UNIVERSITY OF SAN FRANCISCO

COLLEGE OF ARTS AND SCIENCES

Department of Physics

Self–Study

January 2004

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Appendices

(Data is provided since previous program review)

1. Introduction

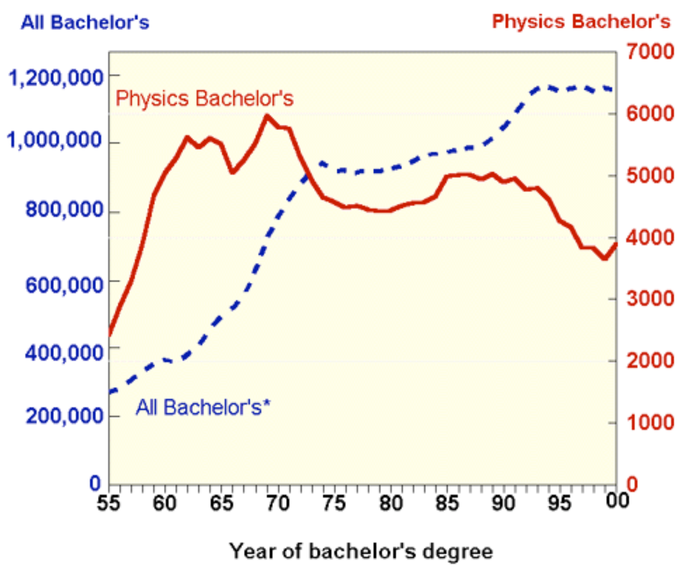
The Department of Physics at the University of San Francisco, as an integral part of a Jesuit institution, inherits a long and rich tradition in education and scholarly work, founded upon the interrelated themes of Jesuit education: a focus on moral reflection, on teaching for social justice, and on the liberal treatment of subject matter.

Scientifically, this tradition was borne by the work of many men of science, like José de Acosta, S.J. (a pioneer of the Geophysical Sciences – 1600), Christopher Clavius, S.J. (with his Gregorian Calendar and his arguments with Galileo – 1612), Christopher Scheiner, S.J. (with his sunspots and his telescope equatorial mount – 1650), André Tacquet, S.J. (and his treatment of infinitesimals – 1660), Francesco Grimaldi, S.J. (and his treatment of the diffraction of light – 1663), Nicolas Zucchi, S.J. (the renowned telescope maker – 1670), Ignace Pardies, S.J. (and his influence on Newton – 1673), Francesco Lana-Terzi, S.J. (an aeronautics pioneer – 1687), Girolamo Saccheri, S.J. (one of the founders of non-Euclidean Geometry – 1733), Vincent Riccati, S.J. (and his hyperbolic functions – 1775), Roger Boscovich, S.J. (and his atomic theory – 1787), Angelo Secchi, S.J. (and his pioneering work on solar astrophysics – 1878), and so many others, culminating in the research fostered by the Vatican Observatory.

As part of the College of Arts and Sciences at USF, we share in the responsibility of administering and delivering the core of liberal learning, the Core Curriculum, which has recently undergone a major overhaul. The Department also fosters the education of our own Physics majors during their four years at the University and offers service courses for other science departments.

2. National Context

In the 1970s, the number of bachelor's degrees in physics in American Universities dropped by almost 50%[1]. In the 1980s, the number of students graduating each year with a bachelor's degree in physics began slowly to recover from a low of 4,200 per year to about 5000 per year at decade's end. However, during the 1990's, physics degree production at the bachelor level consistently declined.



There were 3,894 physics bachelor's degrees conferred in the class of 2000 (which should be contrasted with the 4,950 degrees conferred in 1990). It is important to note that this number of degrees in 2000 comes after a significantly rise, of almost 7%, from the previous year, a variation that still cannot be

[1] American Institute of Physics, *Enrollment and Degrees Report*, 2002.

positively considered a statistically firm trend. These physics degrees in 2000 account for a very small fraction (0.3%) of the overall bachelor degree production in the country. Indeed, as the above graph shows, even though total bachelor degrees conferred nationwide have been consistently on the rise for well over 40 years, physics degrees have consistently declined for the last 35 years.

In 2000, departments with graduate programs, specifically those that offer the PhD as their highest physics degree, still remain home to the largest undergraduate programs in the country, and were those which experienced the largest increases within the overall 7% increase. This contrasts greatly with degree production at departments where the bachelor's is the highest physics degree offered, such as the Physics department at USF. These averaged only 3 degrees per department, with almost two-thirds of the departments conferring fewer than 3 degrees.

Women comprised 21% of the physics degree recipients in the combined classes of 1999 and 2000. They have experienced slow but steady gains in their representation among physics bachelor's, increasing by 6% during the last 10 years. Ninety-four percent of the combined classes were US citizens of which 14% were members of a minority group: African American 5%, Asian American 5%, Hispanic-American 2%, Other 2%. The median age was 22 years, with 11% of the bachelor's being 25 or older. 55% of the students received their degrees at departments where the bachelor's was the highest physics degree offered.

3. Our biggest challenge

The national statistics described above paint a rather bleak perspective for Physics departments around the country. While it is true that the past two years have seen an increase in the number of physics majors nationwide, it is still too early to ascertain whether this is just a statistical fluctuation or a reversal of the clear overall trend seen in the past three decades, most notably during the nineties.

Several years ago the Physics Department at USF started a very aggressive campaign to increase the number of majors. This effort encompassed a large variety of means, from the creation of new programs to the fostering of a true es*prit de corps* and interactive working environment among faculty and students.

The fruit of these efforts can be seen in the fact that over the past few years we have averaged consistently a number of majors that is equal or slightly larger than the national average, despite our being a relatively small liberal arts college, the reputation of which is much larger in the arts and humanities than in the sciences.

Indeed, in about 10 years we have gone from a moribund program with fewer than 10 majors and only two faculty members assigned full-time exclusively in the Physics Department (with three more with joint appointments), to a vibrant teaching/research program with upwards of 25 majors and six faculty members (of which only one has a joint appointment). Moreover, in the last couple of years we have seen upper-division physics courses with enrolments of 6 to 8 students. This may be a small number for any university administrator, but for us it represents enrolment increases of 100–200% over the past 6 or 7 years.

Finally, it is worth noting that we have had approximately the same proportion of minority students as in the national statistics, while our percentage of female students has been (consistently) vastly larger.

Although we certainly consider all of this a success story, the paucity of physics majors still remains a worrisome factor, as it is difficult to explain complex statistics to anyone concerned with the dreaded bottom line.

Students come into any university program either because they start their studies thinking about that particular field of study, or because they are somehow "converted" in the course of their college years. Given the length of the Physics program and the necessary logical progression of courses, combined with typical students' urge to graduate in a timely manner, it is highly unlikely that we may convert any student previously not interested in Physics beyond his or her freshman or sophomore year (although it has happened in one or two occasions in the past few years). Moreover, in the past 7 years or so we have had only a small handful of physics students who transferred to USF from other institutions.

It is important to note here that during the past 7 years we have managed to “convert to physics” a few students who came to USF planning on studying very different things. Some of these have indeed been very good students (two of them were perhaps the best we have ever seen). However, this happened only after some of us devoted an extraordinary amount of time and personal attention to the conversion process. This has been very rewarding at the personal level, and in some cases generated fruitful research collaborations and even friendships that lasted pass graduation. Indeed we will continue concentrating on “wooing away” good students already at USF. However, this cannot be considered a sustainable or cost-effective recruiting method.

It has become clear to us that we can only reliably count with students who came to USF precisely to study Physics, or perhaps with some inclination for it, provided in this case that the student’s advisor would pick up on this and suggest taking Physics quickly, a very unlikely event at USF even for science majors.

In talking about entering freshmen, it is difficult to generalize about the USF student population. Since we are not a very selective institution, many discernible student subpopulations attend our classes. The anecdotal statistics that follow are the product of our collective experiences in the past few years. First of all, comparatively few students enter USF with the notion of pursuing a traditional scientific career or an engineering career (not counting a medical career, which is of an entirely different nature). Second, very few of the incoming students have had sufficient mathematical preparation to begin the physics program in a timely manner, while even fewer have typically taken an appreciable high school physics course.

What we find is a pyramid population within the physics major. At the bottom of the pyramid are about ten or so freshmen that are interested in physics, only a handful of whom typically declare the Physics major from the beginning. On average, we see perhaps one or two good students with significant mathematical preparation or ability, some three or four students with some ability but little preparation for college-level physics, and then the rest of the interested students, who have significant mathematical or analytical difficulties. It is evident that some students in this last group were simply seduced for some reason by the idea of becoming a physicist or an engineer, but never considered what a career in those fields really entails. By the time this student population has reached their junior year, we find that we typically may have retained three or maybe four of this initial group, while we may have converted perhaps one or two more. From there we often lose one or more students in the last stages as they confront the challenges of upper-division coursework.

In the past 5 years the total number of majors (at any given time) has steadily remained within a range between 20 and 28. Despite the tremendous effort that we have devoted to recruiting, it is quite clear that these numbers are unlikely to change significantly without a change of paradigm. This, we believe, would entail a qualitative change in the way the University recruits for the sciences. We offer some recommendations on this within the conclusions of this report.

We have a good track record in terms of our graduates. We have been keeping track to some degree since more or less the time of our last program review (some 7 years ago). Most of our graduates have either already finished or are currently pursuing Ph.D. degrees at Harvard, Cornell, UC Berkeley, UCLA, UC Davis, UC San Diego, UC Irvine, U. of Michigan, U. of Pennsylvania, U. of Washington, USC, and Dartmouth College. Some of these graduates were awarded prestigious fellowships to attend these programs, including two NSF fellowships. One graduate is currently on a postdoctoral position in High Energy Physics in Germany. Many of our graduates pursuing Ph.D. programs have told us that while in their graduate programs they always felt very well prepared, in some cases even better prepared than their peers. Finally, at least two of our graduates have gone into high-school teaching positions, one is in the US Air Force, and one is our current laboratory technician. Two of our most recent graduates are currently applying to graduate study programs. The few remaining graduates have successfully sought or are seeking jobs.

Based, among other things, on student feedback, the level of communication that some of us keep with current students and graduates, and the letters that students have been sending us upon graduation, we are confident to say that our students are in general quite satisfied with our program and with their time with us at USF.

4. Department Personnel

4.1 Faculty composition

As mentioned above, we have five faculty members assigned exclusively to the Physics Department: Professors Gene Benton and Horacio Camblong, Associate Professor **Error! Contact not defined.** (department chairperson), and Assistant Professors Brandon Brown and Thomas Böttger. We also have one faculty member, Professor Carl Naegele, who has a joint appointment with the departments of Physics and Computer Science. In consultation with Professor Naegele and the chair of Computer Science, we strive to adjust his teaching load to maximize the benefit to the whole University and fully utilize his strengths, skills, and experience. In the past few years this has led to his teaching approximately 15–20% in the physics program, with the rest going into the computer science program.

Finally, in the past 10 years we have sporadically hired part-time instructors. Dr. Terrence Mulera has helped us in a part-time but nearly continuous manner for the past 3 years or so.

4.2 Teaching Assistants

Laboratory instruction in our program comprises the lab-only courses Upper Division Laboratory (UDL) I and II, and the laboratory sections associated with General Physics (GP) I and II and with all of our service courses: Introductory Physics (IP) I and II, Astronomy, etc. UDL I and II are of course taught by a faculty member, while we strive to assign faculty members to teach most lab sections in GP I and II, IP I and II, and other lower-division physics courses. Although our goal is to have every lab section taught by a faculty member, this is never quite possible. Thus, while faculty members supervise all laboratory sections, we employ a variety of student teaching assistants (TAs). We also employ students as readers and graders for homework problems and as discussion leaders for recitation sections.

We do not have a graduate program in physics at USF and the Administration is not very keen on hiring outside the University. Thus, finding suitable TAs is never an easy task. Ideally, these TAs would be upper-division Physics majors. However, most semesters there are not enough of them available, especially given their own upper-division physics coursework. Thus, in practice we have had to hire sophomore physics majors, other upper-division science majors (notably from Chemistry), or even graduate students (from USF MBA and computer science programs) who may have had a strong background in physics.

Although the process of hiring TAs has always been somewhat chaotic (i.e. anything but a "process"), we have had some success by training TAs specifically for certain courses (notably our Astronomy for non-science-majors offering) who in turn become "supervisors" of newer TAs. This has helped considerably with continuity.

4.3 Supporting Staff

Faculty members have available to them the services of support personnel in order that the efforts necessary to their successful performance at USF will run smoothly and efficiently. While some level of faculty supervision is always advisable, the specific tasks expected of faculty members should not include assembling lecture demonstrations, repairing equipment, taking inventory of supplies and equipment, ordering routine supplies for laboratories, setting up and taking down laboratories, or handling the considerable departmental administrative duties. Our current support staff includes one Physics

Technician (Mr. Lorenzo Tyler, a USF physics alumnus) and a Program Assistant (Ms. Maureen Fisher). Currently we enjoy the assistance of full-time, qualified, dedicated, and wholly competent staff, although this was not always the case. Until recently, we employed a secretary (now, "Program Assistant") only part-time.

Moreover, for years the technician has reported not to the head of the Physics Department, but to the manager of technical operations (the senior technician in the Chemistry-Biology area), who utilized the physics technician's time as he saw fit. Further demands on his time were made by the needs of the General Education Curriculum (GEC) science laboratories (not a part of the Physics Program but a science survey course designed "by committee" for that specific purpose), that were scheduled at a rate of 15 sections per week. All of this, combined with the meager pay we offered (right at the time of the technology boom), made for a string of nearly incompetent technicians, punctuated by only two very capable people, both of whom justifiably moved on to more promising positions in very short periods of time.

After many years of requests and the aid of an understanding Dean's Office, our secretarial position was converted from part time to full time. A similar process led to a gradual improvement in the area of the physics technician. Despite the fact that the technical chain of command described above is still valid, currently the Physics Department appears to have priority of work assignments. Moreover, a distribution-based Core Curriculum has replaced the GEC, where every course is a regular offering at a USF department. Our technician is thus no longer involved in taking care of non-physics courses; that said, in the spirit of collegiality in which the new Core was created, he still provides assistance for non-physics science courses as needed. In addition, the technician is now also able to provide infrastructural assistance to our various research programs. Nevertheless, there are still occasional conflicting demands on the technician's time, as he is still required to report to the manager of technical operations who, in principle, has the last word on technical work scheduling.

5. Faculty Scholarly Work

5.1 Eugene V. Benton

Radiation physics, space science, health physics, medical physics.

The Radiation Physics Laboratory (RPL) at USF was started in 1969 by Professor Benton to conduct research into the health effects of ionizing radiation exposures incurred by astronauts during space flight. Throughout many years of collaboration with NASA and the space agencies of other countries, the RPL has carried out many radiation experiments aboard spacecraft including the Apollo missions, the NASA Space Shuttles, the Russian Mir Orbital Station, and most recently aboard the International Space Station. The RPL has also carried out radiation experiments using a number of high-energy particle accelerators, including experiments at the Lawrence Berkeley National Laboratory, the Brookhaven National Laboratory, the Japanese National Institute for Radiological Sciences, and CERN. The nuclear track detector-based dosimetry system developed by Professor Benton at USF is now routinely used for Radon dosimetry in public and private buildings and for neutron dosimetry at nuclear power plants and fuel processing facilities, and at high-energy physics laboratories. The research focus of the USF RPL has expanded into a number of related areas including the radiation dosimetry of civilian and military pilots and flight attendants and the characterization of accelerated proton beams used for cancer therapy at the Loma Linda University Medical Center (LLUMC).

The RPL is a state-of-the-art nuclear track detector laboratory equipped with a number of optical microscope-based analysis systems and with an atomic force microscope. These systems are used for the analysis of radiation detectors exposed aboard spacecraft and aircraft and from ground-based accelerator experiments. The RPL uses a Digital Instruments DI-3100 Atomic Force Microscope (AFM) to study the effect of secondary nuclear target fragments produced by proton therapy beams on healthy tissue and bone. The DI-3100 AFM, on loan from the LLUMC Radiobiology Program, is able to image surfaces with nanometer resolution and permits researchers to measure nuclear tracks from secondary charged particles with ranges less than 1 micrometer. At present, this may be the only method of accurately measuring such short-range particles. The AFM also permits analysis of nuclear track detectors exposed to extremely high fluxes of radiation, such as those encountered on the exterior of spacecraft. In 2002, RPL published the first unshielded measurements of the space radiation environment on the exterior of a spacecraft (in this case the Russian Mir Orbital Station) made using nuclear track detectors analyzed using AFM.

The RPL currently has a staff of two research physicists: Allen L. Frank and Eric R. Benton. Allen Frank has worked at PRL since its founding and is responsible for much of the development of the radiation detectors used by PRL. Eric Benton has been with USF RPL since 1986 when he joined as an undergraduate physics major. He is currently completing his Ph.D. in Experimental Physics at University College Dublin, in Ireland, on research he has been carrying out a the RPL. Eric is involved in research on the exposure of pilots and flight attendants to ionizing radiation as part of the European Unions DOSMAX consortium, an international group of research laboratories currently investigating the issue of aircrew radiation exposure. Benton's detectors are routinely exposed on flights of NASA's two ER-2 high altitude research aircraft (civilian versions of the U-2 spy plane). Eric Benton is also deputy director of the ICCHIBAN Project, an international effort to compare the response of radiation detectors used for astronaut dosimetry. He makes frequent trips to CERN and to accelerator facilities in Japan and the United States in support of this work. Eric Benton's Ph.D. thesis is, in part, based on an experiment carried out in 2001 jointly by the USF PRL and the KFKI Atomic Energy Research Institute, Budapest, Hungary, to map the radiation environment inside the International Space Station.

One goal of the USF RPL is to provide physics undergraduates with an opportunity to work in a real research laboratory environment. Since its inception, nearly 100 USF students have participated in its research, and many of the students have been included as co-authors on publications in peer-reviewed journals. Students currently working in the USF RPL are participating in experiments to measure target fragmentation in high-energy proton beams at the Loma Linda University Proton Therapy Center and in the analysis of detectors exposed to ionizing radiation aboard NASA high altitude research aircraft. The environment of the RPL is meant to be informal, giving students the opportunity to work one on one with the lab's staff and visiting scientists. While working for the RPL, undergraduates gain experience using a variety of scientific instruments including optical microscopes, digital image analysis systems, and the AFM. Students learn to gather, process and analyze their own data, including the developing their own computer codes to do number crunching, error propagation, and graphical data analysis. An emphasis is placed on the presentation of scientific results both in an oral and written form. The USF RPL also gives undergraduates an opportunity to work at different scientific institutions including the NASA Ames Research Center, the Lawrence Berkeley Laboratory and the Loma Linda University Proton Therapy Center. In the past a large number of graduate students and post-docs have worked at the RPL including scientists from Japan, Germany, Hungary and Russia.

5.2 Brandon Brown

Sensory biophysics, superconductivity.

Over the past few years, Professor Brown and his collaborators have turned their attention to electrical signal development in the electrosensitive organs of sharks and their relatives. They ask how the material and geometrical/morphological properties of the sense organs affect their function, and this question has taken two forms: one pursuing the measurement and electrical characterization of substances within the organs; and another seeking to explore the effect of whole-body morphology on the electric sense via computational modeling.

Brandon's experimental investigation lives at the intersection of soft condensed matter, polymer physics, sensory biology, and biochemistry. He seeks to understand the role of a sophisticated biological gel in the electrosensory organs of sharks. For the last three years Brandon has collected gel from newly deceased shark specimens. Two of these, *Triaenodon obesus* (white-tip reef shark) and *Carcharinus melanopterus* (black-tip reef shark), were obtained from the Steinhart Aquarium at the California Academy of Sciences, and another (a 15-ft *Carcharodon carcharias*, white shark) was obtained with the cooperation of the Pelagic Shark Research Foundation.

To date, Brandon and collaborators have applied a diverse battery of measurement techniques to the gel, including four-terminal DC electrical transport, impedance spectroscopy, polyacrylamide gel electrophoresis, and thermopower. They apply these techniques to both unaltered samples and dialyzed samples that have been leached of dissolved salts. In addition, they have started collecting noise spectra and thermopower measurements.

In addition to laboratory experiments, they computationally model the electrosensory input of an elasmobranch moving near prey. Though many studies have mapped the neuron firing rates resulting from various electrical stimuli on a single ampulla, little or nothing is known about how an elasmobranch uses the multiplicity of its electrosensors to reconstruct the relevant perturbations (e.g. prey) to its environment. Modeling efforts hope to address this, providing a view of how such creatures view electrical landscapes.

Over the last three years, Brandon's research efforts have produced three papers (*Nature, Journal of Experimental Biology*, and *Physical Review E*). On two of those papers Professor Brown is the sole author, while he is first author on the third one. One of the publications included a USF undergraduate coauthor, and two new manuscripts have multiple USF undergraduate coauthors. Brandon's work has also produced two contributed talks to APS March Meetings, one contributed poster to a March Meeting, and five invited talks.

5.3 Thomas Böttger

Laser frequency stabilization, solid-state laser spectroscopy, spectral hole burning.

Professor Böttger's main research interests are in the field of lasers and the spectroscopy of optical materials. The year prior to coming to the USF he worked as a postdoctoral researcher for Professor Rufus Cone at Montana State University, where his time was divided between a variety of projects including optical material characterization and development and extension of the spectral hole laser stabilization technique to femtosecond mode-locked lasers and mode-locked fiber lasers for time-domain applications.

Tom's work under Professor Cone was devoted to developing and refining the technique for stabilizing lasers to spectral holes, a technique that defines remarkable limits of precision for compact diode lasers. In addition to stable laser source development, his work encompassed the development and optimization of rare earth doped materials for application as frequency references, and in optical spatial-spectral-holography such as real-time, wide-bandwidth information storage and signal processing. He built two external cavity diode lasers operating at the important 1.5 μm optical communication wavelength and stabilized the laser frequency to 1 part in 10^{13} of the optical frequency of the laser light using a small 5 mm cube of solid-state spectral-hole-burning material as the frequency reference.

Tom employed the stabilized laser sources to perform a number of high-resolution laser spectroscopy experiments, investigations previously limited by laser frequency jitter. These experiments reached the limits of precision in the optical spectroscopy of solids by establishing the world record for crystal optical linewidth of 73 Hz in $Er^{3+}:Y_2SiO_5$. For operation in the 1.5 μm communication band, the performance range of $Er^{3+}:Y_2SiO_5$ and related Er^{3+} materials has been significantly extended through Tom's fundamental material studies enabling applications such as laser frequency stabilization, all-optical correlators, and memories. Recently, Tom and his collaborators demonstrated dynamic accumulation of 0.5 GHz periodic spectral holographic gratings, a milestone in the development of devices based on spectral hole burning technology. Professor Böttger's work at MSU was supported by the local optics industry, such as Scientific Materials Corp., Wavelength Electronics Inc., ILX Lightwave Inc., and Advanced Research Inc. (AdvR), as well as the IBM Almaden Research Center in San Jose.

At USF, Professor Böttger plans on setting up a stabilized laser system for high-resolution spectroscopy, which would be the first of its kind at a liberal arts institution. Such a project provides ample research opportunities for undergraduate students, and is likely to garner external funding, ideally through NSF, but also through joint studies with IBM and MSU, as well as international collaborations (CNRS in France). The proximity to Silicon Valley is also ideal for support and cooperation with companies of the local laser and optics industry. Tom hopes to hire soon at least two USF students, and to enable summer internships for talented students.

5.4 Horacio E. Camblong

Theoretical physics, quantum-field theory, gravitational physics, many-body theory

Professor Camblong's research has been centered on miscellaneous topics in quantum field theory, gravitational physics, and many-body theory. His main focus has been on developing general frameworks, with applications to fields as diverse as condensed-matter physics, molecular physics, nuclear physics, elementary particle physics, and quantum gravity. Some of the highlights of his published research over the past decade include collaborative work on a geometrical and gauge-invariant approach to the quantum effective action; a many-body formulation of magnetotransport for inhomogeneous systems; nonlinear redefinitions of quantum fields in path integrals; path integral treatments of singular problems and bound states; a discovery of a quantum anomaly in molecular physics; and various applications of renormalization theory.

His most recent work focuses on the effective field theory approach to a variety of physical problems on different scales. This work involves two major collaborative efforts: with the Theory Group at Universidad Nacional de La Plata (Argentina); and with Professor Carlos Ordonez of the University of Houston—the latter is currently supported by an NSF grant. The effective field theory program consists of: (i) the redefinition of the relevant physical variables of a singular system; (ii) the reinterpretation of the system as "effective," within an approximation scheme in which it asymptotically emerges as a simpler version of a larger system defined over a wider range of scales. These techniques are of particular interest for those singular problems in which a naive analysis would either fail to provide any definite answers or otherwise yield divergent results. The implementation of the required renormalization is an open game (whose rules are to be rewritten) and has acquired renewed interest because such singular problems have been found, over the past few years, in effective field theory analyses of nuclear interactions and in the study of black holes and branes.

With the tools provided by the effective field theory program, Professor Camblong is investigating a number of problems. In particular, with his collaborators, he has identified a remarkable series of examples within the framework known as conformal quantum mechanics (CQM). This research has promoted CQM from a series of theoretical "toy models" to an ubiquitous framework for the analysis of a large class of physical systems. These are systems that exhibit a conformally invariant domain, possibly limited within two scales: one ultraviolet and the other infrared. The conformal symmetry of these models only needs to be approximate within the appropriate domain; it involves invariance under time reparametrizations, with has an enlarged family of three generators that includes the system Hamiltonian and forms an SO(2,1) group. A number of universal results of CQM are currently being derived and applied to a variety of physical systems: dipole-bound molecular anions; neutral-at!
om scattering by charged wires; the Efimov effect for three-body interactions, expected for the three-nucleon problem; the Calogero model, with potential realizations in condensed matter physics; and the Aharonov-Bohm effect. A particular kind of expected behavior, exhibited by the molecular realization (dipole-bound anions) and in the Efimov effect, can be interpreted as a quantum anomaly (or quantum symmetry breaking). This research program has led to a characterization of the algebraic structure of the conformal anomaly, in which the SO(2,1) invariance breaks down at the level of the quantum-mechanical commutators of the symmetry algebra.

Two recent major outgrowths of the study of singular interactions are the study of singular potentials within the brane-world scenario and the characterization of black hole thermodynamics. In the brane-world scenario, the emergence of classical gravitation is shown within a larger anti-de Sitter universe, with the observable low-energy physics confined to a brane; a number of singular problems naturally arise, to which some of the regularization techniques used by Prof. Camblong are proving useful. The other major topic, black hole thermodynamics, has acquired particular prominence in theoretical physics, as a result of its ``confirmation'' by string theory and loop quantum gravity, and of the development of the holographic principle and the AdS/CFT correspondence. A number of connections, involving these different perspectives, highlight the relevance of conformal quantum mechanics. One of the most interesting results being investigated by Professor Camblong and collaborators is the intriguing possibility that the near-horizon conformal symmetry of black holes may carry enough information to complete characterize the emergence of black hole thermodynamics and the emission of Hawking radiation.

5.5 Marcelo Camperi

Theoretical and computational neuroscience, computational physics.

Professor Camperi's research deals with various topics in the field of computational neuroscience and computational physics. His current projects include the simulation of very large network of biologically feasible neurons using parallel computer architectures, the development of models of prey detection and navigation in elasmobranch (in collaboration with Professor Brown), and the use of Information Theory in assessing the degree of synchronicity in real or simulated networks of neurons. In the past five years Professor Camperi has involved more than 10 USF undergraduate students in his research, who came from the Departments of Physics, Chemistry, Biology, Mathematics, and Computer Science. Several of them have been co-authors on peer-reviewed publications and on conference presentations.

Since the pioneering work of Hodgkin, Huxley, and Katz, mathematical modeling has been the main tool of the computational neuroscience trade, with ever improving single-neuron models and on arranging these models into networks of increasing sophistication. However, computational power often severely limits the complexity of the neuronal model one can study or the effective number of neurons that can be included in a network. Although a great deal can be learned from using networks with very few model neurons, sometimes very large systems are needed, as there may be emergent complex behaviors in large networks without a small network counterpart and also statistical properties may not be representative if models are drastically scaled down from the real systems. Since 1997, Camperi and Professor Peter Pacheco (USF Math/Computer Science), together with an array of CS and Physics students, have been working on the development of portable, modular software for the simulation and visualization of large biologically-plausible neuronal networks on parallel computers (clusters or distributed networks of workstations), based on the MPI and OpenGL standards. Currently, the system runs on USF's own 128-CPU Keck Cluster, maintained by the Computer Science Department.

The fundamentals of the Elasmobranch modeling project are described under Professor Brown's work. Brown and Camperi are currently combining experimentation and advanced computer modeling into achieving a realistic rendition of the phenomenon, which would allow them to study, for example, which voltage dynamical conditions may be responsible for the animal's typical attack approach. They also plan on relating the electrical signals in the elasmobranch's head to a realistic neuronal model that may shed light on the type of brain function responsible for the behavior under study.

The Information Theory project is a collaboration with a group at the University of Michigan (one of the group's members is a USF alumna). Synchronous neuronal activity has been observed in many different regions of the brain, often extended over relatively large areas. It has been linked to various behavioral and cognitive states. The degree of synchronous activity within and between different parts of the brain has been linked not only to these states, but suggested as a way in which information can propagate over long distances. If computational models are to address fundamental questions about these phenomena, it is essential to have standardized tools for measuring synchrony over networks of substantial size. Currently, we lack a generally accepted measure of synchrony over a network. Although numerous synchrony measures have been proposed in the literature, most rely either on some variant of cross-correlation or on ad hoc convolution integrals among pairs of spike trains. Often these measures give ambiguous or unacceptably counter-intuitive results, as in certain cases of phase-locking, or cases in which different portions of the large network synchronize locally. Other measures are either tailored to specific problems and fail to generalize, or are highly computation-intensive, and so impractical for networks of realistic size. Some suffer from a combination of these flaws. Camperi and collaborators developed a new measure of network synchrony, based on ideas of Information Theory, most notably the concept of mutual information, and using tools of "computational mechanics", an information-theoretic method for automatically constructing optimal, minimal predictive models of nonlinear stochastic processes. Computational mechanics builds a hidden Markov model for the data, where each hidden or "causal" state corresponds to a statistically-distinct distribution of future events. In this case, each causal state corresponds to a distinct pattern of future firings. A publication with the fundamentals of the methods and some modeled test cases is to be submitted soon, and other work is also being readied for publication. Moreover, Camperi and collaborators are discussing with an experimental group at Rutgers University the possibility of using this new method to analyze real neuronal data on the stomatogastric ganglion in crabs and lobsters.

5.6 Carl Naegele

Physics education, computer data acquisition and analysis, computer networks, information science.

For the past several years, Professor Naegele has served as a consultant to corporations, communities and individuals in the design and implementation of CMTS and wireless network systems. He also serves as a consultant for the National Science Foundation in reviewing programs and proposals related to undergraduate science education.

6. Physics Programs and Physics Curriculum

The Physics Department program offerings comprise the following:

- Honors Major in Physics
- Major in Physics (with flexibility to include the possibility of a double major)
- Minor in Physics
- 3/2 Engineering-Physics Program
- Materials Physics Program

In the following, all listed courses are 4 units, unless noted otherwise.

6.1 Honors Major in Physics

- Required Physics Courses

0208-110	*General Physics I*
0208-210	*General Physics II*
0208-240	*Modern Physics*
0208-371	*Methods of Mathematical Physics*
0208-301	*Computational Physics*
0208-340	*Optics*
0208-320	*Electromagnetism*
0208-330	*Quantum Mechanics*
0208-310	*Analytical Mechanics*
0208-312	*Statistical and Thermal Physics*
0208-341	Upper-division laboratory I (2 units)
0208-342	Upper-division laboratory II (2 units)

0208-299/399	Undergraduate research (flexible)*
0208-276	*Physics Colloquium* (1 unit)**
0208-xxx	Upper-division physics elective***

* 2 units are required, but more are recommended.
** 4 units are required.
*** It is recommended that in addition to the required Physics elective, at least 4 of the 18 general elective units be in Physics.

❖ Required Math Support Courses 3 courses

12 units of Calculus and Analytical Geometry.

❖ Outside-of-Major Required Courses 11 courses

Core Requirements (for Science Students):

Public Speaking
Writing II
Philosophy/Theology I, II, and III
Fine and Performing Arts
History
Literature
Social Science

University Requirements (for Science Students): Foreign Language I and II

Total number of units:

54 in Physics
12 in Math Support Courses
44 Outside-of-Major Required Courses
18 in General Elective Courses
128 units

Upper-division Physics elective courses are to be chosen among the following offerings:

0208-332	*Nuclear and Particle Physics*
0208-333	*Solid State Physics*
0208-343	*Astrophysics*
0208-380	*Foundations of Computational Neuroscience*
0208-410	*Advanced Classical Dynamics*
0208-420	*Advanced Electrodynamics*
0208-430	*Advanced Quantum Mechanics*
0208-450	*Advanced Materials*

6.2 Major in Physics (flexible enough to include double-majors)

❖ Required Physics Courses

0208-110	*General Physics I*
0208-210	*General Physics II*
0208-240	*Modern Physics*
0208-371	*Methods of Mathematical Physics*
0208-301	*Computational Physics*
0208-340	*Optics*
0208-320	*Electromagnetism*
0208-330	*Quantum Mechanics*
0208-310	*Analytical Mechanics*

0208-312	*Statistical and Thermal Physics*
0208-341 or 342	Upper-division laboratory I or II (2 units)*
0208-276	*Physics Colloquium* (1 unit)**

* UD Lab I and II are non-sequential courses
** 2 units are required.

Note: appropriate substitutions are worked out with other departments, such as Mathematics and Chemistry, to facilitate the possibility of double-major programs.

- Required Math Support Courses 3 courses

  12 units of *Calculus and Analytical Geometry.*

- Outside-of-Major Required Courses 11 courses

GEC Requirements (for Science Students):	*Public Speaking* *Writing II* *Philosophy/Theology I, II, and III* *Fine and Performing Arts* *History* *Literature* *Social Science*
University Requirements (for Science Students):	Foreign Language I and II

Total number of units:	**44 in Physics**
	12 in Math Service Courses
	44 Outside-of-Major Required Courses
	<u>28 in General Electives Courses</u>
	128 units

6.3 Minor in Physics

This program requires the completion of twenty (20) units in Physics, as follows:

- Lower-division Physics Courses (all four units)

0208-110	*General Physics I*
0208-210	*General Physics II*
0208-240	*Modern Physics*

- Upper-division Physics Courses

  8 units of upper-division coursework are required, of which no more than two can be fulfilled by registering for the Physics Colloquium.

6.4 3/2 Physics-Engineering Dual Degree Program

In 1997 the 3/2 Physics-Engineering Dual Degree Program was established and an articulation agreement was signed with the University of Southern California. Under this program, an undergraduate student attends the University of San Francisco for three academic years and the University of Southern California for two academic years, and is awarded two bachelor of science degrees: one in physics from USF and one in engineering from USC. The agreement guarantees admission into the USC School of Engineering when a GPA of 3.0 is maintained while at USF. However, a recommendation from the pre-engineering advisor at USF is still required (in the form of a diagnostic letter summarizing the student's academic record).

The rigorous nature of this academic program is noteworthy. In addition to a standard physics training at USF, our students complete their engineering requirements in the final two years at USC□whose engineering school is ranked among the top fifteen in the nation. Our goal has been and remains to provide a thorough physics background: the USF part of the degree is comparable to that of a typical B.S. degree in physics, with the same required courses as in our regular degree program. However, this leaves no room for electives (either at USF or at USC); the only additional course that our students can and should take is General Chemistry, as required by the engineering school. Even though the lack of electives does not appear to be an ideal situation, when all other factors are considered, this is the only sequence that maintains the integrity of our B.S. degree. At the same time, this constrained sequence leads to increased enrollments in all the required upper-division courses, which is a highly desirable outcome.

The number of students pursuing this program has varied from year to year. Several factors have contributed to this: the population involved is small, the emphasis placed on advertising this program and recruiting students (by the Admissions Office) has not been steady, and a stringent selection process operates in our physics courses. In addition, some students start with the 3/2 program but eventually decide to stay within the regular major program. In any case, by the time they finish their junior year, they are fully prepared for the demanding experience of 2 years of engineering.

We are pleased to report that the first group (of 2 students) will be finishing the 5-year program this year. These students have provided us with informal comments and feedback on the program. They both agree that our department gave them the required background to succeed at USC. For example, [Name Redacted] stated in an e-mail sent to us on January 28, 2003: “As far as my courses are concerned, I have performed very well in my chemical engineering (ChE) courses, especially with respect to the rest of my classmates. ChE requires a great deal of applying mathematics, physics, and chemistry. USF established a strong foundation in physics (of course!) and mathematics which have contributed strongly to my understanding of the ChE material ...'”

Finally, we are in the process of revising the program requirements and making the necessary adjustments according to the new 4-unit format and core curriculum. The required courses are essentially identical, except for their upgrade to 4 units, with the expected strengthening of the program above and beyond its original form. The only curricular “reduction” appears in General Physics, which is compressed from 3 to 2 semesters. These changes are currently being discussed (with a few minor adjustments still needed for chemical engineering) and will be presented soon to USC (with their expected approval). It is also anticipated that the program will be considered for the establishment of additional articulation agreements with other schools (for example, Boston University).

All in all, the 3/2 program has contributed (at least initially) to the desired increase in enrollments, but the numbers are still small, appear to be declining, and are hardly predictable. Consequently, we believe that additional recruiting efforts by the Admissions Office are advisable.

❖ Physics Courses

Students in this track follow essentially the "Physics Major Track" described above, although the actual set of courses to be taken while at USF will depend on the chosen engineering field. Under this program dual degree candidates are eligible to seek any of the following degrees from the University of Southern California (which are compatible with the University of San Francisco's educational offerings):

- Bachelor of Science in Aerospace Engineering.
- Bachelor of Science in Chemical Engineering.
- Bachelor of Science in Civil Engineering.
- Bachelor of Science in Computer Engineering.
- Bachelor of Science in Electrical Engineering.
- Bachelor of Science in Industrial & Systems Engineering.
- Bachelor of Science in Mechanical Engineering.

6.5 Materials Physics Program

The Physics Department has advanced a new initiative in Materials Physics. Aspects include a new curriculum track for majors, a new course, an enhanced advanced laboratory, and a grant-based influx of capital equipment that has significantly enhanced both teaching and research in the department.

Tracks in Applied Physics are not uncommon at major American universities, from Yale to the University of Iowa. In the Bay Area, Santa Clara offers a degree in Engineering Physics and Stanford University offers an Applied Physics minor. However, these traditional applied and engineering physics programs are based on a model some twenty-to-thirty years old. Materials Physics, with its emphasis on modern advanced commercial materials, differs from traditional Applied Physics in a great many aspects.

The goal of the new initiative is to provide a more applied alternative to the standard physics major. A robust theoretical understanding of materials combined with hands-on experience with material creation and characterization techniques could ideally place students in the high-tech sector after graduating from the University of San Francisco. It would also serve as excellent preparation for graduate studies in condensed matter physics, material science, or physical chemistry.

The Materials Physics track differs from the typical physics track in several ways. Materials Physics students are required to take the following courses beyond the standard physics track: Solid State Physics, Electronics, Advanced Materials, General Chemistry I, and Computer Science I. On the other hand, the students in this track are not required to take the following courses that are typically required in the major: Statistical and Thermal Physics, Computational Physics, and Analytical Mechanics.

In addition, students are expected to complete a summer internship before their senior year. Internships should be in either an industrial setting or an academic setting that relates to advanced materials. Though the track has just begun (fully eligible students matriculated in fall 2002), two seniors have already completed materials-related internships (one at Argonne National Laboratories, and one at Vanderbilt University).

While the department has previously offered solid state physics as an elective, the Advanced Materials course is new. The course is intended to work smoothly in conjunction with segments of the updated advanced laboratories. It has been approved by the university curriculum committee but has not been offered yet. It will use a book such as Askeland's *The Science and Engineering of Materials* or Hummel's *Understanding Materials Science*. The course outline includes major coverage of semiconductors and photonic materials, but it will also introduced students to thermoelectrics, liquid crystals, and polymer-based materials. Each student will have a term project involving a self-motivated experiment utilizing the new advanced laboratory equipment.

❖ Required Physics Courses

0208-110	*General Physics I*
0208-210	*General Physics II*
0208-240	*Modern Physics*
0208-215	*Electronics* (2 units)
0208-371	*Methods of Mathematical Physics*
0208-340	*Optics*
0208-320	*Electromagnetism*
0208-330	*Quantum Mechanics*
0208-341	Upper-division laboratory I (2 units)
0208-342	Upper-division laboratory II (2 units)
0208-xxx	Undergraduate research (flexible)[*]
0208-276	*Physics Colloquium* (1 unit)[**]
0208-333	*Solid State Physics*
0208-450	*Advanced Materials*

[*] 2 units are required.
[**] 2 units are required.

Note: In addition to the required courses, students on this track will be required to do an industry internship in the summer following their junior year. Several Bay Area companies have already manifested a great deal of interest in hosting students from this new program.

❖ Required Math Support Courses 3 courses

12 units of *Calculus and Analytical Geometry.*

❖ Other Required Support Courses

0202-111	*General Chemistry I*
0203-110	*Introduction to Computer Science I*

❖ Outside-of-Major Required Courses 11 courses

GEC Requirements (for Science Students):
Public Speaking
Writing II
Philosophy/Theology I, II, and III
Fine and Performing Arts
History
Literature
Social Science

University Requirements (for Science Students): Foreign Language I and II

Total number of units:
46 in Physics
20 in Support Courses
44 Outside-of-Major Required Courses
18 in General Electives Courses
128 units

6.6 Physics Service Courses and the New Core Curriculum

The Physics Department offerings are not limited to its major/minor students. Our Department also offers courses for the programs in Biology, Environmental Science, Chemistry, Mathematics, Computer Science, and Exercise and Sport Science, as well as science courses for non-science majors.

Our current service courses targeted to specific programs are:

0208-100/101, Introductory Physics I and II
which serves the Biology, Environmental Science, and Exercise and Sport Science programs.

0208-110, General Physics I
which serves the Chemistry and Computer Science programs (as well as our own Physics program).

0208-130, Concepts in Physics
which serves the Architecture track within the Fine and Performing Arts program (and which has an uncertain future).

0208-210, General Physics II
which serves the Chemistry program (as well as our own Physics program).

0208-213, Introduction to Electromagnetism and Electronics
which serves the Computer Science program (while the course's second half serves our own Physics program).

6.6.1 Physics courses in the new Core Curriculum

In the past few years, the University of San Francisco underwent a long (and at times tortuous) process that culminated in the establishment of the new Core Curriculum, which contains the common core of instruction that every USF undergraduate must fulfill.

The previous system was based on the so-called General Education Curriculum (GEC), a set of essentially fixed requirements (with very few exceptions) that lacked flexibility and imposed a very heavy course load on students. Indeed, anecdotal evidence suggests that the GEC was a significant obstacle in the recruiting of science students.

The new Core Curriculum is a learning-outcomes-based set of requirements that considerably enhances the choices and opportunities for students, while at the same time significantly reducing the unit load associated with the non-major requirements that a student must fulfill. As stated in the Core Preamble, the University's Core Curriculum embodies the Jesuit, Catholic tradition that views faith, reason, and service to others as complementary resources in the search for truth and full human development. The Core promotes these values through their integration across the curriculum. As it develops its course offerings, the University affirms its commitment to provide our students with learning opportunities that embrace the fullness of the Jesuit Catholic intellectual tradition.

The University began the implementation of the new Core Curriculum with the 2002-03 academic year. The requirements are divided in seven areas, and a set of learning outcomes defines what an acceptable area course is. These learning outcomes, as well as the designation of specific courses as "Core approved" are decided by Core Area Committees, composed of faculty members in each area.

The Core breakdown by areas is:

Area A: Foundations of Communication (8 units)
Speaking (4 units)
Rhetoric and Composition (4 units)

Area B: Math and the Sciences (8 units)
Math or Quantitative Science (4 units)
Applied or Laboratory Science (4 units)

Area C: Humanities (8 units)
Literature (4 units)
History (4 units)

Area D: Philosophy, Theology and Ethics (12 units)
Philosophy (4 units)
Theology (4 units)
Ethics (4 units)

Area E: Social Sciences (4 units)
Social Sciences (4 units)

Area F: Visual and Performing Arts (4 units)
Visual and Performing Arts (4 units)

In addition to completing the Core Curriculum requirements, a student will have completed a minimum of two courses *within the Core* or *within his/her major* (i.e. without the need for extra courses) that integrate two mission-driven characteristics: Service Learning and Cultural Diversity.

It is of paramount importance for any department to seize the opportunity afforded by the Core's flexibility by offering a variety of courses with the potential for attracting large student enrolment. The Physics Department is in a somewhat advantageous position, as it can offer courses that satisfy either the Math or the Science area requirements. We have taken advantage of this by developing and offering two courses (and we are planning a few more) which have been approved as granting either Science or Math Core credit:

0208–120, Astronomy: From the Earth to the Cosmos

The goal of our introductory astronomy class is to provide students with an experience of discovery and an opportunity to learn science and nurture their curiosity about the universe. As such, the course is structured as a fascinating tour of the cosmos from our planetary neighborhood to the most distant corners of space and time. This intellectual adventure is enhanced by the astronomical revolution currently underway.

A thorough appreciation of astronomy at this level is possible only through a conceptual foundation, which includes the following elements:

i. Familiarity with the laws of Nature (physical principles).
ii. An understanding of how the universe (the "sky") is viewed from the Earth.
iii. Familiarity with the basic concepts of planetary astronomy.
iv. An understanding of the basic concepts of stellar astronomy, including the origin and evolution of stars.
v. Familiarity with the cosmos on its largest scales (galaxies and beyond), as well as with cosmology: the study of the evolution and structure of the universe as a whole.

Some of the high points in this course include a voyage of discovery of planetary worlds and of our origins; the study of exotic objects such as neutron stars, black holes, quasars, and gamma-ray bursters; and a detailed conceptual analysis of the various perspectives needed to understand cosmology: the expansion of the universe, the Big Bang, and related observational evidence.

A brief history of this course and its genesis is in order. By 1998, after 5 years of continuous development, Foundations of Natural Science (the required science class of the former GEC curriculum) had reached its final form. At the same time, the individual experiences of both faculty and students revealed multiple frustrations with its content and structure at all levels. After a few months of intensive development by Professors Camblong and Camperi, the Physics Department proposed an alternative model totally based on astronomical examples. These efforts required overcoming significant barriers and coordinating the proposed course with other science departments. Finally, it was offered in Fall 1998, together with an innovative set of laboratory exercises that integrate physics and astronomy. These labs have been mostly successful, but their present form reflects the history of the course, with each major physics topic integrated under the premise of its "equivalence" to Natural Science. As a result, the laboratories include greater physics emphasis than is customary in astronomy courses. Not surprisingly, this emphasis, combined with various additional factors, has prevented the astronomy class from reaching its full potential.

We are now at a turning point, due to the required implementation of the new core curriculum. In this new format, the laboratories do not have to conform to the original model. Thus, with this added flexibility, the impending competition with other science courses, and the goal of improving the popularity of this class, we are currently revising the labs. Many of the anticipated changes will have been implemented by the end of the Fall 2003 semester, with subsequent improvements and extensions over the following couple of years. Specifically, the basic labs on triangulation (parallax, etc), gravity, optics of a telescope, and spectroscopic analysis of the expansion of the universe have remained in their original form, while additional astrometry and spectroscopy labs have been developed. Most of the other labs have been replaced by observational exercises in our Lone Mountain Observatory. These sky-watching sessions have become a central part of the course. This balance between physics and the visual imagery of the sky have made this class one of the most popular within the new core curriculum.

In the past few years we have amassed a decent collection of astronomical observational instruments, which are housed on a special shack built for us in the adjacency of the rooftop of the Lone Mountain Campus. Our equipment includes a Meade LX200 GPS, a Meade 10" Newtonian, a Celestron 10" Reflector w/GO-TO Drive system, a Tasco Refractor, and a Questar. Observations are routinely scheduled Mondays through Thursdays throughout the entire academic year.

0208-135, Masterpiece Physics: On Science, Mathematics, and the Arts.

This course is a new attempt at creating a serious science course with an underlying premise that is attractive to students. Despite what appear to be irreconcilable differences, the arts and physics present strong similarities. After all, they are investigations into the nature of reality, and are characterized by powerful and sometimes introspective creative processes. Moreover, artists and scientists are often the first to perceive, think of, and represent the world in new ways. Since ancient times, the mysteries of Nature have provided human beings with a constant source of wonder and inspiration. It should nowadays be obvious that no person can fully appreciate Nature without understanding its basic rules, at least at a conceptual level. This basic tenet also clearly applies to all the man-made contraptions with which we have surrounded ourselves in our everyday life. This extends of course to all the different means of artistic expression, such as painting, photography, music, etc.

This is a science course, not an arts course. It endeavors to use art and music as media to present physics and mathematics to people interested in learning science but without a background in them. However, the course also attempts to bridge the worlds of science and the arts, trying to find some common ground. Emile Zola defined art as "Nature as seen through a temperament" which might also define physics. The pop artist Roy Lichtenstein said that "organized perception is what art is all about", a characterization that could also apply to physics. While their methods differ radically, artists and physicists share the drive to investigate the ways in which disparate pieces of Nature fit together.

The underlying science structure of the course is based on an exploration of the following elements:

- ✓ How does Physics describe sound and light?
- ✓ What does it mean that an object is of a certain color, or that a source radiates light of a given color? What do we really do when we paint something of a different color?
- ✓ What connections do exist between symmetry and perspective in the arts and ideas from mathematics and physics?
- ✓ What are the main visual and auditory pathways in the brain? What are the neurophysiological bases of human perception of sound, color, and shape? Which diseases affect sound and color perception? How has all of this been reflected in the arts?
- ✓ Are opposite concepts such as harmony and noise, consonance and dissonance, and shocking and pleasing visual effects purely cultural or perhaps also in part physiological?
- ✓ How are string, wind, and percussion musical instruments designed? How does Physics describe the musical elements of harmony, rhythm, tone, pitch, scale, octaves, etc.? What is temperament, and why do non-western musical instruments sound different to western ones?
- ✓ The word photography means literally “writing with light”. How is this achieved? How does a photographic camera work? Can we write with lasers as well?
- ✓ What mathematical elements or structures can we find (perhaps unbeknown to the creators) in music, painting, and architectural design through the ages?
- ✓ Can mathematics help to understand at some level the music of such geniuses as Mozart or Bach? Do we really need to “understand” great music to enjoy it?
- ✓ Can we use physical and mathematical principles to understand the arts or at least organize the way we think of them?

In addition, students perform a variety of laboratory experiences that include mechanical waves, sources of sound, building musical instruments, light phenomena, mirrors and lenses, colors and shadows, the workings of a photographic camera and a hologram, etc. Students use some of the same laboratory materials (including computer data-taking interfaces) that Physics majors use, although in specially developed laboratory settings.

The course is being offered in pilot form during this current semester (Fall 2003) for a reduced number of students. A large amount of teaching materials and specially designed laboratory experiments are being developed.

7. Common Facilities

The teaching of physics requires a variety of facilities that must be readily available during the faculty member's preparation time, as well as during actual class time. In the following paragraphs, we assess the adequacy of physical facilities in support of the program.

7.1 Space attrition

USF in general, and the Science departments in particular, face a space crisis of enormous proportions. The demands of a growing student population, an increase in the number of educational programs, and the requirements of contemporary teaching techniques, create enormous constraints and hardships that call for some badly needed investment.

For the Physics department the situation was accelerated by the loss of space accrued over the past decade. No fewer than three large laboratory spaces and a variety of smaller spaces have been reassigned for other purposes (Harney 133 was given to the now phased-out Foundations of Natural Science GEC course, Harney 103 is now used exclusively by the Environmental Science Department, and Harney 141 is now the “Media Lab” for the Communication Department). Even granting the needs of other departments, the loss of space (and the state of some of the existing ones) is particularly problematic for the Physics Department.

We are proud to say that ingenuity and hard work have allowed us to make the best of the situation, even though we have lost approximately 25% of the once-available space. However, the space situation has sadly become one of the most effective and frustrating brakes on our future. Currently, we offer 10 courses with a laboratory component and we would like to introduce at least one more. Thus, in any given semester, we may have five or more concurrent laboratory courses, each with several weekly lab sections, so that our existing three laboratory spaces are insufficient. In addition, it is quite dismaying to hear students complain about the coldness of our labs in winter, the decrepit state of some of the walls, the lack of network connections in some labs, etc. etc.

Returning full use of HR 133 to the Physics Department would be a very good short-term solution for the space problem. This laboratory was fully assigned to the Physics Department until the creation of the Natural Science sequence eight years ago; when it was taken away from us. Eventually it was used approximately 50% of the time for “Astronomy” laboratories (a GEC course offered by the department) and 50% for Natural Science laboratories. The phasing out of the previous GEC, and with it Natural Science, coupled to the dramatic increase in enrolment in Astronomy and the development of other physics courses with a lab component for the Core Curriculum, it would only make sense for this laboratory space to go back to Physics. Aside from the critical need for more space, a good number of the problems we face are mostly cosmetic; and thus should not necessitate great investments to solve.

7.2 Lecture Rooms

The teaching of physics is characterized by its heavy dependence on lecture demonstrations. Ideally, the Physics program should have at least one lecture room fully dedicated to Physics instruction, so that demonstrations may be set up ahead of time. At USF, there are two lecture rooms on the Physics level of Harney Science Center, a large room (Harney 127) and a small one (Harney 143), both shared in principle by all departments at USF. Lecture tables are duplicated in the preparation room (Harney 129), so that a demonstration set up in that room can readily be trundled over to one of the lecture halls. It is only fair to mention that the Dean’s office has always collaborated with us in trying to obtain priority in the assignment of these two rooms, although the final word on this comes from elsewhere at USF.

Each of these rooms features a large lecture table with sink, electrical outlets (AC and DC), gas, compressed air, and abundant blackboard space. Moreover, Harney 127 has recently been transformed into a state-of-the-art “smart” classroom, with dedicated PC and Mac computers, ceiling-mounted projector, and video and sound systems. Sadly, these renovations have not included a much-needed cosmetic overhaul.

We advance a couple of suggestions for much needed classroom improvements:

- The chairs in HR 109 are old and are falling apart. Students consistently complain that having to seat on them for long periods of time is a painful annoyance. Although we have not personally confirmed this, students have told us that the chairs in HR 109 are the worst in the whole USF campus. We believe they should be changed and brought to par with the sitting found in most classrooms at USF, such as in HR 132, which is HR 109’s “equivalent” room (right above it, of similar size and geometry, and also a “smart-classroom”)
- Over the years, we have suggested in many opportunities that a relatively inexpensive and highly desirable classroom improvement would be the replacement of traditional chalkboards with more contemporary whiteboards, which are more amenable to some simple, albeit pedagogically-sound, teaching techniques, such as the use of various colors to draw much more detailed diagrams. A few years ago whiteboards were installed in HR 109 (one of our laboratories), and the accolades from all who use them have been consistent. We suggest that both lecture rooms (HR 127 and HR 143) as well

as the HR 104 laboratory be given whiteboards.

7.3 Other Classrooms

In an ideal world, we would have study and tutorial rooms for students. Instead, problem discussion sections are currently held in laboratories. Essentially, there is nowhere on campus for students to meet and discuss Physics in a conducive atmosphere. Professor Camperi has made special arrangements for students to use his research/teaching laboratory as meeting place. Here is where meetings of the Society of Physics Students take place.

7.4 Laboratories and the Fletcher-Jones Grant

In recent years our laboratory infrastructure has received an infusion of life in the form of a large grant from the Fletcher-Jones Foundation received for the development of the Materials Physics Program (Professor Brown's brainchild, described below). As this new program touches on many areas in the department, the educational benefits arising from the grant were spread to several areas, most notably into computational infrastructure and in the Upper-division laboratory.

7.4.1 Computational Physics Laboratory (Harney 101)

No facility of this kind existed at USF as of 6 years ago. Today, this room doubles as a "smart" classroom and the research facility of Professor Camperi, who built it from scratch and maintains it. The room currently has 11 high-end Macintosh PowerPCs (10 clients and one server), a laser printer, one document camera, and one ceiling-mounted projector connected to the server and the document camera. All computers are networked through a fast-ethernet switch and behind a firewall that shields the local network from outside traffic. Thus, the array of computers can be used as cluster for parallel computations. The laboratory holds site licenses of the packages *Mathematica* and *Matlab*, as well as an assortment of useful programs.

The usability of the room is limited by its size and the number of computers it holds. Thus, it can only be used for upper-division courses, where the enrollment has never been higher than 8 or 9 students. It serves mainly as lecture/laboratory room for the Computational Physics course, and for student research purposes. As indicated above, it has also become the de-facto meeting room for Physics students.

7.4.2 Lower-Division Laboratories

The Department has Harney 109 to support the General Physics Sequence (Calculus based) and Harney 104 to support the Introductory Physics Sequence (Algebra based). HR 109 and 104 share equipment for laboratory setups, and a common battery room with routing panels that can supply any room in our Department with DC or AC current. In addition, each room has provision for water, steam, compressed air, and gas (standard in any science laboratory). HR 104 lacks any computer infrastructure.

7.4.3 Microcomputer-Based Laboratory (Harney 109)

Twelve years ago we introduced the microcomputer-based laboratory (MBL) for the General Physics sequence. This was one of the first MBLs introduced in California. Computer data acquisition and analysis are used in most experiments; even in the remaining experiments, students are expected to take data directly into a spreadsheet and to write their laboratory reports using word processing.

Currently the laboratory has 10 iMac computers connected by a wireless network (Apple's Airport Extreme) and a shared printer. Each computer has word processing and spreadsheet programs that the students are required to use. Moreover, each computer serves as platform for Pasco's Science Workshop software with a SW 500 Interface and its assortment of probeware and associated equipment.

7.4.4 NSF-Sponsored MBL Workshops for Teachers

A few years ago two of our faculty members, Professors Albergotti (retired) and Naegele, received a grant from the National Science Foundation to run the three-year program “Microcomputer-Based Tools for High School Physics.” The program was designed to involve teachers from the San Francisco Bay Area, and comprised an intensive summer component of three weeks’ duration, coupled with daily sessions spaced throughout the school year. In addition to instruction, teachers received eight units of academic credit from USF, a per diem allowance, and funds to purchase interfacing equipment appropriate for use with the computers in their respective schools. The budget for this project was $440,000 and it was considered a success not just by its creators, but also by the teachers who benefited from it. It was cancelled when the NSF funding was not renewed.

7.4.5 Upper-Division Laboratory (Harney 139)

Nowhere else is the impact of the Fletcher-Jones Grant more visible than in the Upper Division Laboratory, which has become the foundation for the Materials Physics program, both pedagogically and economically. In seeking to revamp this laboratory with cutting edge equipment, the department surpassed its initial grant award expectations. Funds have poured into the department’s entire infrastructure as a result.

In early 2000 Professor Brown proposed the new Materials track informally to the department and began seeking funding. The following Summer, Brandon submitted a grant proposal to the National Science Foundation’s (NSF) Division of Undergraduate Education, seeking approximately $80,000 for equipment to update and augment the facilities of the Upper Division Laboratory. This program (Course Curriculum and Laboratory Improvement, CCLI) required a dollar-to-dollar match. On a recommendation from the Dean’s Office, the department applied for funding from the Fletcher-Jones Foundation. Even before hearing from the NSF, the department learned in the fall of 2000 that they would receive $790,000 from the Fletcher-Jones Foundation for the purchase of advanced laboratory equipment in support of the new initiative. In the following months, the NSF notified the department of positive proposal reviews and the affirmative decision to award the requested CCLI funds.

The centerpiece of the Advanced Laboratory is a coherent sequence of activities that build upon one another. First, students synthesize a thin metallic film using evaporation in a high-vacuum chamber. Next, they use photolithography to etch a measurement bridge into the film. A force microscope then allows students to image the resulting film surface. Finally, they make transport measurements of the material to characterize its electronic properties.

Overall, the new funding has been used to purchase a series of systems and devices that benefit both instruction and research in the department. Here, we will simply mention the highlights. The department purchased a Physical Property Measurement System (PPMS) from Quantum Design. This liquid-helium-based system can collect resistivity, magnetization, susceptibility and Hall effect data for temperatures down to 1.8 kelvin, and for magnetic field strengths up to 7 tesla. Students in two iterations of the advanced laboratory have utilized it, and it has been used to make Hall effect measurements on a transparent conductive oxide that will lead to publication. For creating thin films, the department purchased an evaporation unit from Electro-mechanical Services, a company that designs products with student training in mind. We are the first four-year college to purchase equipment from them. The deposition unit successfully deposits copper or aluminum onto glass slides or silicon wafers. To pattern the films, the department purchased a photolithography module, also from Electro-mechanical Services. Students are now using this module to follow the multiple stages of photolithography to etch patterns of their own making into the thin film samples. An array of sophisticated electronics equipment (including Keithley multimeters, a Stanford Research spectrum analyzer, pre-amps, and lock-in amplifier) has also been purchased to assist electrical measurements. The department has purchased a tabletop X-ray diffraction device, with which students now examine the crystal structure of simple systems. An array of sophisticated optics equipment, including a tunable laser and optical spectroscopy system with a closed-cycle refrigerator are now operational in the department’s optics lab. Finally, some of the grant funds have gone to enhancing the computing infrastructure of the department, including that for the freshman General Physics sequence and the department's computational physics laboratory.

Though every student must complete the deposition-patterning-measurement sequence in the advanced laboratory, they can otherwise select from a large menu of other experiments, including the X-ray diffraction exercises, LabView programming, Interferometry, Johnson noise measurements, Hall effect, radioactive decay, or speed of light experiments.

The UDL courses have now been offered a number of times. To date, evaluation has come in two forms: student exit surveys, and evaluation letters written by supervisors of summer internships for students who have already completed the laboratory. In both cases, the results have been very favorable. For instance, a senior research scientist at Argonne National Laboratories wrote glowingly of one USF student who had completed the upper-division laboratory. He wrote that she performed like an advanced graduate student, and he wished he "could replace most of the people working here with people like" the student.

We recently hired Thomas Böttger, whose area of expertise fits neatly within the plans for the new materials program. Indeed, Professor Böttger will contribute to the Materials Physics initiative by introducing new laboratories that supplement existing labs. These labs would address lasers and laser applications. Grating-stabilized tunable diode lasers can provide an inexpensive and versatile source of laser light for doing simple experiments in atomic, molecular, and optical physics. Possible new laboratories would include saturated absorption spectroscopy with a diode laser, high finesse Fabry-Perot cavities, introduction to diode laser frequency stabilization, and frequency modulation spectroscopy.

7.5 Shops

We have two shops, a metalworking shop and a woodworking (now largely plastic) shop. It is important to note that due to changing space needs, the woodworking shop has been moved a number of times in the past few years and we do not see the current location of the machines as a permanent home for the shop. A variety of machines are available: two lathes, a milling machine, two bandsaws, and a table saw. Overseeing these two shops and the Physics stockroom is the Physics technician, Lorenzo Tyler. His duties also include setting up the laboratory experiments and lecture demonstrations.

There is no separate electronics shop where faculty, technicians, and students can repair and fabricate electronic circuits, although we believe we badly need one, given the current faculty's research and teaching needs.

7.6 Gleeson Library

The physics collection in Gleeson Library largely reflects the interests of the Physics faculty. Thus, there may be gaps in the collection in areas where no faculty are working. Since we do not have a graduate program, these gaps do not seem to be a serious problem at the present time. In our past program review we noted that the Reader's Adviser (14th ed., 1994) revealed that our Physics book collection contained 59% (342) of the 580 key works listed. It has not been possible to update these numbers, as the 14th was the last edition of the Adviser available at the Library. However, the collection has grown in the intervening time. Moreover, since our last report, Gleeson has implemented a library liaison program, giving collection development responsibility to a specific librarian. As of this writing, Randy Souther is the library liaison for physics. Some recent significant additions to Gleeson's print collection include the 11-volume Encyclopedia of Materials, and the 24-volume Wiley Encyclopedia of Electrical and Electronics Engineering.

The Library's list of physics journals was compared with the physics section in Magazines for Libraries (11th ed., 2002): the Library subscribes to seven of the nine journals regarded as essential to a basic academic physics collection. The journals we do not subscribe to are *Journal of Physics* (which includes several titles) and *Physics Letters*. In total, the Library subscribes to 31 of all 77 listed physics journals, with 14 of these journals available full text online. Moreover, since the last report, the library has subscribed to

Inspec (online), the primary indexing and abstracting tool for physics and related disciplines.

We want to point out that the interaction among Library personnel and faculty members has been mostly cordial. However, there has always been a definitive element of frustration, particularly when it comes to journals. For example, we recently discussed a reassignment of journals from the Institute of Physics (IOP) with one of its representatives, as the current subscription does not reflect the changing interests of the faculty. Despite the fact that the reassignment would not have implied a higher subscription rate, the Library refused to even consider the matter (indeed, they did not even respond to emails from the IOP representative). Moreover, they also declined to consider an offer to subscribe to the entire IOP database of past journals for $500 per year.

In addition, budgetary problems have always made the Gleeson Library somewhat less than receptive to the needs of faculty members in specialized or non-traditional fields, such as Neuroscience. For a time it seemed possible that the Library would subscribe to online services such as Web of Science, which would have been tremendously positive to many on campus. However, the project was abandoned, again due to budgetary constraints (the cost was described to us as being "staggering")

8. Workload

At USF, the faculty workload is negotiated between the Administration and the USF Faculty Association. At present, it is 15 units (15 hours per week), of which three are assumed to be consumed by activities related to service to the University, to the College, and to the Department. In addition, a faculty member may request up to three units of reduced load for the pursuit of research and other original work. This is normally taken for granted by both faculty and administration, and no formal request actually takes place. Consequently, the normal faculty teaching load is 9 units, which is entirely covered by the teaching of lectures and laboratories, since most other important activities, such as teaching large sections, teaching directed study or directed research, course and curriculum development, and some kinds of professional writing (e.g. authoring curricular materials) are institutionally expected, but are not given teaching-credit recognition.

The numbers mentioned above reflect a negotiation based on a 3-unit course default. As of only one year ago, USF has moved to a 4-unit course default (i.e. most of our courses are 4 unit courses). The non-divisibility of 9 by 4 was solved by the concept of cycles of 4 semesters: in 3 of the 4 semesters the teaching load is 2 courses, while in the remaining 4th semester the load is 3 courses. The often heavy burden of administrative responsibilities for a departmental chair is recognized with a teaching load cycle of two semesters with a sequence of 1:2 taught courses.

After time spent preparing for a lecture, which is nearly the same for any class size, the time devoted to grading, advising, and other necessary forms of faculty-student dialogue is directly proportional to the number of students in the class. Indeed, at USF we take pride in the one-on-one student-teacher interaction that takes place outside the classroom in all courses, even the very large ones. We believe that the workload computation formula should have an appropriate weighting factor. We recommend a factor of one and one-quarter for a class that exceeds 50 students, a factor of one and one-half for a class of 100 students, and so forth.

For the computation of faculty workloads, each contact hour in laboratory should count the same as one contact hour in the classroom. It has been a common practice for some administrators to use a weighting factor of less than one (e.g. one half or two thirds) in computing contact hours in laboratory instruction. This practice is in direct conflict with the recognized demands that are placed on an instructor in the supervision of extended laboratory sessions. From the instructor's point of view, the effort to sustain the expected level of student involvement throughout a full laboratory session warrants a weighting at least equal to the time spent in the lecture mode of instruction. Administrators who use a small weighting factor are in effect forcing physicists to deemphasize the laboratory aspect of the discipline, even though physics is a laboratory science. Unless laboratory contact time receives workload recognition equal to that accorded to lecture contact time, we face a continuing erosion in the quality and quantity of student laboratory experience.

9. Advising

As mentioned above, we take one-on-one student-faculty interaction very seriously, and as such advising is done with great care and consideration. This takes on a whole new dimension with Physics juniors and seniors, with whom we spend hours talking, particularly when they are planning their post-USF careers. We do not have general rules or guidelines, not even as to when and how a student can declare a major in Physics. Each individual case is considered separately and often implies many faculty discussions. We understand that this is possible only because we do not have very many students, but so far this course of action has served our students and ourselves well.

10. Faculty Development

The Administration encourages (and financially supports) faculty members to spend sabbatical leaves in activities that will promote professional growth with respect to personal teaching skills, technical competencies, and general breadth of intellectual perspectives and understanding. The USF Faculty Association current contract allows a sabbatical leave of one year at 3/4 pay, or a half-year at full pay. Professional growth demands professional interaction with peers. Faculty members are expected to attend and support professional association activities. Some funds for faculty development, including scholarly travel, research-related activities (excluding equipment), and teaching improvement, are available upon application and approval by the Arts and Sciences Faculty Development Committee.

11. Physics Colloquium Series

The Physics Colloquium Series follows a long-standing tradition of physics departments around the world: to provide an ongoing series of talks for the faculty and the students. Unlike highly specialized seminars, the physics colloquia are intended to cover a broad spectrum of physics topics at a reduced technical level. Moreover, because of the size of our department and the nature of our curricular offerings (only undergraduate), our invited speakers are given explicit instructions to make their talks accessible to as wide an audience as possible.

The Physics Colloquium Series was conceived in the Fall 1993 semester, as a result of discussions among the faculty about the need to expose our students to cutting-edge physics topics. Since its inception, Professor Camblong has organized it, aside for one year when he was on sabbatical leave and the organization fell on Professor Camperi. Professor Brown has recently joined the organizational effort.

The first six talks were offered in Spring 1994. Even though the first steps were exploratory, because of the obvious success of the Series, it was decided to maintain these efforts on an ongoing basis. Remarkably, by the end of this calendar year, we will have completed an entire decade of uninterrupted colloquia, with close to 140 talks.

After the initial exploratory years, we developed more stringent selection criteria for the talks. As a result we have reached a very satisfying balance: these talks are informative, with considerable introductory background, but they also retain as much physics content as possible. However, it is not expected that the average person in the audience would understand every fine detail; instead, the talks provide enough reference points to establish a good summary of a particular problem or field and to stimulate the attendees to continue their own exploration. The underlying rationale is that there is no substitute for the direct contact with eloquent scientists describing their current research. The experience is often enlightening and memorable.

In order to enhance the participation and active involvement of our undergraduates in this Series, an associated course, Physics Colloquium, was introduced in the Fall 2001 semester. In addition to their required attendance to the talks delivered by visiting scientists, this course provides a platform for the students to deliver their own seminars. These student seminars are only 10- to 15-minutes long and the chosen topics can be freely selected within the boundaries of physics.

Another interesting point in the history of the Series occurred around 1997, when we expanded our outreach efforts to local high schools. As a result, over the years, the Physics Department has mounted a systematic campaign to attract high-school students and teachers from the Bay Area. In a few cases, we have succeeded in gathering audiences of over one hundred people for some of the most enticing talks. However, this link has weakened in recent years and we are trying to determine ways to return to the previous level of participation.

Among the most outstanding speakers, we would like to mention the talks given by four recent Nobel laureates: Professor Martin Perl, 1995 Nobel Laureate in Physics (for his discovery of the tau lepton); Professor Richard Taylor, 1990 Nobel Laureate in Physics (for his discovery of the sub-structure within protons and neutrons, as indirect evidence for the existence of quarks); Professor Douglas Osheroff, 1996 Nobel Laureate in Physics (for his discovery of superfluidity in helium-3); Professor Eric Cornell, 2001 Nobel Laureate in Physics (for the achievement of Bose-Einstein condensation in dilute gases, near the absolute zero of temperature).

A select group of recent speakers also includes many other physicists and astronomers of the highest level of scientific achievement. A very short representative list includes Professor Alex Filippenko, one of the astrophysicists involved in the discovery of the "acceleration" in the expansion of the universe; Professor Geoffrey Marcy, the leading discoverer of planets orbiting other stars; Dr. Jill Tarter, one of the leading scientists of SETI (search for extraterrestrial intelligence); Professor Andrei Linde, one of the proponents of the inflationary model of the universe; Professor Raymond Chiao, well-known for his experiments and theories addressing the concept of faster-than-light propagation.

In short, the Physics Colloquia constitute an important series of events that give our department visibility within the university and in the Bay Area. Like few other events on campus, they elevate the academic level of discussion to the highest expressions of intellectual rigor and passionate inquiry known to humanity. Moreover, they provide our students with an overview of current physics research and with the opportunity to talk informally with a variety of scientists. Over the typical four-year period of their education, students can interact with 50 to 65 visiting scientists (with a typical offering of 7 to 8 talks per semester). These experiences are invaluable, and are critical for those students who are planning to attend graduate school and for their proper selection of future career plans.

12. Society of Physics Students and Sigma Pi Sigma

The presence of a student organization such as the Society of Physics Students (SPS) can make a difference in the quality of undergraduate education. Fortunately, our local SPS chapter has been quite active in the past few years, due to faculty encouragement and, most notably, the energy of a few very dedicated and charismatic students (particularly [Name Redacted] in 1996-2000 and [Name Redacted] after that).

13. Budget

13.1 Full-time faculty

If the Physics program is to be able to recruit and retain high-quality faculty members, their salaries must be competitive with those of other colleges and universities, as well as with other employers who might attract academics. This is an issue of central relevance for us in the San Francisco Bay Area, possibly one of the most expensive areas to live in the country. Incidentally, this issue has manifested itself repeatedly in recent years in every faculty search we have conducted.

As it was already mentioned, faculty salaries at USF are the result of a collective bargaining agreement between the USF Faculty Association and the University Administration. Base salaries, as well as yearly cost-of-living and other increases are governed by this agreement, which is a matter of public record and something that the present program review will not affect in the least. The current yearly full-time faculty budget for the Physics Department is $493,304.

13.2 Student salary pool

These funds are earmarked essentially for the hiring of student teaching and office assistants. This budget item amounts to $15,375 for the current academic year. The normal rates for student assistants are $9 per hour for undergraduate students and $12 for graduate students. Taking $9 as a better indicator of our typical situation (although we do hire graduate students from time to time), we are left with 1708 assistant hours for the whole year. As there are 30 weeks (15 per semester), this comes up to approximately 57 hours per week for the whole department. As a basis for comparison, this fall semester we are teaching 6 lower-division courses that require TAs. Combined, they have 12 laboratory sections, and serve approximately 270 students. In addition to hiring a student to help in our busy office, we need student assistants to teach some of the lab sections, grade all lab reports, grade all homework and other assignments, and conduct the four weekly astronomy observation nights. Simply counting our Astronomy and Intro Physics courses (with a combined enrollment of 161), we are already over the allotted hours for the current semester, which means that some creative thinking will have to take place in the Spring. We believe that the assigned budget is simply not adequate.

The vitality of our programs is enhanced of course by department-sponsored opportunities for undergraduate research participation. The departmental budget does not include any allowance for this. Student research is funded entirely by faculty grants and by special requests to the Faculty Development Fund.

13.3 Travel and entertainment

This is a very small item in the Physics budget that amounts to $675 for the current academic year. It is never used for faculty travel, as it would obviously not cover much. It has never been clear what it is exactly meant by “entertainment”. Consequently, the rather large number of needed and important expenditures that could be construed as belonging in this category has long been covered by the regular operational budget. Indeed, both the administration and us have always considered this to be just part of the operational budget.

As indicated earlier, faculty travel requests are directed to the College Faculty Development Committee. Although the awarding process has its own rules (for example, preference is given to new tenure-track faculty) we know of no recent instance in which a faculty member was denied a reasonable request. However, this favorable situation pertains only to the last few years, as the University has increased the total allowance for the Faculty Development Fund (once again, as a result of the collective bargaining agreement)

13.4 Library Funds

There is no specific line item in the Physics budget dedicated to the purchase of books and periodicals. Although there is not specific rule that prevents departments from purchasing such items, the existing budget would not permit it by any stretch of the imagination.

Gleeson Library personnel informed us that, within the overall Library budget, there used to exist a fixed amount earmarked for each academic department. However, given the serious financial troubles that USF has faced recently, this budget allocation has been all but eliminated. Indeed, we were told that every single purchase request is now reviewed individually, and a series of constraints must be satisfied for the actual purchase to go through.

13.5 Operational budget

Next to faculty salaries, this budget item is the most important in any science department, and is the hardest for which to establish guidelines. It amounts to $29,814 for the current academic year. Expenditures covered by this operational budget include the honoraria and travel expenses for colloquium speakers; the purchase and maintenance of laboratory equipment; the purchase of teaching materials and software; the purchase of all laboratory consumables, such as liquid nitrogen; photocopying and general office supplies (which is quite large in our department); etc…

One possibility for estimating equipment and repair needs is to use an equipment inventory. Ordinarily, an equipment budget is most appropriately related to present equipment value. The AAPT suggests that ten percent of the inventory value of existing instructional equipment be used for the acquisition of new instructional equipment and replacement of worn out or obsolete equipment each year, while five percent of instructional equipment inventory value should be allocated each year for repairs and supplies.

Unfortunately, our last comprehensive survey was conducted in 1992, when it was concluded that we possessed in the order of $270,000 in laboratory and demonstration equipment, not counting faculty research equipment. This amount is now larger due to the Fletcher-Jones grant, described elsewhere in this document.

Therefore, the AAPT suggestion would indicate that we should spend considerably more than our entire operational budget just on acquisition and maintenance of instructional equipment. This is clearly an impossible proposition.

At certain (albeit quite irregular) times, important infusions of funds outside of the regular budget have become available through the College of Arts and Sciences. However, it is difficult to develop a plan for spending these monies, because their availability is unpredictable.

We believe that our current operational budget is adequate for maintenance purposes, including the occasional small-scale purchase of equipment. However, we strongly caution that a thorough overhaul of teaching laboratory instruments is overdue.

14. Conclusions and Recommendations

We believe that this report illustrates the tremendous progress the Physics Department has made since the previous program review in March 1995. We have implemented most of the recommendations contained in the preliminary development plan from that review, namely:

- We increased the number of majors and minors and established a 3/2 physics/engineering program.
- We made the Department more visible, through the Physics Colloquium Series and in a variety of other ways.
- We strengthened the academic program at all levels, including a systematic revision and upgrade of upper-division experimental physics courses.
- We strengthened the faculty.
- We improved the laboratory and demonstration equipment.
- We greatly improved the departmental computing facilities.
- We improved the secretarial and technical assistance.

As a result, we now have a dynamic Physics Department, with a modern undergraduate curriculum and thriving research programs, and we have been able to more than double the number of students since 1995. However, in each of the areas described above we still need to make improvements. In addition, we are still confronted with difficult challenges, although some may be in areas over which we have little control, e.g. the nationwide paucity of Physics students and the lack of space at USF. On the basis of this analysis of the department, we would like to offer our conclusions and recommendations, in order of priority:

1. The most critical challenge we face is in increasing the number of majors. This starts at the Admissions Office. While we have been successful in attracting students to our major within USF, we are severely limited by the very small pool of students who come to USF with an interest in our discipline. We believe that this problem arises partly from the recruiting practices of USF, which are closer to those of regional institutions rather than those of national universities and colleges. The University has much to offer: a privileged location, a fine liberal arts curriculum, and an undergraduate physics program that is comparable to any in the nation. We propose that a concerted effort be made to recruit at the national level, targeting specific areas in the East Coast and in major urban locations throughout the nation. We believe that new recruitment practices would benefit not only the physics program, but also a number of other programs (for example Mathematics), and would enhance the overall academic standing of USF.

2. We believe that the creation of an Astronomy minor and the hiring of an astronomer/astrophysicist will greatly strengthen our program. First, a faculty search in this field might attract a candidate pool that would allow us to address the issue of gender diversity within the department faculty, something that has been nearly impossible to address given the applicant pools of our previous faculty searches. Second, the fields of Astronomy and Astrophysics are highly appealing to students and have the potential to attract new students to our program, generate an interest in science among non-physics majors, and enhance our course offerings and research opportunities in the field. It is important to note that although three faculty members have been hired since 1995, their positions were replacements not new hires (three faculty members having retired). The Physics Department has made real progress in terms of curriculum development and the effective use of faculty time but no new positions have been added over the past decade. We have made effective use of faculty time, deliver an efficient and interesting curriculum and, with the new replacement hires, have a more acceptable distribution of research expertise in theoretical, computational, and experimental physics. However, the Physics Department still needs strengthening in the areas of Astronomy/Astrophysics, where remarkable worldwide research and growth are currently taking place. Moreover, while our astronomy course has been advanced repeatedly as one of our best chances to increase significantly the number of student credit hours in the core curriculum, no other Astronomy classes can be regularly offered. This is a serious limitation, given the central role played by astronomy in contemporary physics - our students often inquire about additional curricular offerings in this area but we are unable to deliver extra classes with the current faculty.

3. The space problem at USF continues to be an acute one and we very much hope that the University will be able to find the resources to build new science facilities. In the meantime, we strongly suggest permanently reassigning room HR 133 to the Physics Department. We also suggest the conversion of under-utilized space into a dedicated electronics shop, where faculty, technicians, and students can repair and fabricate electronic circuits.

4. In addition to the hiring of one faculty member in the area of Astronomy/Astrophysics, we would like to suggest that a new position of “Laboratory Coordinator” be created. This would be highly beneficial to everyone. This would be a full-time appointment and the ideal candidate would have an advanced Physics degree, perhaps a Masters, and experience with laboratory work. The lab coordinator would work in close collaboration with physics faculty members and with the physics technician, and would be responsible for the coordination of all laboratory sections for all of our lower-division courses and the teaching of a significant fraction of these sections. In addition, this new position would involve the ongoing development and cataloging of laboratory exercises and lecture demonstrations and the improvement of existing labs.

5. One of the recommendations of the 1995 Program Review was that "it would be more efficient to have the technicians supervised by the departments they serve." As described in this Self-Study, significant progress has been made in this area, largely because of the gracious intervention of the Associate Dean for the Sciences. Unfortunately, the structural problem still remains, as the physics technician continues to report to the Manager of Technical Operations. With impending departure of the current Associate Dean for the Sciences, this is a formula that spells potential trouble. Given the current distribution of tasks among technicians, the workload of our physics technician, and the increased physics laboratory demands (in teaching and research), the implementation of the 1995 recommendation is long overdue.

6. A thorough and comprehensive overhaul of the lower-division laboratory equipment is long overdue. The recent infusion of state-of-the-art equipment into our laboratory facilities, acquired with funds from the Fletcher-Jones grant, has been as amazing as it was needed. The benefits of these improvements are already visible in upper-division laboratory courses and in our new Materials Physics program. However, the most of the lower-division laboratory equipment is now showing its age. There is always malfunctioning or broken equipment that is beyond the expert touch of our technical staff. This means that we have to take the pedagogically ill-advised step of increasing the number of students assigned to each laboratory station. Moreover, we would also like to create new laboratories for which we would need completely new equipment.

7. We would like to recommend that our classroom and laboratory facilities be given a cosmetic overhaul. This would begin with the replacement of all chalkboards by whiteboards and the replacement of the old chairs in HR 127.

8. We recommend that the two basic Physics journals to which we do not currently subscribe, *Journal of Physics* and *Physics Letters*, are finally included in our collections in Gleeson Library. We also believe that the library should subscribe to some of the remarkable online services available today, such as Web of Science and the Science Citation Index.

Appendices (data is provided since previous program review)

APPENDIX A:
Faculty Grantmanship

Gene Benton

- ✓ *Lily-Drake Endowment.* A continuing grant for research on "Energetic Charged Particle Treatment of Cancer".

Brandon Brown

- ✓ *National Science Foundation.* Major Research Instrumentation grant, Division of Chemistry. Co-PI with PI Margerum and co-PI Curtis (USF Chemistry). $40,000 (2002-present).
- ✓ *Fletcher Jones Foundation.* Departmental grant for the "Materials Physics" initiative. Lead author. $790,000 (2000-present).
- ✓ *National Science Foundation.* Course Curriculum and Laboratory Improvement grant, Division of Undergraduate Education. $80,000 (2001-2003).

Horacio Camblong

- *National Science Foundation.* "Collaborative Research: Renormalization, Path Integrals, and Applications of Conformal Quantum Mechanics, Singular Potentials, and Quantum Field Theory" PI, with PI Carlos R. Ordoñez (University of Houston). $50,000 (2003-2006);

Carl Naegele

- Raised $750,000 from corporations, private and public foundations, including NSF, to fund the USF Science Teacher Institute, 1993-1998.

APPENDIX B
Faculty in the News

Gene Benton

- Professor Benton was recently interviewed by several radio stations and newspapers in relation with the Space Shuttle disaster. He is quoted from time to time on print articles about radiation in space and the American and other space programs.

Brandon Brown

- *National Public Radio.* Interviewed on "All Things Considered," concerning our research (2003).
- *BBC radio.* Interviewed on "Science in Action," concerning our research (2003).
- *Alaska Public Radio.* Interviewed on "Fishing Report," concerning our research (2003).
- *Duetschlandfunk (German Public Radio).* Interviewed by Dagmar Röhrlich, concerning our research (2003).
- *California Academy of Sciences.* Temporary public museum exhibit devoted to our research work (2003).
- *New York Times, Scientific American, Boston Globe, Financial Times, Chemical and Engineering News, Science News, Xinhua News Agency (China), Agence France-Presse (Paris), Financial Times, et alia.* Various periodicals and news wires ran short pieces, some carrying photos and quotations, concerning a biophysics discovery made in our research laboratory at USF. (early February, 2003).
- *News Day.* Feature article concerning our investigation of gel collected from sharks, including photos and quotations. (July 16, 2002).
- *Science Update.* Interviewed for the national radio program of the American Association for the Advancement of Science. (June, 2002).

Horacio Camblong

- The work "Quantum Anomaly in Molecular Physics," has been featured prominently by the American Institute of Physics and the American Physical Society. Physics News Update # 568, Dec 7, 2001.

APPENDIX C
Other Physics Related Activity and Honors

Gene Benton

- Editor-in-Chief *Radiation Measurements*, Pergamon press (1989-present)
- *Space Technology*, Editorial Advisory Board (1990-present)
- COSPAR (Committee on Space Research): ISC F Sub-Commission F.2 on Radiation Biology (1985 to present)
- NCRP (National Council on Radiation Protection and Measurements): Adviser to Scientific Committee 75, Guidance on Radiation Received in Space Activities (1984 to present).
- NASA Material Science/ Radiation Advisory Group (1998 to present).
- DOE-NEER program proposal review panel.
- King Fahd University, Saudi Arabia, member of rank and tenure committee.

Brandon Brown

- Referee for *Journal of Animal Biology, Journal of Comparative Physiology, Physica C, and Physical Review B.*
- *American Physical Society's Division of Biological Physics.* Nominated for an at-large seat on the Executive Committee for the division (2002).
- Grant Review Panelist: National Science Foundation, Washington DC. Served on a grant review panel for Physics proposals to the Division of Undergraduate Education (July, 2002).
- Grant Review Panelist: National Science Foundation, Washington DC. Served on a grant review panel for Physics proposals to the Division of Undergraduate Education (July, 2001).
- Grant Referee: Refereed for the National Science Foundation's Division of Condensed Matter Physics (1999).

Horacio Camblong

- Referee for *Physical Review Letters* and *Physical Review*.
- University of Houston, Visiting Assistant Professor of Physics (Fall 1999–Spring 2000) and Adjunct Professor of Physics (since Spring 2003)
- Universidad Nacional de La Plata, Argentina, Visiting Research Scientist (annual visits since year 2000)
- USF Distinguished Research Award, University of San Francisco, academic year 2001-2002.
- Arthur Furst Award for Outstanding Research Advancing Science for the Betterment of Humanity, University of San Francisco, College of Arts and Sciences, April 2001.
- (USF) College (of Arts and Sciences) Service Award, University of San Francisco, College of Arts and Sciences, Spring 1998.

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- Referee for *Journal of Computational Neuroscience*
- Visiting Scientist, Santa Fe Institute, Summers 2001 and 2002.
- Visiting Scientist, Center for BioDynamics, Boston University (Spring 2001)

APPENDIX D
Peer-Reviewed Publications

"Sensing Temperature without Ion Channels." **B. R. Brown**, *Nature* 421, 495 (2003).

"Extracellular signal fluctuations in shark electrosensors," **B. R. Brown**. M.E. Hughes, J. C. Hutchison, in *Fluctuations and Noise in Biological, Biophysical, and Biomedical Systems.* SPIE Series, Volume 5110, Bellingham, WA, (2003).

"Programmable sub-kHz Diode Laser Stabilization at 1523 nm Using Persistent Spectral Holeburning," **T. Böttger**, G.J. Pryde and R.L. Cone, *Optics Letters* **28**, 200 (2003).

"Material Optimization of Er^{3+}:Y_2SiO_5 at 1.5 μm for optical processing, memory, and laser frequency stabilization applications," **Thomas Böttger**, Yongchen Sun, Charles W. Thiel, and Rufus L. Cone, Proceedings of SPIE Vol. 4988 *Advanced Optical Data Storage*, edited by Hans J. Coufal, Alan E. Craig, Zameer U. Hasan (SPIE, Bellingham, WA, 2003 pp.51-61)

"Path Integral Treatment of Singular Problems and Bound States," **H. E. Camblong** and C. R. Ordonez, to appear in *International Journal of Modern Physics A* (2003)

"Anomaly in Conformal Quantum Mechanics: From Molecular Physics to Black Holes," **H. E. Camblong** and C. R. Ordonez, to appear in *Physical Review D* (2003)

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APPENDIX E
Other Publications

"Radiation on the MIR Space Station," **Benton, E.V.**, Benton, E.R. (2002), *Radiation Measurements* 35 (5).

"Prediction and Measurements of Secondary Neutrons in Space," **Benton E.V.**, Badhwar, G.D. (2001) *Radiation Measurements* 33 (3).

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"A Theory for Stretchiness," **Brandon Brown**, *Physical Review Focus*, (September 7, 2000).

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"Cooking with Qubits", (feature article detailing the latest advances in quantum information processing), **Brandon Brown**, *New Scientist*, pp 38-41. (August 28, 1999).

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APPENDIX F
Work Submitted or In Preparation

"Thermoelectricity in a Polymer Hydrogel." **B. R. Brown**, M. E. Hughes, and C. Russo, submitted to *Physical Review Letters.*

"Hydrogels in the electric sense viewed with electrical impedance spectroscopy." **B. R. Brown**, M. E. Hughes, and C. Russo.

"Magnetic Field, Temperature, and Concentration Dependence of Spectral Diffusion in Er^{3+}:Y_2SiO_5 at 1.5 μm," **T. Böttger**, C. W. Thiel, Y. Sun , R. L. Cone,

"Coherent Spectroscopy and Optimization of Er^{3+}:Y_2SiO_5 at 1536 nm for Spectral Hole Burning Applications," **T. Böttger**, Y. Sun , C. W. Thiel, R. L. Cone.

"Numerical studies of laser stabilization to spectral holes," G.J. Pryde, **T. Böttger**, C. W. Thiel and R.L. Cone.

"Photon Echo Characterization in the Electro-Optic Material Er^{3+}:KTP at 1.5 μm," G. Reinemer, **T. Böttger,** Y. Sun, and R. L. Cone.

"Renormalization in Conformal Quantum Mechanics," **H. E. Camblong** and C. R. Ordonez [e-print archive: hep-th/0305035].

"Black Hole Entropy from Near-Horizon Conformal Quantum Mechanics", **H. E. Camblong** and C. R. Ordonez.

"Absorption in Conformal Quantum Mechanics," **H. E. Camblong**, L. N. Epele, H. Fanchiotti, C. A. Garcia Canal, and C. R. Ordonez.

"Comparative Analysis of Self-Adjoint Extensions and Renormalization for Singular Systems," **H. E. Camblong**, L. N. Epele, H. Fanchiotti, C. A. Garcia Canal, and C. R. Ordonez.

"Hawking Radiation from Near-Horizon Conformal Invariance," C. P. Burgess, **H. E. Camblong**, and C. R. Ordonez.
"Singular Potentials and the Randall-Sundrum Mechanism," **H. E. Camblong** and C. R. Ordonez.

"Causal Synchrony in Networks", C. Shalizi, K. Klinkner, and **M. Camperi**, submitted to *Physical Review E.*

"Measuring Synchrony in Neuronal Networks with Mutual Information", **M. Camperi**, K. Klinkner, and C. Shalizi.

APPENDIX G
Talks and Conference Presentations

We provide only statistics here. Details can be found in the individual faculty members' vitas. Since the previous program review, members of the Physics department at USF have given over:

39 invited talks or colloquia (including some in France, Italy, Japan, and Germany, besides the US)
29 invited conference presentations.
68 contributed conference presentations.

Appendix H
Course Development

Brandon Brown

Developed the *Materials Physics Track* (2002) (described above).

Developed the course:

0208□450. Advanced Materials.
Surveys modern advanced materials; emphasis on fundamental underlying principles; semiconductors; superconductors; photonic materials; liquid crystals; polymers.

Horacio Camblong

Developed the *3/2 Physics-Engineering Program* (1998) (described above)

Co-developed (with **Error! Contact not defined.**) the course:

0208□120. Astronomy: From the Earth to the Cosmos.
An exploration of the universe, from the Earth to the most distant galaxies, touching upon the fundamental scientific principles that explain the order that characterizes the cosmos. The course includes a number of foundational topics such as gravitation, light, and atomic structure, as well as the history of astronomy and its impact on the development of science and technology. The course is based on a conceptual approach, and it includes observation nights and field trips to the local Planetarium.

Error! Contact not defined.

Developed the new major programs under the thorough 3-unit to 4-unit model overhaul.

Developed the courses:

0208□130. Concepts in Physics.
A self-contained introduction to Physics for students who do not need the depth and rigor of courses for science majors. It includes a number of foundational topics, such as the laws of motion, the universal principles of conservation, gravitation, and the properties of matter, light and sound. The course is based on the conceptual approach, although it contains a mathematical component. Lecture sessions will also include a number of additional elements, such as hands-on demonstrations of physical phenomena, computer-simulated physical experiments and videos.

0208□135. Masterpiece Physics: On Science, Mathematics, and the Arts.
While their methods may differ radically, artists and scientists share the drive to investigate the ways in which disparate pieces of Nature fit together. This course will attempt to bridge those seemingly distinct worlds, using art, literature, and music to present physics and mathematics. Within a background of artistic masterpieces, we will explore sound, light, color, and how the brain perceives them. We'll dissect musical instruments, photographic cameras, and paintings. We will also learn to discern mathematical structures within pieces of artistic expression.

208□213. Introduction to Electromagnetism and Electronics.
This course is designed to meet the needs of the student whose major is Computer Science. Introduction to the physics of electricity and magnetism (including charge and current, electric and magnetic fields, and basic circuit theory) and digital electronics (including analog-digital converters, logical networks, flip-flops, shift registers, combinatorial logic, etc.).

0208□301. Computational Physics.

An introduction to the use of computer simulations in Physics. It builds upon the physical principles covered in General Physics, using computer models and numerical techniques (such as the Runge-Kutta, Gear, Crank-Nicholson, and Montecarlo methods, among others) to simulate physical situations. In addition, new topics such as chaos, fractals, and neural networks, and some elements of statistical physics (random walks and Ising model) are introduced. Moreover, the course covers the application of physical and computational techniques to the study of the most complex system in nature, the human brain. No previous familiarity with programming languages is assumed. The aims of the course also include learning the C, OpenGL, and Mathematica programming languages.

0208-380. Foundations of Computational Neuroscience.
An introduction to the physical, mathematical, and computational concepts and techniques used to formulate biophysical models of neurons and synaptic transmissions to study the brain and neural systems. Simple biological systems, such as population growth and predator-prey models, are used to introduce dynamical systems. This is followed by a physiological description of the neuron, including its biophysical and electrical properties. Each topic covered includes a physiological introduction, physical-mathematical analysis, and computer modeling. Topics include ion movement through cell membranes, single-neuron models, generation of action potentials, synapses and neurotransmitters, neuronal networks, and learning and memory. Software simulation platforms are used both in lectures and in laboratories. The course does not assume previous physics, biology, or programming experience.

Co-developed (with Horacio Camblong) the course:

0208-120. Astronomy: From the Earth to the Cosmos.

Carl Naegele

Professor Naegele developed the service course program for the Computer Science Department in the early 1990's, and has served as its coordinator since then. He played a major role in developing and updating nearly all of the courses that are currently offered. These courses include (all one-unit courses):

Creating Images: Photoshop I, II, and III.
Word Processing.
Desktop Publishing I and II.
Spreadsheet Analysis: Introductory, Intermediate, and Advanced.
Introduction to Database Software.
Designing and Using Relational Databases
Structured Query Language and Database Programming.
Internet: Searching and Researching the Web.
Internet: Web Site Design.
Internet: Advanced Web Site Design
Creating Presentations with Power Point I and II
Creating Animated Interfaces with Flash

APPENDIX I
List of Departmental Colloquia

Fall 2003

"The Heart in Chaos"
Dr. Mark Spano
Carderock Laboratory
US Navy
Thursday, October 2nd, 4:00-5:00 PM, Harney 127

"Defending Earth Against Asteroids: How Astronomers are Saving the World"
Dr. David Morrison
NASA Astrobiology Institute
NASA Ames Research Center
Thursday, October 9th, 4:00-5:00 PM, Harney 127

"Radio Pulsars: Exploring Nuclear and Particle Physics with a Telescope"
Professor Stephen Thorsett
Department of Astronomy & Astrophysics
University of California, Santa Cruz
Thursday, October 16th, 4:00-5:00 PM, Harney 127

"Upcoming Tests of Relativity on the International Space Station"
Dr. Joel Nissen
Department of Physics
Stanford University
Thursday, November 6th, 4:00-5:00 PM, Harney 127

"Are Black Hole Candidates Actually Black Holes?"
Professor Elliott Bloom
SLAC
Stanford University
Thursday, November 13th, 4:00-5:00 PM, Harney 127

"Stellar Magnetic Activity: Causes and Consequences"
Dr. Carolus J. Schrijver
Lockheed Martin Advanced Technology Center
Thursday, November 20th, 4:00-5:00 PM, Harney 127

"Mesoscopic Magnetic Imaging"
Professor Kathryn Moler
Department of Applied Physics
Stanford University
Thursday, December 4th, 4:00-5:00 PM, Harney 127

Spring 2003

"Diluted Magnetic Semiconductors Based on the Layered A2VB3VI Compounds"
Dr. Jeffrey Dyck
University of Michigan
Thursday, February 6th , 4:00-5:00 PM, Harney 127

"Diode Lasers Stabilized to Spectral Holes and Material Optimization of R3+:Y2sio5 at 1.5 mM"
Dr. Thomas Bottger
Montana State University
Thursday, February 13th , 4:00-5:00 PM, Harney 127

"Burning Holes in an Atomic Spectrum with a Laser to Search for Extraterrestrials or Store a Library on a Single CD"
Dr. Todd Harris
IBM Almaden Research Center
Thursday, February 18th*, 4:00-5:00 PM, Harney 127
(exceptional date: Tuesday)

"Using Strong Interactions Between Atoms and Light to Compute"
Professor Dan Stamper-Kurn
University of California at Berkeley
Thursday February 27, 12:00-1:00 PM, Harney 235
Jointly sponsored with the Computer Science Lecture Series
NOTE: **exceptional time: 12 noon to 1:00 PM**

"Evidence from Type Ia Supernovae for an Accelerating Universe and Dark Energy"
Dr. Alexei Filippenko
University of California at Berkeley
Thursday, March 13th, 4:00-5:00 PM, Harney 127

"Probing the Sun's Interior by Helioseismology"
Dr. Alexander Kosovichev
Stanford University
Thursday, March 27th, 4:00-5:00 PM, Harney 127

"Imaging Molecules and Chemical Reactions on Surfaces by Scanning Tunneling Microscopy"
Dr. Shirley Chiang
University of California at Davis
Thursday, April 3rd, 4:00-5:00 PM, Harney 127