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APAM NEWS

THE DEPARTMENT OF APPLIED PHYSICS & APPLIED MATHEMATICS

THE FU FOUNDATION SCHOOL OF ENGINEERING & APPLIED SCIENCE, COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

Dear Alumni and Other Friends of APAM:

When we started the planning for this second issue of the APAM Newsletter, we wondered if we would have enough news to fill even four pages. We shouldn't have. These are still exciting times for our department and the updates that fill this issue prove it.

The range of APAM activities and events is amazing, from the awards received by our graduate teaching assistants to the song composed by one of our faculty members.

In this issue, we shine the faculty activities spotlight on our faculty's ventures in licensing their inventions, through their interactions with Columbia University Science and Technology Ventures. James Im, Gertrude Neumark, and Richard Osgood have had remarkable success in producing semiconductor films for displays, devising critical steps in the building of semiconductor lasers, and designing optical networks, and in transitioning this success to industry.

I close with two thoughts: To Ms. Christina Rohm: thank you for producing another fantastic issue. To our alumni and other friends of the department: please let us know what you are doing.

Best,

Irving P. Herman
Chair, APAM

APAM Holiday Party, December 2006 (left to right) Kristi Hultman, Sean Polvino, Gideon Simpson, Bryan DeBono, Andrew Ying, and Jeff Levesque

In this Issue

The APAM Newsletter is published twice a year. To request a hard copy of this issue, please contact the APAM Department (see page 8).

Above: Students from the Columbia MRS chapter pose for photo with an NYPD criminologist after discussing hair and DNA.

Right: Prof. Siu-Wai Chan and Brian White discuss ballistics with an NYPD officer.

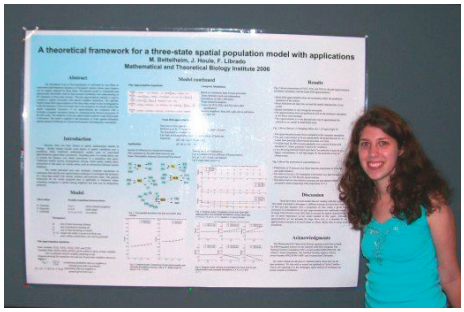
MRS Students Visit NYPD Crime Lab

by Joan Raitano

Last July, the Columbia student chapter of the Materials Research Society (MRS) visited the NYPD crime laboratory in Jamaica, Queens. Although the lab's director, Dr. P. Pizzola, generally does not allow tours, the Columbia group was given a comprehensive overview of the facility's work from arson investigation to ballistics to testing of confiscated drugs.

The students and faculty co-advisor, Prof. Siu-Wai Chan, were even given an introduction to handwriting analysis and viewed some unintentionally humorous bank hold-up notes. The guides for the day were scientists from each division, who, except for the firearms unit, are not policemen, and who showed the group a cross section of the instrumentation regularly used including a large room filled with gas chromatographs, complete with autosamplers. The outing ended at a display of infamous guns, including those used in the Son of Sam killings and in the murder of John Lennon.

Undergraduate Student News



Michelle Bettelheim, Applied Mathematics Senior, (pictured above) participated in the Mathematical and Theoretical Biological Institute in Tempe, Arizona over the summer.

She also presented at a life sciences meeting at the Society for Industrial and Applied Mathematics (SIAM), and at meetings for the Society for Advancement of Chicanos and Native Americans in Science (SACNAS) and the American Mathematical Society (AMS).

Commendations to **Michael Silberman**, Applied Mathematics Senior, for a new column in Columbia's Daily Spectator on technological change and the post-industrial economy based on sustainable development.

Graduate Student News

Congratulations to **Teresa Fazio**, Materials Science & Engineering Graduate Student, for winning a National Science Foundation Graduate Research Fellowship Award. This award is given to outstanding graduate students who demonstrate the potential to contribute significantly to research, teaching, and innovations in science and engineering. The fellowship provides funding for a maximum of three years, which can be used over a five-year period.

Yongfeng Guan, Applied Physics Graduate Student, was the 2006 Materials Research Society (MRS) Spring Meeting Graduate Student Silver Award Winner. He developed an element-and-layer-specific time-resolved x-ray magnetic circular dichroism (TR-XMCD) technique for driven ferromagnetic resonance (FMR) precession. He also developed a dual-frequency ferromagnetic resonance (FMR) technique for electrical control of ferromagnetic relaxation.

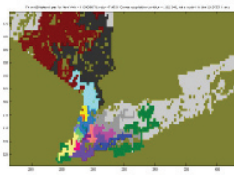
Irina Kalish, Materials Science & Engineering CVN Graduate Student, was offered a position as a Materials Engineer in Engine Materials Engineering at General Motors Corporation.

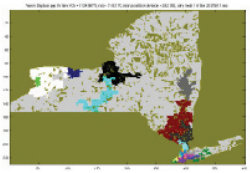
COMAP Modeling Contest

The COMAP Mathematical Contest in Modeling (MCM) is an annual international contest where teams of three undergraduates use mathematical modeling to solve a real world problem. Each team is required to choose one of two problems posed and submit a solution within 96 hours. During this brief period of time, students must clarify and make necessary assumptions about the problem, develop and implement a mathematical model, and incorporate their findings in a clear and coherent paper.

The subjects of this year's MCM problems were gerrymandering and airplane seating. APAM's team consisting of **Joe Jailer-Coley** (Applied Math '07), **James Gambino** (Applied Physics '08), and Rajesh Ramakrishnan (Computer Science '09) chose to solve the problem on gerrymandering. They implemented a crystallization method and defined a metric to optimize parameters within the method for "simplicity" and "fairness". Applying this algorithm to New York State census data, they achieve new districts (pictured below).

If you are an undergraduate and this competition interests you, contact Prof. David Keyes at <david.keyes@columbia.edu> or Braxton Osting at <bro2103@columbia.edu>. But be careful warns Joe, "The MCM is as dangerous as it is exciting."





Congratulations to the Fall 2006 Great TAs

Dean Galil recently announced the "Great TAs" for the Fall 2006 semester, which included 5 first-year APAM graduate teaching assistants. Results were based on CourseWorks student evaluations, pertaining to a TA's availability, knowledge of the subject, and ability to communicate. Congratulations **Austin Akey** (MSE), **Paul W. Brenner** (PP), **Bryan A. DeBono** (PP), **Wenjia Jing** (AM), and **Jeffrey P. Levesque** (PP).

2006 APAM Welcome Party

Avishai Ofan, Yutian Wu, and Ophir Gaathon

Prof. Guillaume Bal and Dr. Kui Ren speak with students

Masha Kamenetska and Sean Polvino

Career Connections

The Center for Career Education, the Columbia Alumni Association, and several undergraduate advocates have combined forces to launch a new online networking system for undergraduates and alumni. Columbia Career Connections will give students the opportunity to make connections with alumni in a wide variety of professions, industries and locations.

Alumni are able to create profiles on their current and past work experience, including the evolution of how they were able to achieve their current position. Each profile also may contain information on the industry, organization, and type of work the alumnus/a is engaged in. Alumni also have the option of identifying networking preferences based on common interests and affinity groups. Students will be able to search profiles by a variety of criteria and, using blind e-mail functionality, contact directly those alumni who have expressed a preference to network with students.

For more information, please contact Columbia University Alumni Relations at <udar@columbia.edu> or see **http://www.alumni.columbia.edu/**.

Alumni Reports

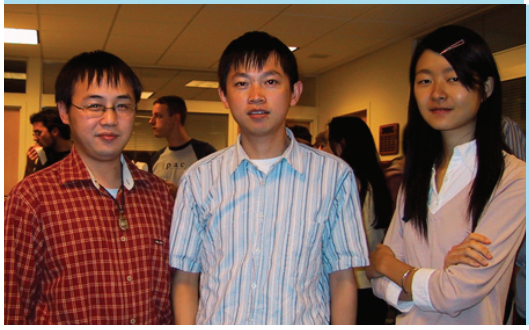
Pearl Flath (B.S. '05, Applied Mathematics) is currently in the Computational and Applied Mathematics Ph.D. program at the University of Texas at Austin and works with Omar Ghattas. She is the founder and current president of their SIAM Chapter and recently helped to organize Texas Applied Mathematics Meeting for Students (TAMMS), which met this past February. The conference provided students the opportunity to present research and build synergy among participants from universities throughout the region.

Eli Furhang (Ph.D. '96, Applied Physics, Medical Physics): After thesis research and subsequent employment at Memorial Sloan Kettering Cancer Center, Dr. Furhang accepted the position of Director of Radiation Oncology Physics at the Beth Israel Hospital Center in NYC. He is responsible for the oversight of Departments of Radiation Oncology at Beth Israel and St. Luke's/Roosevelt Hospitals. Graduates of the M.S. Program in Medical Physics working for Dr. Furhang include James Dolan (M.S. '05), Robert Masino (M.S. '05), and Manuel Orlanzino (M.S. '06).

Tracy Hammond (B.S. '97, Applied Mathematics) received her Ph.D. in Computer Science from M.I.T. and is now an Assistant Professor in the Department of Computer Science at Texas A&M University. Her research focuses on sketch recognition, artificial intelligence, concept learning, and human-computer interaction.

Ajay Kapur (M.S. '94, Medical Physics) has been appointed Assistant Professor in the Department of Radiation Oncology. In 1999 he earned his Ph.D. in Biophysics from Stanford University. Before returning to Columbia, he worked for six years as a physicist at the GE Global Imaging Technology Center. His research at Columbia focuses on Monte Carlo radiation transport simulation, digital imaging systems, and image guided radiation therapy. Prof. Kapur co-teaches Diagnostic Radiological Physics, a course required for the M.S. in Medical Physics.

Feryal Ozel (B.S. '96, Applied Physics & Applied Mathematics) is an Assistant Professor in both Physics and Astronomy at the University of Arizona. Her research interests include the physics of compact objects, high energy astrophysics, neutron stars, magnetars, black holes and accretion disks and gravitational lensing.



(Left)
Xuan Gao, Yongfeng Guan, and Ting Rao

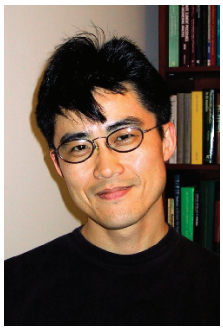
(Right)
Luis Sampedro and Jack Berkery

For more photos see: http://www.apam.columbia.edu

For more than 25 years, scientists at Columbia have developed groundbreaking technologies that have been commercialized and have immeasurably improved the lives of many people.

Columbia University's Science and Technology Ventures (STV), an organization responsible for transferring inventions and innovative knowledge from Columbia to external organizations, recently featured Prof. James Im, Prof. Gertrude Neumark, and Prof. Richard Osgood in their latest New Inventions/New Discoveries report.

Sequential Lateral Solidification

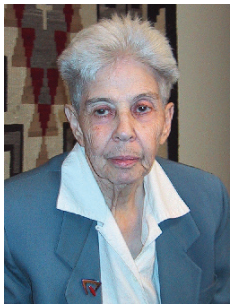


James Im

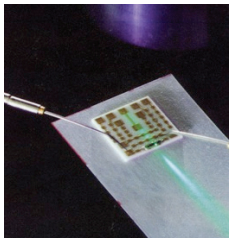
Professor of Materials Science and Metallurgy, Director of the Materials Science and Engineering Program

Invented by Columbia professor James Im, this discovery describes a laser process capable of generating the optimal crystalline material - something that can lead to lower cost and higher performance macroelectronic devices. Prof. Im's method, called Sequential Lateral Solidification (SLS), is based on his fundamental breakthrough in understanding how a substance is rapidly melted and solidified. The result is that silicon-based transistors can be put on inexpensive and transparent glass or plastic substrates, replacing the silicon wafers previously used. The new material can be used to create a variety of devices, from solar cells to thin film transistors for flat panel displays built on glass or plastic sheets. (In theory, the discovery may eventually allow for an entire computer to be put on a sheet of glass or plastic.) Top display makers, including L.G. Philips LCD Co., Ltd., and Samsung, have already licensed this technology. The innovation is also applicable to smart cards, RFIDs, image sensors, and three-dimensional integrated circuit devices.

Blue LEDs



(below) Blue-green diode laser as pictured in *Physics Today*, June 1994



Gertrude Neumark

Howe Professor of Materials Science and Engineering and Professor of Applied Physics

Columbia professor Gertrude Neumark is one of the world's foremost experts on doping wide-band semiconductors and holds a number of U.S. and foreign patents that claim a process for the manufacture of "hard to dope" semiconductors. The process claimed in the patents is used by commercial manufacturers of blue semiconductor diode lasers and LEDs (light-emitting diodes). Doping is the process of adding impurities to semiconductors in order to provide better conductivity.

Prof. Neumark patented a process that is applicable to any wideband gap material. In particular, her work applied to gallium nitride semi-conductors, where work on these materials has resulted in one of the most important breakthroughs in electronics and optoelectronics of recent years. GaN-based LEDs have begun replacing traditional light bulbs in traffic lights and are likely to gain an ever-increasing market share for many other lightening applications. GaN-based blue lasers allow data storage with much higher density than traditional red lasers. In addition, there are many less obvious applications in medical fields including diagnostics, among others.

For more information about Science and Technology Ventures, please see:

www.stv.columbia.edu

Prof. Neumark has reached agreements with a number of companies including most recently Toyoda Gosei, for worldwide rights under a number of patents held by her.

BeamPROP

Richard Osgood, Jr.

Higgins Professor of Electrical Engineering and Applied Physics

New Photonics Software and Partnership with RSoft Design Group, an Industry Leader

Robert Scarmozzino

CEO and CTO of RSoft Design Group

Photonics is a short-hand name for a variety of practical, emerging technologies that use light instead of electrons to carry out a variety of "high-tech" applications such as in communications and controlling data flow. For example, photonics technology has increasingly become a full partner with electronics in making faster electronics systems such as special-purpose supercomputers. It is already being used in certain applications, such as ultrahigh-speed data transmission in long-distance telephone links, which utilize light waves sent through fiber-optics cables. Now industry watchers are predicting that, in the future, photonic devices will become increasingly important as a means of sending ultrahigh-bit-rate signals on and off chips or even across chips. Photonics has important advantages for this ultrahigh data rate role due to the ease with which multiple optical signals can be carried by its extremely broad "spectral" bandwidth.

This and other applications require that the design of photonics systems be carried out in a manner similar to that of electronics – that is with the use of computer-aided design (CAD) and simulation. Columbia University has been fortunate to have been an incubator for the premier international firm in the area of integrated photonic design and simulation tools, namely RSoft Design Group, head quartered in Ossining, NY (**www.rsoftdesign.com**). The first tool in this area was BeamPROP,

Science & Technology Ventures, continued

a sophisticated design package that enables one to solve the Helmholtz equation as an initial value problem and thus predict and design a complex integrated photonics layout.

Developed in Columbia labs by Dr. Robert Scarmozzino, a senior research scientist working with Prof. Richard Osgood who received his Ph.D. from APAM in 1987 in Plasma Physics, this software program has become the worldwide leading design tool in the area of photonics. BeamPROP, one of the earliest tools in photonics computer-aided design, has provided the necessary foundation for the development of the industry. Dr. Scarmozzino co-founded RSoft in 1990 and licensed the technology from Columbia in 1993. The software has been commercially available since 1994 and is in use by leading researchers and development engineers in university and industrial environments worldwide.

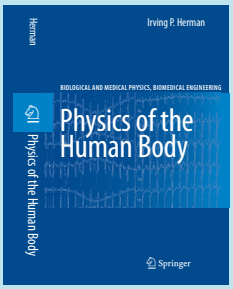
The Columbia University Applied Physics and Applied Mathematics Department has played a major role in the intellectual and personnel resources of RSoft. In addition to Dr. Scarmozzino and Prof. Osgood, the company has drawn in two Columbia APAM Ph.D.s, Zheng-Yu Huang (currently VP for International Sales and Business Development) and Hong-Ling Rao, as well as many other scientists and engineers from within the Department and from other departments at Columbia. RSoft has been an important partner in several major joint Columbia University/Industry sponsored research programs. Columbia has also worked with RSoft to preview other software packages such a FullWAVE, a finite difference time domain computation system, BandSOLVE, a photonic-crystal band-structure solver, DiffractMOD, a rigorous-coupled wave analysis package, and FemSIM, a finite-element mode solver. These software tools have played a major role in the international and US development of nanoscale optical phenomena for use in photonics systems.

IN MEMORIAM

Surendra Nath Purohit, a nuclear reactor physicist, died on December 30, 2006 of leukemia. His groundbreaking work in the 1960's at the University of Michigan in the field of neutron thermalization led to a better understanding of the design of power reactors. He did research as a physicist at Oak Ridge and Brookhaven National Laboratories, AB Atomenregi, Sweden, and Rensselaer Polytechnic Institute. He taught graduate courses as an adjunct professor in the Division of Nuclear Engineering of Columbia University between 1971-1990, as well as at the Royal Institute of Technology, Stockholm, Sweden in 1964. He was on the executive committee and served as the chairman, treasurer and secretary of the Metro New York division of the American Nuclear Society as well as on other American Nuclear Society committees. He both chaired and served as a delegate at IAEA (International Atomic Energy Agency) Symposia. His papers were published in various scientific journals including the *Journal of Nuclear Science and Engineering*, *Journal of Physics and Chemistry of Liquids*, *Brookhaven National Laboratory Reports*, *Oak Ridge National Laboratory Reports*, and *AB Atomenergi Reports*. He retired from Con Ed as the Manager of Nuclear Fuel Analysis in 1993. After retiring, he lectured at several universities including Texas A&M and Penn State. He is survived by a wife, Henriette; a daughter and son-in-law, Tara and John Wojak, and grandchildren, Tyler and Alexa Wojak; a son and daughter-in-law, Eric and Caroline Purohit, and grandchildren, Hailey and Evan Purohit; brothers, Narendra, Chaitan, Chum and Shanti Purohit; and a sister, Nirmal Vias.

Faculty Updates

Prof. Harish Bhat has completed his two-year appointment as the Chu Assistant Professor of Applied Mathematics at Columbia University and has accepted a tenure-track assistant professorship in the Department of Mathematics at Claremont McKenna College (CMC), located in Claremont, CA. CMC is part of the Claremont Consortium, a group of five undergraduate colleges and two graduate institutions, each with its own mathematics department. He joins approximately fifty mathematicians, both pure and applied, in various parts of the Claremont system.



Prof. Irving P. Herman's book *Physics of the Human Body*, ISBN 978-3-540-29603-4, was published by Springer in February.

The text comprehensively addresses the physics and engineering aspects of human physiology by using and building on first-year college physics and mathematics. Topics include the mechanics of the static body and the body in motion, the mechanical properties of the body, muscles in the body, the energetics of body metabolism, fluid flow in the cardiovascular and respiratory systems, the acoustics of sound waves in speaking and hearing, vision and the optics of the eye, the electrical properties of the body, and the basic engineering principles of feedback and control in regulating all aspects of function. The goal of this text is to understand physics issues concerning the human body, in part by developing and then using simple and subsequently more refined models of the macrophysics of the human body. Many chapters include a brief review of the underlying physics. There are problems at the end of each chapter; solutions to selected problems are also provided.

This text is geared to undergraduates interested in physics, medical applications of physics, quantitative physiology, medicine, and biomedical engineering. The book evolved from a course Prof. Herman developed for 1st and 2nd year undergraduates, APPH E1300 Physics of the Human Body.

Prof. David Keyes and Prof. Marc Spiegelman were 2 of 4 faculty panelists at a special program created by Columbia's NSF-funded ADVANCE Program on January 19. The ADVANCE program works for the promotion of women into faculty positions in science and engineering and also counsels junior faculty on the tenure process at Columbia. Prof. Keyes spoke about professional societies and networking while Prof. Spiegelman focused on proposal writing vs. paper writing.

Prof. David Keyes and Prof. Michael Weinstein were 2 of 6 faculty panelists chosen to speak at a program hosted by Columbia's Center for Career Education to counsel graduate students about applying for post-doctoral fellowships and faculty positions, and preparing their resumes while still students for such future applications. Approximately 100 graduate students attended the event.

Prof. C.S. Wuu: One of the highest honors the ACR can bestow on a radiologist, radiation oncologist, or medical physicist is recognition as a fellow of the American College of Radiology. ACR Fellows demonstrate a history of service to the College, organized radiology, teaching, or research. Approximately 10% of ACR members achieve this recognition. Wuu joins Prof. Nickoloff in this distinction.

"The Mathrigals" Premiere *Anthematica*

On February 28, Prof. Keyes concluded a panel discussion of faculty advisors from Biomedical Engineering, Chemical Engineering, Electrical Engineering/Computer Engineering, and Mechanical Engineering in an optional evening session of APMA 2101 Differential Equations with Linear Algebra, with a musical premiere.

"The Mathrigals", a pick-up college *a capella* group, comprised of current APMA 2101 students (SEAS undergrads) and several of APMA 2101 alums and friends, performed a new composition by Prof. Keyes entitled *Anthematica*, a contemporary SATB anthem to quantitative reasoning written specifically for this occasion (and, undoubtedly, for use in other future occasions).

"The Mathrigals"

(left to right)

SOPRANOS:

Maritza Harper, CC '08, Chemistry
Christina Beck, SEAS '08, Biomedical Engineering

ALTOS:

Faye Bi, SEAS '10, Engineering
Amy Stetten, BC '09, Physics

TENORS:

Alex Xin, SEAS '08, Biomedical Engineering
Sean Peters, SEAS '08, Electrical Engineering

BASSES:

Mitch Flax, CC '09, Mathematics
Scott Brown, SEAS '08, Electrical Engineering
joined by Prof. Keyes, far right

Anthematica

Joy abounds for all who dwell in realms quantitative,
Who scale and estimate with ease, in any space are native,
Who traverse rungs of abstraction, who logic navigate,
Who sort and bin with insight, behaviors demarcate.

Nature's laws have beauty stark, though nature coyly conceals them
The same resplendent beauty marks the tools with which we reveal them
An asymptotic limit; fields transformed, then unwound.
The elegance of equals, the bulwark of a bound!

Mathematics is the music of the conscious mind.
Music is the mathematics of the soul behind.
Out of chaos, patterns form that nature organize.
Fed with patterns, humans dream and must hypothesize.

Brick by brick, a house is built; we stand today on shoulders
Of those who labored with less light, of those who moved the boulders.
With chalk or with computer, our vantage do we grow.
Vistas only glimpsed today will our students know.

Mathematics is a scientific universal:
Transfers knowledge from one field to others in the circle.
The queen is vibrant on the throne, her court illuminates.
Bathed in light, the court at work her wisdom illustrates.

Human fashions come and go; wealth and power scatter.
Dogmas once allowed full sway now no longer matter.
Mathematics from millennia past is however fresh.
Across all cultures, in all tongues, her form and content "mesh".

Mathematics is a scientific universal:
Transfers knowledge from one field to others in the circle.
In SEAS do mathematics and her partners meet.
The fellowship of pilgrims here is infinitely sweet.

"FOLLOWING THE LAW"

Prof. Irving P. Herman's advice to graduate students was published in the January 11, 2007 edition of *Nature*. Each "law" contains advice about the facts of life in graduate research, particularly from the viewpoint of a thesis adviser. Several have been slightly exaggerated for effect, or are not to be taken too literally. Some clearly pertain to experimental research, although they have obvious counterparts for other types of research. Prof. Herman developed the laws to help motivate some of the graduate students in his own group, to explain how to be an effective student and to convince them that supervised research is a symbiotic (although not symmetric) interaction between student and adviser.

1. **Your vacation begins after you defend your thesis.**
2. **In research, what matters is what is right, and not who is right.**
3. **In research and other matters, your adviser is always right, most of the time.**
4. **Act as if your adviser is always right, almost all the time.**
5. **If you think you are right and you are able to convince your adviser, your adviser will be very happy.**
6. **Your productivity varies as (effective productive time spent per day)^{1,000}.**
7. **Your productivity also varies as 1/(your delay in analyzing acquired data)^{1,000}.**
8. **Take data today as if you know that your equipment will break tomorrow.**
9. **If you would be unhappy to lose your data, make a permanent back-up copy of them within five minutes of acquiring them.**
10. **Your adviser expects your productivity to be low initially and then to be above threshold after a year or so.**
11. **You must become a bigger expert in your thesis area than your adviser.**
12. **When you cooperate, your adviser's blood pressure will go down a bit.**
13. **When you don't cooperate, your adviser's blood pressure either goes up a bit or it goes down to zero.**
14. **Usually, only when you can publish your results are they good enough to be part of your thesis.**
15. **The higher the quality, first, and quantity, second, of your publishable work, the better your thesis.**
16. **Remember, it's your thesis. You(!) need to do it.**
17. **Your adviser wants you to become famous, so that he/she can finally become famous.**
18. **Your adviser wants to write the best letter of recommendation for you that is possible.**
19. **Whatever is best for you is best for your adviser.**
20. **Whatever is best for your adviser is best for you.**

These laws were inspired by the 'Laws of the House of God' from The House of God by Samuel Shem (Richard Marek, 1978), which provided a somewhat different brand of advice to medical interns. Prof. Herman thanks Jonathan Spanier, Yigal Komem and other colleagues for suggestions.

Staff News

We are pleased to announce that Michael Churilla has joined the department as our new business manager. Welcome, Michael!

DEPARTMENT OF APPLIED PHYSICS & APPLIED MATHEMATICS FUND

Yes, I want to support the APAM Department with my gift of:

☐ $1,000 ☐ $500 ☐ $250 ☐ $100 ☐ Other: _____

I have enclosed my check in the above amount made payable to Columbia University. Please direct my gift to:

☐ APAM Special Projects Fund ☐ Other: _____

Name _____

Address _____

City _____ State _____ Zip Code _____ Email _____

This gift is tax deductible as allowed by law. Please return this form and your check to:

Prof. Irving P. Herman, Chair
Department of Applied Physics & Applied Mathematics at Columbia University
500 W. 120th Street, 200 Mudd, Mail Code 4701, New York, NY 10027

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Alma mater statue in front of Low library of Columbia University in New York

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