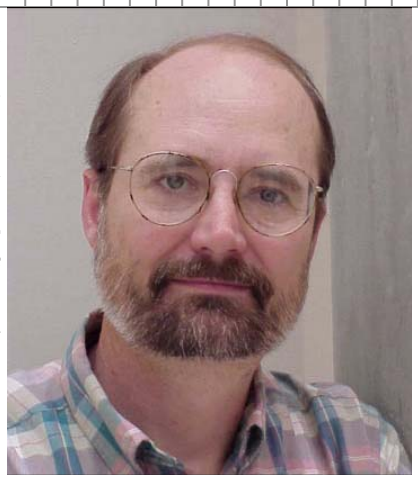
Applied Physics
Message From the Department Head



The Colorado School of Mines (CSM) is fortunate in many ways. It is located along the beautiful Front Range of the Rocky Mountains near Denver, an area of intense activity among high-technology industries and government Research laboratories. Although CSM itself is small, the concentration of programs involving minerals, energy, and materials and the proximity of so much other work in these fields provides the excitement and ambiance of much larger institutions.

The Physics Department at CSM is a very active place. In addition to the faculty and about 40 graduate students, the department is home to more than 270 undergraduates majoring in Engineering Physics, making it one of the largest undergraduate physics programs in the country. There is exciting experimental and theoretical research underway particularly in the areas of solid-state physics, solar energy, nuclear physics, and applied optics. Research activities are supported by about two million dollars per year of external funding.

CSM and the Physics Department are small enough to give personal attention to each student. There is also an impressive level of interdepartmental activity, both in research and instruction. The Physics Department has ongoing collaborations with the Departments of Metallurgical and Materials Engineering, Chemistry and Geochemistry, Chemical Engineering, GeoPhysics, and the Division of Engineering among others. We participate with several departments in the interdisciplinary Materials Science graduate program, the senior design program, the Honors program in Public Affairs, and similar educational endeavors.

In this brochure you will find an explanation of our programs, general information about CSM and some of the special centers and institutes that may interest you. We hope that you will get a sense of our enterprise and excitement and that you will seriously consider joining us.

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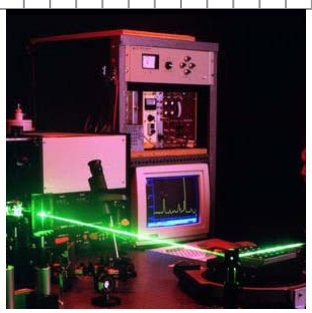

The Physics Department at CSM offers a full program of instruction and research leading to the MS and PhD in applied physics. The department is housed in Meyer Hall, but has now expanded its operations to the Center for Learning Media and Technology which houses the Studio Physics introductory course and the General Research Building. which houses two of the most powerful ultrafast lasers in the world. The department also works closely with the nearby National Renewable Energy Laboratory through a joint research agreement.

Graduate students are given a solid background in the fundamentals of classical and modern physics at an advanced level and are encouraged early in their studies to learn about the research interests of the faculty so that a thesis topic can be identified. It is through the one-on-one student/professor interaction that professional skills are honed. By the time they graduate, it is common for students to have published articles on the intermediate results of their research and to have presented their work at national meetings.

The atmosphere in the Department is one of intellectual challenge and stimulation. The weekly Physics Colloquium brings in experts from outside CSM to describe their research and to interact with people in the Department. Special seminars are also held on a regular basis.

The graduate students in the Physics Department form a cohesive group. Mutual support and cooperation among the students helps each person to feel at ease. This feeling is amplified through interactions with the faculty. The physics faculty members at CSM have been attracted from the top universities and research institutions; their reputations, internationally as well as nationally, are based on contributions to physics research and education.

Research

Applied Optics, Nuclear Physics, and Condensed Matter Physics are major focus areas for the Physics Research Program. A wide range of research projects is being actively pursued within each area and there is a great deal of collaboration between these groups. Current fields of research include:

Applied Optics: Lasers, ultrafast optics and x-ray generation, spectroscopy, near-field and multiphoton microscopy, non-linear optics, quasi-optics and millimeter waves.

Ultrasonics: laser ultrasonics, resonant ultrasound spectroscopy, wave propagation in random media.

Nuclear: Low energy reactions, nuclear astrophysics, fusion plasma diagnostics.

Electronic Materials: Photovoltaics, nanostructures and quantum dots, thin film semiconductors, transparent conductors, amorphous materials, magnetic materials.

Solid State: x-ray diffraction, Raman spectroscopy, electron microscopy, self assembled systems.

Surface and Interfaces: x-ray photoelectron spectroscopy, Auger spectroscopy, scanning probe microscopies, second harmonic generation.

Theory: nuclear, condensed matter, atomic, molecular and optical theory, nonlinear dynamics, quantum and wave chaos, many body, and ultracold atoms.

Physics faculty are also active in several interdisciplinary research centers.

Center for Solar and Electronic Materials -- The Center's largest research activity is directed at the photovoltaic industry. It also supports research in thin film materials, polymeric devices, electrophotography, encapsulants, electronic materials processing, and systems issues associated with electronic materials and devices.

Center for Space Resources -- a NASA/Industry/ University space commercialization center based at CSM. The mission of the Center is to assist industry in developing commercial products by conducting combustion research which takes advantage of the unique properties of space. Examples of current research include projects such as Combustion Synthesis of Glass-Ceramics and Optical Fiber Processing, and Combustion Synthesis of Porous Ceramics for Bone Replacement and Other Applications.

Advanced Coating and Surface Engineering Laboratory a multidisciplinary laboratory that serves as a focal point for industry-driven research and education in advanced thin films and coating systems, surface engineering, tribology, electronic, optical and magnetic materials.

Facilities

The applied physics research programs at CSM are supported by high-performance equipment and instrumentation. All of the professors engaged in experimental physics maintain laboratories in which their groups develop and exploit front-line techniques in the perf-ormance of their research. Research is also conducted at national facilities such as the National Renewable Energy Laboratory, NIST's Cold Neutron Research Facility, Oak Ridge National Laboratory, and Triangle Universities Nuclear Laboratory. Graduate students have the opportunity to travel to these locations and to interact with international communities of physicists.

Applied Physics

Degree Programs

The Physics Department offers both the *Master of Science* and *Doctor of Philosophy* degrees in *Applied Physics.* The program of study is selected by the student, in consultation with an advisor, according to the student's career needs and interests. Core courses are required of all candidates for graduate degrees; however, there is considerable room for flexibility, especially at the PhD level.

The *Master of Science* (MS) degree requires a minimum of 20 semester hours of course work in an approved program plus 16 semester hours of research credit, with a satisfactory thesis. Fifteen semester hours of coursework plus thesis must be taken in residence. There is no comprehensive examination for the MS degree.

The curriculum for the MS in Applied Physics is as follows:

Core Courses:
- PHGN 511 - Mathematical Physics I
- PHGN 520 - Quantum Mechanics I

One additional course from:
- PHGN 505 - Classical Mechanics I
- PHGN 507 - Electromagnetic Theory I
- PHGN 521 - Quantum Mechanics II
- PHGN 530 - Statistical Mechanics

Electives - 9 hours
Graduate Seminar - 2 hours
Master's Thesis

The *Doctor of Philosophy* (PhD) degree must complete 34 semester hours of course work plus 38 semester hours of research credit, with a satisfactory thesis. Twelve semester hours of coursework will be in an approved minor area. Minor programs focus in areas offered by other CSM Departments or may include the following specialty programs:

Optical Science and Engineering
Photovoltaics and Electronic Materials
Nuclear Physics and Astrophysics

The curriculum for the PhD in Applied Physics is as follows:

Core Courses:
- PHGN 505 - Classical Mechanics I
- PHGN 507 - Electromagnetic Theory I
- PHGN 511 - Mathematical Physics I
- PHGN 520 - Quantum Mechanics I
- PHGN 521 - Quantum Mechanics II
- PHGN 530 - Statistical Mechanics

Minor Program - 12 credits
Doctoral Thesis

Students must receive a grade of B or better in all core courses. Students not achieving the standard must pass oral examinations covering the areas of weakness identified in the core courses or retake the respective course with a grade of B or better within one year.

Further details on the Department's programs and degree requirements can be found online on the Physics homepage: http://www.mines.edu/Academic/physics

Admission/Entrance Requirements

The graduate program in Applied Physics is open to graduates from four-year programs at accredited colleges or universities. Admission is competitive, based on an evaluation of undergraduate performance, standardized test scores, and references. The undergraduate course of study of each applicant is evaluated according to the requirements of the Physics Department.

The completed application must contain two official transcripts of all previous college work, three letters of recommendation, Graduate Record Examination (GRE) results, financial affidavit (international students), and any supporting materials that the applicant wishes to provide. International students whose native language is not English must submit scores from an English proficiency examination (TOEFL or IELTS). For students applying for financial assistance, the Department requires scores from the GRE subject test in physics.

For more information, see Graduate Admissions Requirements http://www.mines.edu/Admiss/grad/grad_admissions.htm and the online application http://www.mines.edu/Admiss/grad/onlineapp.html

Financial Assistance

Full financial support is available for virtually all CSM physics graduate students. Beginning graduate students are normally supported on teaching assistantships. For students who have successfully completed one or more years of graduate study at CSM, a substantial number of graduate research assistantships are available on sponsored research projects. These provide academic-year stipends in addition to possible summer employment. Both teaching and research assistantships provide free tuition. For more information on federal student loans or other program outside of CSM, see http://www.mines.edu/Admin/fin_aid/

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Faculty in Applied Physics

James E. Bernard, Research Associate Professor. BS Case Western Reserve University; PhD University of Delaware. Computational solid-state physics; novel semiconductor materials and structures; semiconductor alloys; properties of surfaces and interfaces.

Lincoln Carr, Assistant Professor. BA, U.C. Berkeley; MS, PhD University of Washington. Research in theoretical many body quantum and classical mechanics in application to ultracold quantum gases: quantum phase transitions; atomic and molecular superfluidity and superconductivity; atom lasers; nonlinear waves; fractals, solitons and vortices.

F. Edward Cecil, Emeritus Professor. BS University of Maryland; MA, PhD Princeton University. Low-energy applied experimental nuclear physics; applications to fusion plasma diagnostics and primordial nucleosynthesis.

Mark Coffey, Research Professor. BS, University of Iowa; PhD New York University; PhD Iowa State University. Investigations of new application areas of quantum information science and the physical constraints and limits on computation. Investigations in mathematical physics including special function theory and inverse problems.

Reuben T. Collins, Professor. BA University of Northern Iowa; MS, PhD California Institute of Technology. Condensed matter physics semiconductor science; electronic and optical properties; photovoltaic materials and devices.

Charles G. Durfee, Assistant Professor. BS Yale University; PhD University of Maryland, College Park. Laser physics and ultrafast optical phenomena.

Thomas E. Furtak, Professor. BS University of Nebraska; PhD Iowa State University. Optical properties of surfaces, interfaces, and thin-fims; Raman scattering; ellipsometry; nonlinear optical methods; photovoltaic and electronic materials; liquid crystals and soft condensed matter.

Uwe Greife, Associate Professor. Diplom-Physiker Westfaelische Wilhelms-Universitaet Muenster, Germany; Dr. rer.nat. Ruhr-Universitaet Bochum, Germany. Nuclear astrophysics, low energy nuclear physics.

Robert Holub, Research Professor. BS, MS Charles University, Prague, Czech Republic; PhD McGill University, Canada. Radioactive aerosols and aerosols in soil air (geoaerosols).

Frank Kowalski, Professor. BS University of Puget Sound; PhD Stanford University. Laser physics; frequency shifted feedback lasers and applications of lasers to precision measurements.

James A. McNeil, Professor and Department Head. BS Lafayette College; MS, PhD University of Maryland. Theoretical nuclear physics; relativistic approaches to nucleon and nuclear structure and scattering.

Timothy R. Ohno, Associate Professor. BS University of Alberta; PhD University of Maryland at College Park. Surface physics; thin film epitaxial growth; interfacial properties; photovoltaic materials; catalysis.

Frederic Sarazin, Assistant Professor. PhD University of Caen (France). Low energy nuclear physics, nuclear structure and astrophysics.

John Scales, Professor. BS, University of Delaware; PhD University of Colorado. Application of optical and RF techniques to materials characterization. Wave propagation in random media; laser ultrasonics; millimeter wave and ultrasonic spectroscopy. Remote sensing with applications to landmine detection. Mesoscopic phenomena, including quantum chaos, amorphous materials and nonequilibrium statistical mechanics.

Jeff Squier, Professor. BS, MS Colorado School of Mines; PhD University of Rochester. Development of novel ultrafast laser sources; application of the lasers to nonlinear microscopy and micromachining; development of high contrast, ultra-high intensity (>10 20 W/cm 2) lasers with application to ultrafast x-ray diffraction and absorption and high-field physics.

P. Craig Taylor, Professor. AB Carleton College; PhD Brown University. Optical, electronic and structural properties of crystalline and amorphous semiconductors; localized electronic states in amorphous semiconductors; electronic instabilities in films of hydrogenated amorphous silicon and related alloys; electronic properties of III-V semiconducting nanostructures; ordering in ternary III-V alloys.

David M. Wood, Associate Professor. BA Princeton University; PhD Cornell University. Computational condensed-matter physics; new semiconductors; first principles phonon calculations.