarding it with circularly polarized gamma rays, and detecting the scattered neutrons. In order to do this, the polarization of the ^{3}He target must be known. Jessica's part of the project was automating the process of measuring the polarization of a ^{3}He target with LabView. She used the electron paramagnetic resonance method to measure the polarization.

As a part of the REU program, Jessica lived with other REU students, went to nuclear physics talks every week, visited the physics departments at NC State and UNC, and took a trip to the beach. The trip to the beach was by far her favorite "social event," traveling to Wilmington Beach for the weekend. In November, five of the REU students, including Jessica, were invited to present their

Jessica and a friend at Wilmington Beach

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research at the Department of Nuclear Physics Conference in New Mexico. She had the opportunity to learn about what other students did over the summer, talk to graduate students about their research, and talk to representatives from different graduate programs. The REU program was a great opportunity to understand different areas of physics and investigate fields in which she may want to specialize.

"I focused on the lower two-thirds of the Delta rocket - the liquid oxygen and liquid hydrogen booster tanks."

-DJ Arend

It's not Rocket Science...O wait, yeah it is: The Summer of DJ Arend

This summer DJ Arend had the opportunity to work in Denver, Colorado with the aerospace engineering company, United Launch Alliance (ULA), which is the world's largest employer of rocket scientists and provides launch systems to companies across the United States. He worked in the engineering department for the Booster Strength Analysis group. DJ said that, "Essentially, I focused on the lower two-thirds of the Delta rocket - the liquid oxygen and liquid hydrogen booster tanks. I worked on several projects while I was there."

For one of those projects, he created memorandums to summarize the maximum loads (including forces, pressures, and temperatures) that the tanks would undergo during flight, and compare them to the allowables. These memorandums show that the rocket won't tear apart when it launches, showing their relevance to the process of readying a launch vehicle for flight.

DJ also worked on updating some files from an older version of a program, NASGRO, which was used to iteratively simulate small fractures that naturally occur in the skin of the booster tanks. Using this program, he could determine how many times a tank could be reused before the cracks grew too large to be safe. His favorite project involved a 3D analysis program called Finite Element Modeling and Postprocessing (FEMAP). DJ learned how to create solids and other geometry, assign material properties, define boundary conditions and loads, and perform stress analysis on various parts. He also got the opportunity to modify a part that is currently used on the spacecraft, with the goal of reducing weight while minimizing increase of stress.

In addition to this, DJ also had the opportunity both to meet with the CEO, COO, and other heads of departments of ULA for question and answer sessions and to sit in on a video communication to support a test that was being performed at the Vandenburg Air Force Base in California. One of his favorite activities was working on the third annual Intern Rocket Project, where DJ and his fellow interns built and launched a 25 foot tall, 280 lb rocket named "Future" with an impulse of just over 40kNs.

"Future" being raised onto the launch pad

David Swenson Goes off the Richter with Geophysics at the U of MN

This past summer, David Swenson researched seismic wave activity in order to discover more about the profile of the earth far below its surface. When an earthquake occurs it emits spherical seismic waves. Two varieties are surface waves, which travel around the earth through the crust, and body waves. A shear wave is a body wave that only causes deformation of the medium of travel.

To study the mantle, the horizontal component of the shear wave is isolated by rotating the data into a shear horizontal polarized seismogram. Shear horizontal waves are investigated because their displacements lie in planes parallel to the reflecting discontinuities. In this case there is nearly complete reflection at the core-mantle boundary and at the free surface of the earth. Waves reflecting off these surfaces only are known as 0^{th} order reverberations. Conservation of energy at these surfaces is important for seeing higher order reverberations that arise due to the mantle's other discontinuities. Much like an electromagnetic wave reflecting off glass, these shear waves will reflect a portion of their energy when they encounter discontinuities in the earth's mantle.

This enabled David to isolate the higher order reverberations through a series of filtering and stacking techniques. Finally he was able to use synthetic models to generate reflectivity profiles of the mantle as a function of depth. Wherever there are large maximums there is a positive reflection coefficient, and the seismic wave velocity increases across the interface.

Interpreting these reflectivity profiles allows David to learn more about the physical make-up of the earth, rather than just looking at stratified layers. This will pave the way for more accurate models and a better understanding of why earthquakes occur where and when they do. More specifically, the project he worked on collected data from the Hawaiian Islands seismometer stations KIP, POHA and MAUI. David said that "It was really interesting to see how related physics is to seismology, and I really enjoyed working on this project at the University of Minnesota this summer."

"It was really interesting to see how related physics is to seismology..." -David Swenson

Dissecting a Tweet with James Benhardus

James Benhardus spent the summer at the University of Colorado at Colorado Springs participating in a REU for Natural Language Processing and Machine Learning with 11 other students from around the country. James researched methods of detecting trending topics on Twitter, a microblogging service where users post short (<140 character) messages, called "tweets." Trending topic detection is the process of identifying words or phrases that are currently popular in users' tweets, analogous to identifying the "topics of conversation" among Twitter users. James' project involved using a method of analysis known as term frequency-inverse document frequency weighting to identify the most relevant words in a stream of data.

In addition to his project, James' summer included excursions to Royal Gorge and Pikes Peak, countless rounds of board games and card games, and the construction of a ranked graph detailing the interactions and relationships between the REU participants.

The University of Colorado at Colorado Springs

Bethel University Physics & Engineering Newsletter

Newsletter article and photo submissions to Dr. Beecken (beebri@bethel.edu) or Dr. Stein (k-stein@bethel.edu) are welcome and appreciated.

BETHEL UNIVERSITY
College of Arts & Sciences

JOKES

Heisenberg is out for a drive when he's stopped by a traffic cop. The cop says, "Do you know how fast you were going?"
Heisenberg says, "No, but I know where I am."

Rene Descartes sits down for a meal at a Parisian restaurant. The waiter asks for his order, and he orders a hamburger. The waiter asks, "Would you like fries with that?"
Descartes says, "I think not," and instantly disappears.

http://cas.bethel.edu/dept/physics/

Traditional physics chants resonate with students as they echo throughout the halls of the Steins' home

Great times were had by all as physics carols were sung to the tune of Jessica Doehrmann playing guitar