UNDERGRADUATE MATHEMATICS SEMINAR

The first seminar of the spring term will be:

DATE: TUESDAY, April 6th
Time & 3:45pm – Refreshments in the Math Common Room, Bailey 204
Location: 4:00pm – Seminar in Bailey 207

In this seminar, Union College’s own Professor Pablo Suarez will present the following talk.

TITLE: Introduction to Perturbation Theory

ABSTRACT: Perturbation theory comprises mathematical methods that are used to find an approximate solution to a problem that cannot be solved exactly, by starting from the exact solution of a related problem. Perturbation theory is applicable if the problem at hand can be formulated by adding a "small" term to the mathematical description of the exactly solvable problem. Perturbation theory leads to an expression for the desired solution in terms of a power series in some "small" parameter that quantifies the deviation from the exactly solvable problem. The leading term in this power series is the solution of the exactly solvable problem, while further terms describe the deviation in the solution, due to the deviation from the initial problem.

HRUMC XVII - April 17, 2010: Sign-up Now!

The 17th annual Hudson River Undergraduate Mathematics Conference (HRUMC) will be April 17, 2010 at Keene State College in Keene, NH.

The HRUMC is a one-day mathematics conference held annually each spring, attended by students and faculty from colleges and universities throughout New York and New England. It was founded by four colleges, Siena, Skidmore, Union, and Williams, with the goal of providing undergraduates with the experience of attending and/or presenting at a professional mathematics meeting, and was designed primarily with the student in mind. It is the premier regional undergraduate mathematics conference after which several others have been subsequently modeled nationwide.

The conference features short, 15-minute talks primarily by students and faculty, as well as a longer invited address by a noted mathematician. This year, two Union students, Foyroj Kabir '10 and Gabriel Webster '10 will be speaking. The keynote address this year will be delivered by Erik Demaine from MIT. His talk is entitled “Algorithms Meet Art, Puzzles and Magic.”

The Math Department strongly encourages you to attend this free conference. It provides you with (breakfast, lunch, and) a great opportunity to meet math majors from other institutions, to discuss and share the math that you have been doing, to hear about work other students have been doing, to get ideas for new projects (like a senior thesis!) and simply to learn some math that you might not have the opportunity to learn elsewhere.

Interested in attending HRUMC? Sign-up by Wed. April 14th by emailing Professor Friedman (friedmap@union.edu) or stopping by the Math Department office. The math department will arrange carpooling for all of the interested Union participants.
From Thursday, February 18th at 8pm to Monday, February 22nd at 7:59pm, Peter Bonventre, Steven Neier and Zhang Pengfei locked themselves away for 96 hours in the physics study lounge to participate in the mathematical contest in modeling (MCM). In this contest, COMAP provided two open-ended modeling problems for participants to solve. This year’s question involved geoprofiling in criminology and the sweet spot of a baseball bat.

When we first got the questions at 8pm, we distributed time to research various topics related to these two problems, with a purpose of finding applicable principles and theories to come up with models. After surfing on line and checking out books from Schaffer Library, we gathered information on the whiteboard in the Physics Study Lounge and discussed pros and cons for each question. We determined that geoprofiling required more complex programming techniques that we did not have; by comparison, the sweet spot of a baseball bat applies to more interesting sports science, and we had already come up with an idea of the basic model that we had the skills to develop into a complete understanding. Thus, we decided to focus on Question B: finding the sweet spot of baseball.

For the definition of the sweet spot, we referred to the explanation by MCM in the statement of the problem; that is, the sweet spot is the location of maximum power transfer from the bat to the ball. We interpreted this to be equivalent to the location of maximum final ball velocity when all other variables are held constant. We continued to research online, with help from Google Scholar and Union College’s access to the American Journal of Physics. After several hours of researching and reading, we gathered whole articles and documents of relevant information and printed them out, and read through each file carefully and highlighted key points. A little after midnight, we called the day over, and decided to meet early next morning to organize information we had obtained so far.

When we gathered at the “sweet home” (the physics lounge) the next morning, we started to develop a model that explained the bat-ball collision in terms of the interaction between two spring systems. We defined the ball as a massless damped linear spring with one end attached to a mass and one end open, and the bat as two masses connected by a linear spring. Our goal was to calculate the rebound velocity of the ball after it is no longer in contact with the bat. This spring setup was combined with the knowledge that the bat also acts as a rigid board, and will vibrate as such. Thus, the vibration modes of the bat must also be taken into account, for their strength will determine where energy is transferred in the bat-ball collision system.

From our results we have found the “sweet spot” on the bat, the place with the maximum final velocity of the baseball, to be around 71.5 cm up from the knob of the bat for two ‘typical’ bats. This is due to the inherent forces involved in the collision, in conjunction with the shape of the vibrational modes of the recoiling bat. We found that the bending vibrational modes steal energy away that could have been transferred to the ball, and thus our sweet spot should occur where these modes are the smallest; the nodes from the first four vibrational modes are within 3 cm of our location, confirming that this is the case. This model also shows that the “sweet spot” varies in non-wood bats, such as aluminum bats, by approximately 1.5m.

Additionally, we modeled the “corking” of the bat and determined how the parameters of the model would change when a section of the bat is removed and filled with a different lighter material. The analysis of our model suggested that “corking” a bat does not increase the size of the “sweet spot”
or the maximal velocity of the ball. We therefore concluded that corking of the bat produces no additional advantage in this regard when compared to other alterations of the bat permissible by Major League Baseball standards.

In conclusion, we found this “sweet spot” to be located at a unique point on the baseball bat between the center of mass and the second vibrational node. This is a region of minimized energy loss due to vibrations, and maximized impact energy. The “sweet spot” was also determined to be consistent for “corked” bats. Additionally, the maximal energy produced by a “corked” baseball bat was reduced from the traditional legal bat. Additional variations in construction of these bats allowed for more precise controlling and manipulation of the various physical characteristics of the bat, with the goal of optimizing the “sweet spot”. Because of these advances in bat technology, baseball organizations must regulate and control the bats used in order to offer a safe playing environment, as well as preserve the integrity of the game.

Overall, this was an energetic and enlightening experience, with a 38-page research paper to show for it, and we hope that people can come to our talk next term in the Math Department and at Steinmetz to learn more about how we solved our modeling problem.

Problem of the Newsletter: April 2, 2010

On Saturday, March 27th, Union College students participated in the 4th annual Rochester Olympiad. This was a contest in which participants had three hours in which to solve four problems. Throughout the term, the problems from the Olympiad will be issued as Problems of the Newsletter. Here is one such problem.

This week’s problem. In the figure drawn below, Triangle AOB is an equilateral triangle inscribed in a semicircle centered at O, of radius 1. Find the radius of the circle that is tangent to OA, OC, and the semicircle.

Professor Friedman will accept solutions to this problem until 12:00 noon Thursday, April 8th. Email your solution to him (friedmap@union.edu) or put it in his mailbox in the Math office in Bailey Hall.