OGI School of Science & Engineering

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2001 | 2002 ACADEMIC CALENDAR

FALL QUARTER 2001

August 6	Registration begins for fall quarter
September 20	Last day to register without late fees
September 21	New student orientation (Dept of Grad.Ed closed 1-5 p.m.)
September 24	Fall quarter instruction begins
November 12	Registration begins for winter quarter
November 22-23	Thanksgiving holiday (no classes, OGI offices closed)
December 3-7	Final exams
December 25	Christmas holiday (OGI offices closed)

WINTER QUARTER 2002

November 12	Registration begins for winter quarter
January 1	New Year's holiday (OGI offices closed)
January 3	Last day to register without late fees
January 7	Winter quarter instruction begins
January 21	Martin Luther King, Jr.'s Birthday (no classes, OGI offices closed)
February 11	Registration begins for spring quarter
February 18	Presidents' Day (no classes, OGI offices closed)
March 18-22	Final exams

SPRING QUARTER 2002

February 11	Registration begins for spring quarter
March 28	Last day to register without late fees
April 1	Spring quarter instruction begins
May 6	Registration begins for summer quarter
May 27	Memorial Day holiday (no classes, OGI offices closed)
June 10-14	Final exams
June 15	Commencement

SUMMER QUARTER 2002

May 6	Registration begins for summer quarter
June 20	Last day to register without late fees
June 24	Summer quarter instruction begins
July 4	Independence Day holiday (no classes, OGI offices closed)
September 2	Labor Day holiday (OGI offices closed)
September 3-6	Final exams

WELCOME

HISTORICAL BACKGROUND

The OGI School of Science & Engineering's roots go back to the early 1960s when Oregon Governor Mark Hatfield and an advisory committee of industrial and educational leaders recommended creating an independent institution for graduate education and research in the Portland metropolitan area. In 1963 they established the Oregon Graduate Center for Study and Research, which changed its name to Oregon Graduate Institute of Science and Technology in 1989.

By the 1990s OGI had emerged as a mature institution, and over the course of the decade it awarded more than 1,000 graduate degrees, offered hundreds of continuing education classes and workshops, and pursued more than $100 million in largely federally funded research. Then, in July 2001, laying the groundwork for the next phase of the institution's growth, OGI merged with Oregon Health & Science University, becoming OHSU's fourth school alongside the Schools of Dentistry, Medicine and Nursing.

The merger was particularly timely because of the growing need for collaboration between the health sciences, the information sciences and the environmental sciences. The resulting benefits will include the design of new medical instrumentation, the development of bioinformatics databases, a better understanding of the relationship between the environment and human health, and the cross-fertilization that takes place whenever interdisciplinary investigations occur. The merger is also helping OGI expand its programs in computer science, computer engineering and environmental science.

A LETTER FROM THE DEAN

The OGI School of Science & Engineering at Oregon Health & Science University is one of the most innovative, exciting and productive schools of its size anywhere in the world.

Indeed the school's modest size has long been one of its attractions. Students have close access, for instance, to top-notch faculty in both the classroom and the research lab, plus we pride ourselves on our flexibility in meeting students' academic needs. And our recent merger with OHSU further raises our stature as one component of a highly regarded institution that shares our dedication to education and research.

We have long been extremely successful in competing for limited research funding. A wide variety of public- and private-sector funding organizations believe in us so firmly, in fact, that they support nearly $20 million in research annually at OGI. Students can thus be assured that OGI faculty are providing instruction grounded on leading-edge research in their discipline. Such research-informed education has always been the cornerstone of our approach to graduate education in disciplines such as computer science, environmental science, electrical engineering and molecular biology. And our merger with OHSU will bring added growth in those disciplines as well as more interdisciplinary activities, including a major new initiative in biomedical engineering.

OGI's close relationship with the high-tech industry is also very important. Many of our part-time students, for instance, are full-time employees of companies both large and small. As a result, these students acquire pragmatic knowledge and skills that will enhance their careers, plus our full-time students establish valuable contacts within industry. And classroom interactions benefit from a healthy measure of real-world experience.

Classroom and research interactions are further enhanced by the diverse backgrounds of our faculty and students, who represent a cross section of cultures and sub-disciplines.

All of which taken together helps explain why our alumni find great success in a variety of career paths — whether their inclinations lead them toward academia, entrepreneurship or advancement with established companies. We pride ourselves on their achievements.

MISSION

The mission of the OGI School of Science & Engineering is to provide outstanding graduate and professional education and conduct internationally acclaimed research in science and engineering to meet regional and national needs.

TO ACCOMPLISH THIS MISSION, THE SCHOOL:

- provides students with the necessary knowledge, skills and breadth for leadership in a technological society;
- supports, through research, education and training, the people, industries and organizations that drive the economic growth of the Pacific Northwest;
- attracts and develops high-quality faculty, students and staff.

EQUAL OPPORTUNITY

The OGI School of Science & Engineering at Oregon Health & Science University is committed to providing equal opportunity and access to all school facilities and academic programs to everyone without regard to race, color, religion, gender, national origin, age, sexual orientation, disability or veteran's status.

ABOUT THIS CATALOG

This catalog is as accurate as possible as of Oct. 1, 2001. Information contained in the catalog may be changed during the course of any academic year, including but not limited to changes in policies, fees, course offerings and requirements. This document should not be construed as forming the basis of a contract.

OVERVIEW

ACADEMIC DEPARTMENTS

The OGI School of Science & Engineering has five academic departments: Biochemistry and Molecular Biology (BMB), Computer Science and Engineering (CSE), Electrical and Computer Engineering (ECE), Environmental Science and Engineering (ESE), and Management in Science and Technology (MST). Research and educational interaction among these departments is ensured in part by research programs that utilize faculty members from multiple departments. This encourages the exchange of ideas between persons working in related research areas and enables the fullest use of the wide range of instrumentation available at the School.

DEGREE PROGRAMS

The OGI School of Science & Engineering offers Master of Science degrees and Ph.D. degrees in Biochemistry and Molecular Biology, Computer Science and Engineering, Electrical Engineering, and Environmental Science and Engineering. The school offers Master of Science degrees in Management in Science and Technology and in Computational Finance. OGI also offers a professional degree, the Oregon Master of Software Engineering.

CERTIFICATE PROGRAMS

Three certificate programs are offered in Applied Computing, Computational Finance, and Management in Science and Technology.

STUDENTS NOT SEEKING DEGREES

Any qualified student may take courses at OGI in a part-time capacity without enrolling in a degree program. Students may take a full-time course load for only one quarter while waiting for a decision regarding admission to a degree program. Up to 21 credits taken at OGI prior to matriculation (enrollment in a degree program) may be accepted toward degree requirements. Individual departments' regulations may be more restrictive.

COLLABORATIVE/JOINT PROGRAMS

Full-time students in the school's Computer Science and Engineering (CSE) and Electrical and Computer Engineering (ECE) departments may take certain courses at Portland State University at no additional cost. Similar arrangements are being explored for other OGI departments. Contact the Department of Graduate Education for details.

The OGI School also participates in the Oregon Master of Software Engineering (OMSE) program, a joint program with Portland State University, Oregon State University and the University of Oregon. Students apply for this master's degree through one of the participating schools. Please direct inquiries to (503) 725-2900 or lytler@omse.org.

ACCREDITATION

Oregon Health & Science University is accredited by the Commission on Colleges of the Northwest Association of Schools and Colleges, an institutional accrediting body recognized by the Council for Higher Education Accreditation and the U.S. Department of Education. The commission's address is 11130 NE 33rd Place, Suite 120, Bellevue, WA 98004.

ADMISSIONS PROCEDURES

Printed application forms are available from the school's Department of Graduate Education. Completed applications, transcripts and other application materials should be sent to:

Department of Graduate Education
OGI School of Science & Engineering
20000 NW Walker Road
Beaverton, OR 97006-8921
Phone: (503) 748-1027
Toll-free: (800) 685-2423
Fax: (503) 748-1285
E-mail: admissions@admin.ogi.edu

You may also apply for admission on-line at www.ogi.edu/forms/application.html

Students may become matriculated (enrolled in a degree program) only after completing the requirements for a bachelor's degree or its equivalent, although students may be provisionally admitted prior to that time.

DEGREE PROGRAMS

The following items must be submitted:

- Complete OGI School of Science & Engineering application form or Oregon Master of Software Engineering (OMSE) degree program application form, if applicable.
- $50 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.
- Official transcripts from each college or university attended.
- Three letters of recommendation.
- Official GRE scores.

The GRE general test is required for M.S. applicants in Computational Finance (GMAT could be substituted); Computer Science and Engineering; Environmental Science and Engineering; Environmental Systems Management, and the Oregon Master of Software Engineering.

The GRE general test is required for PhD applicants in Biochemistry and Molecular Biology (subject test is also required); Computer Science and Engineering; Electrical and Computer Engineering, and Environmental Science and Engineering.

Applications may be submitted as early as one year before the proposed date of enrollment.

Applications received by March 1 (Feb. 15 for the Environmental Science and Engineering Department) will receive priority review for admission and financial support.

CERTIFICATE PROGRAMS

The following items must be submitted:

- Completed OGI certificate program application form.
- $20 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.

ADDITIONAL REQUIREMENTS FOR INTERNATIONAL STUDENTS

To be considered for admission to OGI for a full course of study, international students must also provide documents to show that they meet the requirements described below.

- Evidence of adequate financial resources to pay for their OGI education and their cost of living.
- Written TOEFL scores are required of all M.S. and Ph.D. applicants whose native language is not English. Students who have earned a degree in the United States are exempt from this requirement. Minimum required TOEFL scores vary by department: BMB 550; CSE 600; ECE 575; ESE 600; MST 625. The minimum desired TOEFL score for admission is 575, but a lower score may be offset by excellent GRE scores.

  Please note: the minimum TOEFL scores above are for the paper-based test only. The computer-based TOEFL uses a different score scale. For more information on the computer-based score scale, please visit www.toefl.org.

TUITION AND FINANCES

TUITION

For the 2001-2002 academic year, tuition for full-time matriculated students (defined as 9 or more credit hours per quarter) is $4,905 per quarter. Part-time tuition for regular OGI School of Science & Engineering courses is $545 per credit hour or audit unit. Please note that there is no full-time tuition rate for non-matriculated students, except when an admission decision is pending. There are no student fees.

- Tuition for Computational Finance core courses is $695 per credit hour or audit unit. Students matriculated in the Computational Finance degree pay only for credits required to fulfill degree requirements. Credits taken during the 12-month program beyond the 45 required to fulfill degree requirements will not incur charges (up to a limit of 54 credits). Full-time quarterly tuition for students not matriculated in the Computational Finance program who take one Computational Finance course is $5,355; with two Computational Finance courses it is $5,805. Full-time Ph.D students do not incur additional cost for registering for Computational Finance courses.
- ESE students pay tuition on an annual basis. That tuition may be paid in full at the beginning of the year or in quarterly installments.
- Courses in the Oregon Master of Software Engineering program are $495 per credit hour. Full-time matriculated students may register for OMSE courses when paying full-time tuition.

Note: Payment or arrangement for deferred payment for all courses must be made before your place in a class is confirmed. The school offers students the option of deferring most of the payment through no-interest promissory notes. Students who are reimbursed for their courses must make payment arrangements with their employer, but those students still incur financial responsibility for courses. Courses sponsored by the Oregon Center for Advanced Technological Education (OCATE), whether taken for credit or audit, must be paid in full at the time of registration.

FINANCIAL AID

Entering full-time Ph.D. students can obtain financial support though a combination of tuition scholarships, OGI fellowships, named fellowships, graduate research assistantships and (for U.S. citizens only) low-interest student loans. Part-time Ph.D. students may be eligible for some of the above. Partial-tuition scholarships may be awarded to entering full-time M.S. students, and full- and part-time M.S. students who are U.S. citizens may apply for low-interest student loans.

Fellowships, scholarships and assistantships are awarded by individual departments.

Title IV Federal Student Loan programs are administered through the OHSU Financial Aid office. These loans are available to U.S. citizens and eligible non-citizens. For application materials and additional information, contact Cherie Honnell, Director of Financial Aid & Registrar, at (503) 494-5117 or honnellc@ohsu.edu. Applications for federal student loans (FAFSA) are available from OGI's Department of Graduate Education, or www.ogi.edu/students/fin.html.

ACADEMIC POLICIES

The following is a summary of select OGI School of Science & Engineering academic policies. A more comprehensive listing can be found in the school's Student Handbook at www.ogi.edu/students/studenthandbook.pdf.

ON SITE (RESIDENCY) REQUIREMENTS

The school has a two-year Ph.D. residency requirement. For full-time students, this requirement is normally met by an on-site dissertation project. In exceptional circumstances (e.g., dissertation topics requiring access to special facilities only available elsewhere), other arrangements may be proposed to the Educational Policy Committee (EPC). In such cases, a written plan of the research, with a schedule and description of the special circumstances and understandings between the student, thesis advisor and Student Program Committee (SPC), must be included. Approval of this plan by the EPC is required before a student is granted candidacy status for Ph.D. work under such an arrangement. For part-time Ph.D. students, the first year of the residency requirement can be satisfied by attendance in classes on the OGI campus. The second year of residency, however, must be spent full-time on campus under the advisement of an OGI faculty member.

There is no residency requirement for M.S. or certificate programs at OGI.

TIME LIMITS TO COMPLETE THE DEGREE

Ph.D.: Six years of full-time study or eight years of part-time study.

M.S.: Three years of full-time study or four years of part-time study.

Petitions for extensions must be approved by the department and submitted to the Educational Policy Committee for approval.

CONTINUOUS ENROLLMENT

A Ph.D. or Master's student who has begun work on the dissertation or thesis must register and pay for at least one credit hour of research per quarter in order to maintain matriculated status. If all requirements have not been satisfied at the end of four consecutive academic quarters of registering for only one credit per quarter, or if an alternate plan of completion has not been approved by the department and the Educational Policy Committee, matriculated status will be terminated. If the student wishes to return to his or her program at a later date, it will be necessary to reapply for admission. Continuous enrollment is not required of Master's students not pursuing a thesis, nor of Master's or Ph.D. students who have not yet begun working on the thesis or dissertation. However, all matriculated students are required to register for classes OR to indicate temporary inactive status by filing a Temporary Inactive Status form with the Department of Graduate Education.

LEAVE OF ABSENCE

In special circumstances, leaves of absence from a graduate program may be allowed. A student considering a leave should first discuss the issue with his or her advisor or another faculty member. If the department supports the leave of absence, the student then submits a petition to the school's Educational Policy Committee for approval.

STUDENT STATUS

A matriculated student is one enrolled in a degree program. A non-matriculated student is not working toward completing a degree. Full-time matriculated students carry a minimum of nine credits per quarter. (Audit units do not count toward this minimum except in special circumstances.) Academic departments may require students to carry more than nine credits per quarter as a condition of eligibility for a stipend and/or tuition scholarship. Part-time matriculated students are admitted to a degree program, carry fewer than nine credits per quarter and pay tuition at the appropriate per credit rate.

Non-matriculated students have not been admitted into a degree program, typically carry fewer than nine credits per quarter, and pay tuition at the appropriate hourly rate.

AUDITING A COURSE

OGI courses are offered for graded graduate credit hours or ungraded audit units. Students may register to audit an OGI course on a space-available basis. Students taking a course for credit have priority over students taking a course for audit. Audits are recorded on the student's transcript at the discretion of the instructor, based upon a reasonable expectation of attendance and minimal participation. Audits are charged at the standard tuition rate. Audit units do not count toward a student's full-time status. Instructors have final discretion over allowing audits of their classes and defining the academic expectations of audits.

CREDIT LOAD PER QUARTER

Twelve credits per quarter is considered a normal course load for full-time students, although nine or more is also considered full-time. Up to 18 credits/audits may be taken with the approval of the department. Registering for more than 18 credits requires Educational Policy Committee permission; 18 credits plus up to 4 audit units does not require EPC permission and does not incur additional cost. Students in the Electrical and Computer Engineering Department are limited to 12 credits per quarter, but may take up to16 with their advisor's and home department's written approval.

TRANSFER CREDIT

OGI accepts transfer credit from accredited institutions provided that such prior academic work has not been previously applied toward another degree. A maximum of 21 credits earned prior to matriculation at OGI may be applied. This may include up to 12 credits transferred from another institution (up to 18 from Portland State University, University of Oregon and Oregon State University) and/or up to 21 credits taken at OGI prior to matriculation. Contact each academic department for specific policies and procedures. Transfer credit grades, other than those from OGI, are not calculated in the OGI grade-point average (GPA).

GRADING/SATISFACTORY ACADEMIC PROGRESS

All OGI courses are graded with a letter grade; an exception is that Ph.D. students may receive P/NP for work in a seminar. In addition, faculty may assign P/NP or letter grades to research work, but grades for research cannot be counted in a student's GPA.

The following scale is employed at the school:

A = 4.0 B- = 2.67 C = 2.0

A- = 3.67 B = 3.0 C- = 1.67

B+ = 3.33 C+ = 2.33 F = 0.0

The grading system is defined as:

A = Excellent

B = Satisfactory

C = Below graduate standard

F = Failure

The following marks are also used:

AU = Audit, no credit

P = Satisfactory completion

NP = No credit, unsatisfactory

I = Incomplete

PI = Permanent Incomplete

W = Withdrawn (after the add/drop period) Matriculated students must maintain a cumulative GPA of 3.0 on all work taken at OGI. Failure to do so may result in probation or dismissal.

INCOMPLETES

The school's policy is that an Incomplete must be completed by the end of the quarter following that in which the Incomplete was awarded. In cases where the Incomplete is not completed, the instructor has the choice of assigning a grade or converting the Incomplete into a Permanent Incomplete. The grade may be an F if the course work was not completed, but instructors have the option of assigning another grade if they feel quality and quantity of work that was accomplished warrants it. If an extension of this one-quarter deadline is desired, the student may petition the Educational Policy Committee, showing the instructor's support of the extension (a separate letter or signature on the petition will suffice). Normally an extension will be granted, as long as the plan is specific, includes a date by which the grade will be assigned, and is submitted to the Graduate Education manager in writing.

400-LEVEL COURSES

Courses offered and designated by 400-series numbers within academic departments at the school are not considered to satisfy any degree requirements. These courses do not carry graduate credit at the school, but are entered on the transcript.

CONFIDENTIALITY OF STUDENT RECORDS

With the passage of the Federal Family Educational Rights and Privacy Act (FERPA) of 1974, OGI adopted rules to govern the collection, use and disclosure of student records with the goal of ensuring their privacy. Students have the right to inspect their educational records that are maintained by OGI; the right to a hearing to challenge the contents of those records when they allege the records contain misleading or inaccurate information; and the right to give their written consent prior to the release of their records to any person, agency or organization other than OGI officials and certain authorized federal and state authorities.

DIRECTORY INFORMATION

Certain public domain information, known as directory information, can be released by the school unless a student files a written request in the Graduate Education Department. The school limits this information to the student's name, home address, e-mail address, dates of attendance, degrees and awards received, number of credits earned and the fact of enrollment, including whether the student is enrolled full- or part-time. The school does not make this information available to vendors.

TRANSCRIPTS

Your transcript is a formal, written record of your educational experience at the OGI School of Science & Engineering. All courses you take at the school are recorded on it, as are all grades and degrees you earn while at OGI. If you have transferred credits from another institution, they will be recorded on your transcript as well. By law, requests for transcripts must be in writing and submitted by fax, mail or in person to the Department of Graduate Education. Official transcripts

are on special paper and have the official school seal; unofficial transcripts are printed on regular paper without the seal. There is no charge for unofficial transcripts; official transcripts cost $4 per copy. Requests are usually processed immediately, but we ask that you allow three days. Your request must have your name, signature and social security number (if applicable); indicate whether you will pick up the transcript(s) or include the address(es) to which the transcript(s) should be mailed; and include payment information, if relevant. You can send a check, submit a credit card number or pay cash. Sending cash through the mail is not recommended.

THE CAMPUS

GEOGRAPHIC SETTING

The greater-Portland metropolitan area has a population of about 1.5 million, nearly half the population of Oregon. It provides diverse cultural activities, including art, music, entertainment and sports. Portland has an extensive park system, including the largest wilderness park within the limits of any city in the United States. The OGI School of Science & Engineering is located 10 miles west of downtown. We are the newest school within Oregon Health & Science University (OHSU), joining the Schools of Medicine, Dentistry and Nursing, which are located on the main campus on Marquam Hill overlooking downtown Portland. OGI is now part of OHSU's newly named West Campus, which also includes the Neurological Sciences Institute, the Oregon Regional Primate Research Center, and the Vaccine and Gene Therapy Institute. OGI's campus consists of modern, attractive buildings, providing spacious laboratories, offices and a research library.

LIBRARY

The Samuel L. Diack Memorial Library's collection includes more than 18,000 monographic titles and 400 print journal subscriptions. These support the teaching and research efforts at OGI by providing texts, conference proceedings, reference materials, journals and research monographs in the subject areas of computer science, electrical engineering, environmental sciences, biochemistry, molecular biology, and management as related to science and technology. In addition, the OHSU Library holds more than 74,000 monographs and 1,200 journal subscriptions. These print collections are available for use when visiting the libraries. Materials unavailable at OGI are obtained on interlibrary loan for faculty, staff and students. An on-line catalog, acquisitions and circulation system is in place. Access to other college and university collections is provided by access to databases, library catalogs and grants circulation privileges to OGI students at 13 other area institutions, including Portland State University and Reed College.

OGI library workstations not only enable students and faculty to search the catalog and the library's databases but also provide entry to Web resources, telnetting and ftp options for faculty, staff and students. The OGI librarians will perform searches on the systems and databases that are not directly available to students. Library orientation is part of the introduction to OGI for new students, and classes on library research methods are offered throughout the year.

Most of OGI's electronic library resources will be integrated with those of the other OHSU schools and institutes by 2003.

COMPUTER FACILITIES

The OGI School of Science and Engineering's computing environment gives members of the community access to a rich array of technologies and information resources. Many of these resources, including networks and telecommunications, are the responsibility of OHSU's central Information Technology Group (ITG). In addition, many school departments and laboratories maintain their own computing facilities. Most of OGI's computers connect to a school-wide local-area network and to the Internet, providing convenient access to the World Wide Web. The local-area network is connected to the Internet through two high-speed data paths. In addition, it is also connected to Internet 2 (Internet2.edu) resources. The Internet 2 connection was made possible through an alliance of local academic institutions.

HOUSING

While OGI has no on-campus housing, it is located in the midst of a very large residential area. There are numerous apartment complexes, rental houses, bu and light rail lines, and shopping areas near the school. The Office of Student Services in the Graduate Education Department maintains a list of local apartment buildings for students to reference. In addition, the Student Council has a Web site for current, new and prospective OGI students who are looking for housing information, roommates, etc. This service is found at cslu.cse.ogi.edu/council/st_forum.html.

STUDENT COUNCIL

The Student Council serves as the liaison between the student body and the faculty and administration, and it strives to improve OGI students' quality of life. Student representatives make themselves available to students in their department in order to forward their comments, ideas and concerns to the Student Council and to promote their involvement in student body activities. Representatives also serve to disseminate all pertinent information to the students in their departments. As liaisons, members of the Student Council represent the student body and student interests on a wide variety of OGI task forces and committees, including the Faculty Senate, the Educational Policy Committee and the Safety Committee. Each quarter the Student Council also sponsors and coordinates at least one major social event, which is open to everyone at OGI. These events have included a coffeehouse with live music performed by people from throughout the school, an annual international food and cultural fair, and an educational forum. There are also monthly and weekly events, including movie nights and bagel breakfasts in the student lounge. More information on the Student Council is available on its Web site at cslu.cse.ogi.edu/council/ or by e-mail at scouncil@admin.ogi.edu.

Department of Biochemistry and Molecular Biology

www.bmb.ogi.edu

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THE DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY offers graduate study leading to M.S. and Ph.D. degrees. Participation in research begins immediately upon entering our program. This early exposure to research allows each student to become familiar with the variety of activities represented in the department and aids the student in thesis research selection.

RESEARCH AREAS INCLUDE:

- Metallobiochemistry (with an emphasis on the structure and function of metal ions in proteins and the mechanisms of metal trafficking in cells)
- Fungal and yeast biochemistry and molecular biology (with an emphasis on gene regulation and enzyme characterization)
- Ion transport across biological membranes (with an emphasis on molecular biology and reconstitution of cation or anion carriers)

The research experience at OGI is extensive. Much of the research is interdisciplinary, covering basic and applied aspects. Students are involved in all aspects of the departmental research program and have ready access to modern research instrumentation. As a result, our graduates are well qualified for research careers in academia, government and industry.

ADMISSION REQUIREMENTS

Admission requirements are the same as the general requirements of the institution. In addition, Ph.D. applicants must submit general GRE scores and a GRE subject score for one of the following tests: (a) biology, (b) chemistry or (c) biochemistry, cell and molecular biology. M.S. applicants are not required to submit GRE scores. Prospective students should carefully examine the faculty research interests and departmental research programs to determine whether their specific professional needs can be fulfilled at OGI. Communication with individual faculty members is encouraged prior to applying or enrolling.

DEGREE REQUIREMENTS

M.S. PROGRAMS

Two options are offered for the M.S. in biochemistry and molecular biology.

NON-THESIS OPTION

The non-thesis M.S. requires satisfactory completion of 44 credits, 28 of which are in graded courses and 16 of which are derived from an experimental research project (BMB610); and a written report on the research. Graded courses include 12 credits in BMB527-528-529, and 16 or more credits in advanced courses (BMB532-542), student seminars (BMB594 or 596) and Special Topics (BMB580). The research for the non-thesis degree is typically a specific contribution to a larger project, providing the student with extensive hands-on experience in biochemical and molecular biological techniques. The non-thesis M.S. degree can be completed in one year of full-time study.

THESIS OPTION

The thesis M.S. is a research degree that requires satisfactory completion of 44 credits, 20 of which are in graded courses (12 credits in BMB 527-528-529 and eight or more credits in advanced courses), and a written thesis based on independent research (BMB700). The thesis M.S. degree can be completed in 18 months of full-time study.

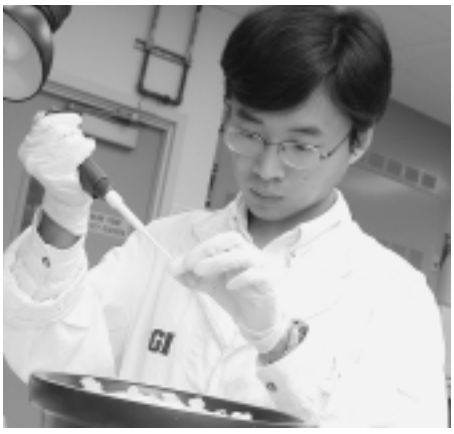
PH.D. PROGRAM

The department offers a Ph.D. in biochemistry and molecular biology. Ph.D. candidates are required to take the BMB 527-528-529 biochemistry sequence and three of the following core courses:

BMB532	**Bioenergetics and Membrane Transport, 4 credits**
BMB533	**Enzyme Structure, Function and Mechanisms, 4 credits**
BMB534	**Instrumental Methods in Biophysics I, 4 credits**
BMB540	**Advanced Molecular Biology, 4 credits**
BMB542	**Molecular Cell Biology, 4 credits**

Students must register for 12 credits per quarter. These credits typically include student seminars (BMB594 or BMB596), Department Seminar (BMB 591) and Research (BMB600 or BMB800).

The qualifying examination for the Ph.D. is a comprehensive examination. The qualifying exam must be completed within two years of entering OGI. An oral defense of the Ph.D. dissertation is required.



Cheng Wu is a doctoral student in Matt Sachs's lab.

COURSE DESCRIPTIONS

BMB527 Biochemistry I: Proteins and Enzymes
Primary, secondary and tertiary structure of proteins; enzyme mechanisms; enzyme kinetics. 4 credits

BMB528 Biochemistry II: Introduction to Molecular Biology
DNA replication, RNA synthesis and protein synthesis; genetic code; gene regulation. 4 credits

BMB529 Biochemistry III: Metabolism and Bioenergetics
Metabolism of carbohydrates, lipids and amino acids; bioenergetics; photosynthesis; oxidative phosphorylation. 4 credits

BMB532 Bioenergetics and Membrane Transport
Critical evaluation of the chemiosmotic theory with specific reference to oxidative phosphorylation, photophosphorylation and metabolite transport. Biochemical mechanisms of energy transduction common to bacterial and mitochondrial respiration, and bacterial and plant photosynthesis are reviewed. 4 credits

BMB533 Enzyme Structure, Function and Mechanisms
Provides an in-depth analysis of the structural origins of protein interactions and catalysis that are the basis for biological function. The course develops the basic principles of structural biology through an overview of X-ray crystal structures and folding processes, acquainting students with computational resources for protein structure analysis. The structural foundation is expanded into a detailed investigation of enzyme active sites, including the application of kinetic approaches to understanding enzymatic reaction mechanisms. 4 credits

BMB534 Instrumental Methods in Biophysics I
Theory and application of physical techniques to problems in biochemistry. Optical, fluorescence, circular dichroism, infrared and Raman spectroscopy of chromophoric groups. Magnetic susceptibility and nuclear magnetic resonance of metalloproteins. 4 credits

BMB535 Instrumental Methods in Biophysics II
Investigation of physical techniques particularly useful for studying metalloproteins. Electron paramagnetic resonance, electron spin echo, magnetic circular dichroism, and X-ray absorption spectroscopy. The course has significant "hands-on" exposure to instrumentation and computer simulation techniques. 4 credits

BMB537 Metals in Biochemistry
Comprehensive study of the chemistry and biochemistry of metal ions in biological molecules and living systems. Topics include metalloprotein structure, metal ion specificity, biological oxidation mechanisms, metal ion catalysis in enzymes, metal ion transport and gene regulation. 4 credits

BMB538 Coordination Chemistry
Structures and stabilities of transition metal coordination compounds with mono- and multi-dentate ligands; coordination compounds as models for biological metal centers; strategies for synthesis of transition metal complexes. 4 credits

BMB539 Chemical Group Theory
Properties of mathematical groups; symmetry properties of molecules; symmetry groups, representations and character tables. Applications of group theory to the study of structure and spectroscopy of organic and inorganic molecules; Hückel molecular orbital theory; ligand field theory; electronic spectroscopy and vibrational spectroscopy. 4 credits

BMB540 Advanced Molecular Biology
An in-depth study of the molecular mechanisms governing the replication, recombination, transcription and translation of genetic material. Emphasis is placed on experimental approaches that have led to our understanding of these fundamental processes. 4 credits

BMB541 Molecular Genetics of Development
A focused study of selected topics examining the regulation of gene expression during cellular differentiation. Emphasis is placed on the molecular nature of cell-cell interactions and the genetic control of complex cellular responses to developmental and environmental stimuli. 4 credits

BMB542 Molecular Cell Biology
The techniques of molecular biology have created an explosion in knowledge of cell structure and function. This course examines the following topics: cellular organization; cell signaling; cell differentiation; cell evolution. Knowledge of the cell is obtained through combining core readings and lectures with student-led discussions of primary research papers. 4 credits

BMB543 Current Topics in Proteomics
Proteomics is a new area of molecular biology that aims to identify and map the total protein complement of a genome. It expands the scope of biological investigation from studying single proteins to systematically studying all proteins. Proteomics has broad applications in disease diagnosis, drug discovery and agriculture. The key technologies used in proteomics are two-dimensional gel electrophoresis, mass spectrometry (ESI-MS, MALDI-TOF), imaging and database software. This course will use lectures, student seminars and literature readings to focus on electrophoresis, mass spectrometry and applications. 3 credits

BMB544 Introduction to Bioinformatics
Primary literature of computational biology and hands-on experience in data manipulation from local and remote databases. 3 credits

BMB580 Special Topics in Biotechnology
Examination of current and past research papers in a specific area of biotechnology that is of mutual interest to the student and the faculty member. Requires a written review paper or seminar presentation in one of the Student Seminar series. Variable and repetitive credit

BMB591 Department Seminar: Biochemistry/ Molecular Biology
1 credit, repetitive

BMB594 Metallobiochemistry Student Seminar
Presentations and discussions of selected topics from the recent literature and of ongoing research projects in the department. 2 credits, repetitive

BMB596 Molecular Biology/Biochemistry Student Seminar
Presentation and discussion of journal articles from the recent literature in molecular biology, genetics and biochemistry. 2 credits, repetitive

BMB600 Research
Supervised research participation. Variable and repetitive credit

BMB610 Nonthesis Research
Supervised research as a component of the nonthesis M.S. degree. Variable and repetitive credit

BMB620 Professional Internship
These courses provide the student with an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for their future careers. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available. Variable credit

BMB700 M.S. Thesis Research
Research toward the thesis for the M.S. degree. Variable and repetitive credit

BMB800 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree. Variable and repetitive credit

RESEARCH PROGRAMS

Translational Control in Fungal Amino Acid Biosynthesis

A greater understanding of many human health issues relies on increased knowledge of how cells express genetic information. Gene expression can be controlled by regulating the synthesis and stability of functional RNA and protein. The goal of our research is to obtain a greater understanding of how these mechanisms work using the *Neurospora crassa arg-2* and *Saccharomyces cerevisiae CPA1* genes as models. These homologous genes encode the first enzyme in arginine biosynthesis, and they are negatively regulated at transcriptional and translational levels in response to the availability of arginine. An evolutionarily conserved upstream open reading frame (uORF) present in the 5'-leader regions of these transcripts is responsible for translational control. Synthesis of the uORF-encoded peptide causes ribosomes to stall when the level of arginine is high, blocking access of ribosomes to the translation initiation site for the polypeptide encoding the arginine biosynthetic enzyme. Our current work is focused on developing a molecular understanding of how synthesis of this uORF-encoded peptide causes ribosomes to stall, since this will provide important insights into the fundamental cellular process of protein synthesis. *Sachs*

Translational Control of Human Proto-Oncogenes

The transcripts specified by many genes involved in human cancers contain uORFs; these include the *her-2* and *bcl-2* proto-oncogenes. Using methods similar to those developed for understanding the roles of the uORFs of *N. crassa arg-2* and *S. cerevisiae CPA1* gene expression, we are examining

the functions of these mammalian uORFs, to better understand their role in controlling the expression of these critically important genes. *Sachs*

The Neurospora Genome

We are part of a team that is sequencing and annotating the genome of *Neurospora crassa* (see www.genome.wi.mit.edu/annotation/fungi/neurospora/), and are gearing up to apply this information to large-scale community-wide efforts in functional genomics. This is the first genome of a filamentous fungus that has been sequenced with public funds; the annotation of this sequence is proving invaluable for understanding fungal genome evolution; many fungi important for agriculture and medicine are closely related to *N. crassa.* We recently began experiments aimed at cloning and analyzing the telomeric regions of *N. crassa* and the closely related pathogenic rice blast fungus *Magnaporthe grisea* because mounting evidence indicates that genes near telomeres evolve more quickly and are frequently involved in pathogenic interactions with hosts. *Sachs*

Mechanisms of Mammalian Chemical Communication and Vomeronasal Olfaction

Chemical communication plays a significant role in life strategies for many mammals. Our research focuses on chemical identification of pheromones functioning during reproductive events in the Asian elephant, *Elephas maximus*. A female-to-male preovulatory urinary sex pheromone, (Z)-7-dodecen-1-yl acetate, has been identified and demonstrated to be robust in its synthetic form. This compound is also bioactive in many Lepidoptera, making it a good example of convergent evolution of structure and function. Biochemical studies have established the presence of the pheromone in the serum, and future studies will investigate its biosynthetic pathways. Considerable progress has been made on establishing the proteins functioning as pheromone transporters prior to signal transduction in the neuroreceptive cells of the vomeronasal organ. Radiolabeled analogs, competition experiments and molecular biological studies have established unusual roles for elephant albumin and olfactory binding protein. A second pheromonal system is actively being investigated. The facial temporal gland, breath and urine exude unusual chemical compounds during musth in Asian male elephants. These signals have a role in mate choice by female elephants, spatial distribution by male elephants and other reactions by conspecifics. Utilizing several state-of-the-art gas chromatographic/mass spectrometric techniques, we are identifying specific compounds that have a chemical communication function, i.e., elicit behavioral responses, and correlating the release of such compounds with serum androgen levels. *Rasmussen*

Chemistry of Copper-Containing Enzymes

Increasing numbers of important enzymes are known to contain copper at their active sites. Of particular interest are enzymes involved in biogenic amine biosynthesis and metabolism (including important neuroactive amines such as nor-adrenaline and amphetamine); enzymes protecting against oxidative cellular damage caused by reduced oxygen metabolites; and enzymes catalyzing the biosynthesis of neuropeptide hormones. A major goal is to understand the catalytic role of copper and the molecular mechanism of oxygen binding and utilization by these oxidase and oxygenase enzymes. *Blackburn*

Spectroscopy of Copper Proteins

Spectroscopic techniques are used to probe the structures of the copper sites in the native proteins and their complexes with substrates and inhibitors. Since the chemistry of the catalytic processes is generally centered on the Cu(I) forms of the enzymes, we are concentrating on the challenging task of developing spectroscopic probes of the Cu(I) oxidation state, which is transparent to most common spectroscopic techniques. Our work thus includes Fourier transform infrared, X-ray absorption edge and EXAFS spectroscopies, and emphasizes the use of computer simulation of spectra on our Alpha work station. Data for the latter two techniques are collected at national and international synchrotron radiation facilities. Proteins under investigation include dopamine-beta hydroxylase, cytochrome *c* oxidase, hemocyanin, peptide amidating enzyme, Menkes and Wilson's disease proteins, and copper chaperones. *Blackburn*

Radical Copper Oxidases

Radical copper oxidases are a new class of redox metalloenzymes (including the fungal enzymes galactose oxidase and glyoxal oxidase) containing a protein free radical directly coordinated to a copper center. This free radical-coupled Cu complex catalyzes the two-electron oxidation of simple alcohols and aldehydes and the reduction of O_2 to hydrogen peroxide, fueling extracellular peroxidases involved in lignin degradation. In these proteins, the free radical is localized on a tyrosine residue covalently crosslinked to a cysteinyl side chain (a Tyr-Cys dimer). The catalytically active enzyme is an intense green color, a result of unusual optical spectra arising from electronic transitions within the copper radical complex. Low energy transitions in the near IR result from interligand redox in this metal complex, ligand-to-ligand charge transfer (LLCT) processes that are closely related to the electron transfer coordinate for substrate oxidation. The active site metal complex is surprisingly flexible, twisting through a pseudorotation distortion when exogenous ligands bind, thereby modulating the basicity of a second tyrosine ligand that serves as a general base in catalysis. Many of these aspects of electronic structure and dynamics of the radical copper oxidases are the focus of active research. *Whittaker*

Manganese Metalloenzymes

Manganese is an essential element for life, forming the active site for a large number of metalloenzymes catalyzing hydrolytic or redox reactions, including the photosynthetic oxygen evolving complex. We are interested in the Mn redox sites in Mn superoxide dismutase (MnSD, mononuclear Mn) and Mn catalase (MnC, dinuclear Mn), enzymes that provide protection from toxic oxygen metabolites. The key question is: How do interactions between the protein, metal ion and exogenous ligands tune the redox potential and chemistry of these complexes? We are combining the powerful tools of molecular biology with advanced spectroscopic and computational approaches to explore the structure and dynamics of Mn active sites. For MnSD, we find an unexpected temperature dependence for the structures of anion complexes, which change coordination as the temperature is raised. This thermal transition implies that the stability of the active site structure is determined by dynamical features of the complex and that dynamical excitation may play an important role in controlling the energetics of ligand binding and redox. A wide range of projects relating to the chemistry and biology of Mn are in progress. *Whittaker*

Electronic Spectroscopy of Biological Metal Complexes

Electronic spectroscopy extends structural studies of biomolecules beyond the atomic resolution of X-ray crystallography to a level of structural detail that directly relates to chemistry. The techniques used in these studies span five decades of the electromagnetic spectrum, from microwaves to the ultraviolet and beyond. At the lowest energy, electron paramagnetic resonance (EPR) spectroscopy gives information on the electronic ground state, defining the molecular orbital that contains the unpaired electron in a paramagnetic complex. At higher energy, UV-visible absorption spectroscopy excites orbital transitions between electronic states, giving information on characteristic metal-ligand interaction energies that can be understood in terms of a ligand field or molecular orbital analysis. Polarization spectroscopy (linear dichroism, circular dichroism and magnetic circular dichroism) can give more detailed information on ground and excited state electronic wave functions using geometric features of light to probe the active site. These experimental approaches can be complemented by spectroscopic modeling and computational biology methods to provide a detailed description of a metalloprotein complex and its interactions. *Whittaker*

Vibrational Spectroscopy of Metalloprotein Active Sites

Many spectroscopic methods are available for the investigation of structural and functional properties of metal ions in enzymes and proteins. We use electronic, vibrational (especially resonance Raman) and EPR spectroscopy to characterize metal-ion active sites. Our laboratory has a sensitive, state-of-the-art Raman instrument: a fast spectrograph with a liquid N_2-cooled CCD detector. We also use a combined FT-IR/FT-Raman instrument for protein and model compound studies. Our research focuses on the description of the molecular and electronic structures of heme (iron porphyrin), nonheme-iron and copper enzymes to gain an understanding of the role of the metal ion in enzymatic catalysis. Of particular interest is the biochemistry of O_2. Metalloproteins are involved in O_2 binding (hemoglobin or hemocyanin) and in oxidative chemistry whereby O_2 is reduced and substrates are oxygenated or oxidized. Trapped reaction intermediates and model

compounds help us unravel these complex processes and define reaction mechanisms. In all projects, modern molecular biology techniques provide site-directed mutants that permit alterations in structures and reactivities. *Loehr*

Heme Oxygenase

Heme oxygenase is a fascinating system that uses the O_2-binding affinity of its heme substrate in the cellular degradation of heme to open-chain biliverdin. These studies are carried out with Paul R. Ortiz de Montellano's group at U.C. San Francisco. The resting heme-heme oxygenase enzyme substrate complex is much like myoglobin: The heme is linked to the enzyme by an iron-histidine bond, and the iron exists mainly in a six-coordinate, high-spin state with an additional water ligand. The Fe-N(His) bond was identified from its resonance Raman vibration at 216 cm^{-1} in the Fe(II)-heme complex. The absence of this fingerprint frequency in the H25A mutant clearly identified His25 as the axial ligand. Remarkably, when imidazole was added to the inactive H25A preparation, activity was fully restored. Our current efforts, in collaboration with Angela Wilks at the University of Maryland, examine the structure and activity of several bacterial heme oxygenases. *Loehr and Moënne-Loccoz*

Oxygen Activation by Iron Proteins

Several diiron enzymes react with molecular oxygen to form powerful oxidizing agents important in biology. Examples include (i) ribonucleotide reductase protein R2, which oxidizes its tyrosine 122 to its catalytically important neutral radical form; (ii) methane monooxygenase, whose hydroxylase component oxidizes hydrocarbons to alcohols; (iii) plant desaturases, which oxidize fatty acids to olefins, e.g., stearoyl to oleoyl; and (iv) ferroxidase reactions, in which Fe^{2+} is oxidized to Fe^{3+}. A common feature of these enzymes appears to be the formation of an initial peroxo intermediate from the reduced enzyme. However, in the respiratory protein, hemerythrin, binding of dioxygen is accomplished by reduction to peroxide in a reaction that is readily reversible. In ribonucleotide reductase, peroxide is similarly formed but decomposes irreversibly to a ferryl intermediate that is capable of carrying out oxidative chemistry. This dichotomy of behavior is reminiscent of the respiratory vs. peroxidase functions of different heme-containing proteins. We are interested in determining common principles that influence the pathways of oxygen utilization. This problem is being approached by structural elucidation of the iron sites in the proteins themselves and in model complexes, as well as by studying mechanisms of their reactions with oxygen-containing substrates. *Loehr and Moënne-Loccoz*

Interaction of Nitric Oxide with Metalloproteins

Nitric oxide (NO) is of intense interest due to its role in a diverse range of biological processes. The importance of NO in mammalian physiology is indicated by the award of the 1998 Nobel Prize for Medicine for the discovery of its role as a signaling molecule in the cardiovascular system. In bacteria, NO is produced as an intermediate during denitrification — the process by which certain organisms convert nitrate to N_2 or N_2O. The production of NO is the first opportunity for fixed nitrogen to be lost from the soil to the atmosphere, with implications ranging from fertilizer loss to atmospheric pollution. Throughout biological NO chemistry, proteins with Fe- or Cu-containing active sites play a central role in generating and releasing NO as well as in sensing and initiating chemistry in response to changes in NO levels. Our research is aimed at investigating the structures and mechanisms of these metalloproteins through the use of a variety of spectroscopic, biochemical and kinetic techniques. *Andrew*

Regulation of Long Chain Fatty Acid Transport and Oxidation in Mammalian Heart and Liver

The rate-limiting step in ß-oxidation is the conversion of long-chain acyl-CoA to acylcarnitine, a reaction catalyzed by the outer mitochondrial membrane enzyme carnitine palmitoyltransferase I (CPTI) and inhibited by malonyl-CoA. The acylcarnitine is then translocated across the inner mitochondrial membrane by the carnitine/acylcarnitine translocase and converted back to acyl-CoA by CPTII. This reaction in intact mitochondria is inhibited by malonyl-CoA, the first intermediate in fatty acid synthesis, suggesting coordinated regulation of fatty acid oxidation and synthesis. Although CPTII has been examined in detail, studies on CPTI have been hampered by an inability to purify CPTI in an active form from CPTII. In particular, it has not been conclusively demonstrated that CPTI is even catalytically active, or whether sensitivity of CPTI to malonyl-CoA is an intrinsic property of the enzyme or is contained in a separate regulatory subunit that interacts with CPTI. To address these questions, the genes for human heart muscle M-CPTI and rat liver LCPTI and CPTII were separately expressed in *Pichia pastoris*, a yeast with no endogenous CPT activity. High levels of CPT activity were present in purified mitochondrial preparations from both CPTI- and CPTII-expressing strains. Furthermore, CPTI activity was highly sensitive to inhibition by malonyl-CoA while CPTII was not. Thus, CPT catalytic activity and malonyl-CoA sensitivity are contained within a single CPTI-polypeptide in mammalian mitochondrial membranes. My laboratory is the first to describe the kinetic characteristics for the yeast-expressed CPTIs, the first such report for a CPTI enzyme in the absence of CPTII. Both yeast-expressed M-CPTI and L-CPTI are inactivated by detergent solubilization. However, removal of the detergent in the presence of phospholipids resulted in the recovery of malonyl-CoA-sensitive CPTI activity, suggesting that CPTI requires a membranous environment. CPTI is thus reversibly inactivated by detergents. We have isolated and sequenced the promoter region of the gene for the human heart M-CPTI. We have mapped the malonyl-CoA and substrate binding sites in human heart M-CPTI and liver L-CPTI by deletion, site-directed mutagenesis and chemical modification studies using residue-specific reagents. Our deletion and point mutation analyses have demonstrated that glutamate-3 and histidine-5 are necessary for malonyl-CoA inhibition and binding of CPTI but not for catalysis. We will determine the structural basis for the high malonyl-CoA sensitivity of M-CPTI by constructing chimeras between M-CPTI and L-CPTI and by site-directed mutagenesis. We will prepare milligram quantities of the expressed highly purified human heart M-CPTI and liver L-CPTI for structural characterization studies. Finally, we plan to study the regulation of human heart M-CPTI gene expression by hormonal, developmental and dietary factors. Our goal is to elucidate the molecular mechanism of the regulation of fatty acid transport and oxidation in mammalian cells. *Woldegiorgis*

The Mitochondrial ATP-sensitive K^+ Channel (mitoKATP)

MitoK_{ATP} resides in the inner membrane of mitochondria, where it serves to regulate the volume of mitochondrial compartments and also to trigger cell signaling leading to cardioprotection and gene transcription. We showed that mitoK_{ATP} mediates the actions of potassium channel openers and ischemic preconditioning to protect the heart against ischemia-reperfusion injury. We are now working to understand the mechanisms of this effect and the normal physiological role of mitoK_{ATP} in heart and brain. We introduced techniques for purification and reconstitution of mitoK_{ATP} in lipid vesicles and use this preparation to study the transport kinetics of the channel. We have purified the mitoK_{ATP} subunits to homogeneity and will use these to obtain the molecular structure of mitoK_{ATP}. *Garlid*

Mitochondrial Uncoupling Proteins

Our laboratory was the first to demonstrate reconstitutive activity of the new uncoupling proteins, UCP2 and UCP3, and we have long been active in the study of UCP1. Flux studies in proteoliposomes containing UCP have led to a new mechanism of UCP-mediated uncoupling in which the fatty acid anion is transported by UCP and the protonated fatty acid cycles spontaneously back across the bilayer to deliver protons. *Garlid*

Mitochondrial Bioenergetics

Progress in understanding mitochondrial bioenergetics has not kept pace with the enormous progress in structure-function of the enzymes of oxidative phosphorylation. This occurs at a time when understanding bioenergetics at the physiological level is most needed, in view of the increased recognition of the roles played by mitochondria in cell physiology and pathophysiology. A number of unresolved questions relating to the mechanism of energy conservation in mitochondria are being addressed by theoretical and experimental approaches. Subjects being investigated include the question of redox slip; volume activation of electron transport; and the role of the intermembrane space in regulating energy transfers between matrix and cytosol. *Garlid*

Anaerobiosis of *Bacillus subtilis*

A gram-positive soil bacterium, *B. subtilis,* is highly amenable to genetic analysis and has been used as a model system to study fundamental microbiological research. In addition, *B. subtilis* is medically and industrially important since it produces a variety of antibiotics and extracellular

enzymes. Although the organism has been widely used, it has been mistakenly referred to as a strict aerobe until recently. Our studies, together with others, have shown that *B. subtilis* is able to grow under anaerobic conditions by utilizing nitrate or nitrite as an alternative electron acceptor. In the absence of terminal electron acceptors, it undergoes fermentative growth. Our research aims include elucidation of the regulatory mechanisms through which the cells adapt to oxygen limitation. Molecular genetic and biochemical approaches are applied. *Nakano*

Two Physiological Roles of Nitrate and Nitrite Reductases

Nitrate and nitrite reductases have two roles in metabolism of *B. subtilis*: assimilation of nitrate/nitrite and anaerobic respiration. Two genetically and biochemically distinct nitrate reductases are present to fulfill the dual roles; in contrast, a single nitrite reductase functions in both assimilation and respiration. The functional differences of the enzymes correspond to the difference in gene regulation. We have studied how these nitrate and nitrite reductase genes are regulated in response to nitrogen and oxygen limitation by promoter analysis of these genes and identification of trans-acting factors. The mechanisms of transcriptional activation of the nitrate/nitrite reductase genes are being investigated. *Nakano*

ResD-ResE Two-Component Signal Transduction System

Bacteria often encounter sudden environmental changes. Cells cope with such changes by an elaborate network of adaptive responses. The two-component signal transduction system senses and then processes information derived from environmental changes so that the cell can choose the appropriate adaptive response. This simple signal transduction system is widespread in bacteria and also found in plants and lower eukaryotes. ResE is a histidine kinase and ResD is a response regulator of this large protein family. We have shown that ResD and ResE are indispensable for anaerobic respiration in *B. subtilis*. A specific signal derived by oxygen limitation is recognized by the N-terminal input domain of the ResE kinase leading to autophosphorylation of a conserved histidine residue in the C-terminal transmitter domain. This phosphoryl group is then transferred to aspartate in the conserved N-terminal domain of ResD, altering the activity of its C-terminal domain as a transcriptional activator. The ResD-ResE signal transduction system is activated by oxygen limitation or by addition of nitric oxide generators. The objectives of our studies are to determine how ResE senses oxygen limitation or nitric oxide and how anaerobically induced genes are activated by ResD. *Nakano*

Flavohemoglobin (Hmp)

Flavohemoglobin is a ubiquitous protein present in organisms ranging from *Escherichia coli to Saccharomyces cerevisiae*. The N-terminal part of the protein has similarity to hemoglobin, and the C-terminus is homologous to reductase with a flavin-binding domain. Recent studies showed that flavohemoglobin is involved in detoxification of nitric oxide. *B. subtilis hmp* was identified among genes, expression of which is induced by oxygen limitation. The anaerobic induction of *hmp* requires the ResD-ResE signal transduction pairs and nitrite. The expression is also induced by exogenous nitric oxide through ResDE-dependent and -independent mechanisms. The detailed regulatory mechanism of *hmp* expression and its functional role in anaerobiosis are under investigation. *Nakano*

Peptide Antibiotic Biosynthesis

Our research is aimed at understanding the mechanism of antimicrobial peptide biosynthesis. Peptide antibiotics are synthesized either by the non-ribosomal thiotemplate mechanism or are bacteriocins that are gene-encoded and synthesized on ribosomes. Both classes are used as bio-control agents in medicine, agriculture and the food industry. Non-ribosomally synthesized peptides also include iron-scavenging siderophores which are required for virulence by some bacterial pathogens and toxins produced by a variety of bacterial and fungal species that infect plants. A knowledge of how peptide and bacteriocin biosyntheses are carried out at the molecular level may provide information that can ultimately be used to design ways to control the virulence of pathogenic microorganisms and to synthesize peptides with a defined structure and bioactivity. The spore-forming bacterium *Bacillus subtilis* will produce an abundance of peptide antibiotics and bacteriocins under conditions of nutritional stress and oxygen limitation. The genes encoding the enzymes that catalyze peptide biosynthesis have been cloned, and we are engaged in genetic engineering of the enzymes to understand the mechanism of antimicrobial peptide biosynthesis. *Zuber*

Prokaryotic Signal Transduction/Gene Regulation

Bacteria can respond in a variety of ways to a growth-restricting environment. Prolonged exposure to a nutritionally poor environment results in the induction of antibiotic biosynthesis, functions required for cell motility and processes of cellular differentiation that give rise to highly resistant cell types. How cells respond to nutritional stress is profoundly influenced by cell density. Extracellular signal molecules accumulate in the local environment of densely populated cell cultures and trigger antibiotic production and developmental processes such as sporulation and genetic competence. The objective of our research is to understand, in molecular terms, the regulatory networks that cells utilize to choose the most appropriate response to harsh conditions. In the spore-forming bacterium *Bacillus subtilis*, establishment of genetic competence is co-regulated with peptide antibiotic biosynthesis by a complex network of signal transduction pathways that utilize protein components common to all prokaryotic and most eukaryotic organisms. *Zuber*

Biochemistry of Lignin Degradation

Lignin is the most abundant renewable aromatic polymer, constituting approximately 25 percent of woody plant cell walls. Our multidisciplinary

RESEARCH FACILITIES

The department is well equipped to carry on a vigorous research program. Instruments and equipment available in the department include:

- **Gas chromatograph/mass spectrometer with computer data system**
- **High-resolution mass spectrometer**
- **Capillary column gas chromatographs with flame ionization detectors**
- **Fourier transform infrared spectrometers**
- **Fourier transform Raman spectrometer with CW Nd:YAG laser**
- **X-band electron paramagnetic resonance spectrometer**
- **Ultraviolet/visible/near-infrared spectrophotometers**
- **Scanning fluorescence spectrophotometers**
- **Magnetic circular dichroism (MCD) spectrometer**
- **Diode array UV/VIS spectrophotometer**
- **Laser Raman spectrophotometer**
- **Raman spectrograph with CCD detector**
- **Ar, Kr, He-Cd, He-Ne, and dye lasers**
- **High-vacuum lines**
- **Phosphor imager**
- **Controlled atmosphere reaction chamber**
- **Super speed centrifuges**
- **Ultracentrifuges**
- **HPLCs**
- **FPLCs**
- **Fraction collectors**
- **Liquid scintillation systems**
- **Gel electrophoresis systems**
- **Laminar flow hoods for sterile culture**
- **Growth chambers**
- **Constant temperature rooms**
- **Light and electron microscopes**
- **Ultrafiltration systems**
- **Autoclaves**
- **Photographic facilities**
- **Probe type sonicators and extruder**

research program aims to understand and exploit the fungal degradation of this underutilized resource. The metabolic pathways and enzymatic components of the lignin degradative system are examined using biochemical, enzymological and molecular biological methods. Two novel extracellular heme peroxidases (lignin peroxidase and manganese peroxidase) involved in the degradation of lignin were discovered in our laboratory. Lignin peroxidase oxidizes a variety of nonphenolic lignin model compounds and priority pollutants. Manganese peroxidase oxidizes Mn^{II} to Mn^{III}, which in turn oxidizes phenolic and nonphenolic substrates. The structures, active sites, mechanisms, catalytic cycles and regulation of these enzymes are being characterized in our laboratory and via collaborations using spectroscopy, stopped-flow kinetics, protein chemistry, enzymology, X-ray crystallography and bio-organic and molecular genetic methods. Recently, we developed a homologous expression system for these peroxidases. This system allows structure/function studies by site-directed mutagenesis. Applications for lignin-degrading systems include the more efficient utilization of biomass, nonpolluting forest products technologies and toxic waste cleanup. We also are studying several intracellular enzymes such as quinone reductases, ring-cleaving dioxygenases and reductive dehalogenases that are involved in lignin and pollutant degradation. *Gold*

Molecular Biology and Genetics of *Phanerochaete chrysosporium* and Its Lignin-Degrading System

We are isolating and sequencing the genes encoding components of the *P. chrysosporium* lignin-degrading system. These include genes encoding lignin and manganese peroxidases, a novel quinone reductase and several other genes. We are analyzing the coding and promoter regions of these genes and studying the regulation of their transcription. We have discovered that Mn peroxidase is regulated by Mn ion, the substrate for the enzyme, as well as by nutrient nitrogen, heat shock and oxidative stress. Using reporter genes and RT-PCR, we are elucidating the molecular mechanisms involved in Mn peroxidase gene regulation. Recently we developed a transcriptional reporter system based on the gene encoding green fluorescent protein from jellyfish. We also are undertaking molecular biology studies on the manganese peroxidase gene of *Dichomitus squalens* and on its heterologous expression in *P. chrysosporium*. *Gold*

Biodegradation of Aromatic Pollutants

The nonspecific and oxidative nature of the lignin degradation system of the fungus *Phanerochaete chrysosporium* enables this organism to degrade a variety of toxic aromatic pollutants, including polychlorinated phenols, polychlorinated dioxins, chlorophenoxyacetic acid and nitrotoluenes. We are examining the biochemical pathways, enzymes and regulatory mechanisms involved in the total degradation of these compounds. We have shown that the fungus utilizes extracellular peroxidases as well as intracellular quinone reductases, reductive dehalogenases and dioxygenases to carry out these processes. We are attempting to characterize these enzymes and their encoding genes to more fully understand the mechanisms involved in the degradation of these pollutants. Recently we discovered a novel reductive dechlorination system in white-rot fungi that removes chlorines from chlorinated hydroquinones. This system is being examined by biochemical and molecular biological methods. *Gold*

Oxidative Enzymes Involved in Fungal Cellulose Degradation

Cellulose constitutes 40 percent to 60 percent of plant cell wall material; its biotechnological conversion, initially to glucose and then to ethanol, can provide an alternative source of energy. This application requires a complete understanding of the various enzymes involved in fungal cellulose degradation. The cellulose-degrading cultures of *Phanerochaete chrysosporium* produce a unique hemoflavoenzyme, cellobiose dehydrogenase (CDH), which oxidizes cellobiose to cellobionolactone. We have purified CDH to homogeneity in high yields. Cellulases bind to crystalline cellulose using a specific cellulose-binding domain. CDH appears to have a similar domain for cellulose binding. The amino acid sequence responsible for cellulose binding and the binding mechanism are under investigation. Our recent research suggests that a possible physiological role of CDH is to enhance crystalline cellulose degradation by cellulases, the rate-limiting step in the bioconversion of cellulose to glucose. A detailed study of the structure, function and mechanism of CDH using spectroscopic, biochemical and molecular biological methods is in progress. *Gold*

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RESEARCH INTERESTS

Structure and function of oxidase and oxygenase metalloenzymes; spectroscopy of metal sites in proteins with emphasis on EPR, EXAFS, absorption edge, and FTIR spectroscopies; coordination chemistry and biochemistry of copper. Biochemistry of metal trafficking in cells.

REPRESENTATIVE PUBLICATIONS

F.C. Rhames, N.N. Murthy, K.D. Karlin and N.J. Blackburn, "Isocyanide Binding to the Copper(I) Centers of the Catalytic Core of Peptidylglycine Monooxygenase (PHMcc)." J. Biol. Inorg. Chem. 2001, 6, 567-577.

S. Jaron and N.J. Blackburn, "Characterization of a Half-Apo Derivative of Peptidylglycine Monooxygenase. Insight into the Reactivity of Each Active Site Copper." Biochemistry 2001, 40, 6867-6875.

N.J. Blackburn, F.C. Rhames, M. Ralle and S. Jaron, "Major Changes in Copper Coordination Accompany Reduction of Peptidylglycine Monooxygenase: Implications for Electron Transfer and the Catalytic Mechanism." J. Biol. Inorg. Chem. 2000, 5, 341-353.

J.F. Eisses, J.P. Stasser, M. Ralle, J.H. Kaplan and N.J. Blackburn, "Domains I and III of Human Copper Chaperone for Superoxide Dismutase Interact via a Cysteine-Bridged Dicopper(I) Cluster." Biochemistry 2000, 38, 7337-7342.

N.J. Blackburn, M. Ralle, R. Hassett and D.J. Kosman, "Spectroscopic Analysis of the Trinuclear Cluster in the Fet3 Protein from Yeast, a Multinuclear Copper Oxidase." Biochemistry 2000, 39, 2316-2324.

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RESEARCH INTERESTS

Bioinorganic chemistry; structure, function and spectroscopy of metalloenzymes; generation, mobilization and sensing of nitric oxide by metalloproteins; redox-active copper proteins.

REPRESENTATIVE PUBLICATIONS

C.R. Andrew, E.L. Green, D.M. Lawson and R.R. Eady, "Resonance Raman Studies of Cytochrome *c* Support the Binding of NO and CO to Opposite Sides of the Heme: Implications for Ligand Discrimination in Heme-Based Sensor." Biochemistry 2001, 40, 4115-4122.

D.M. Lawson, C.E.M. Stevenson, C.R. Andrew and R.R. Eady, "Unprecedented Proximal Binding of Nitric Oxide to Heme: Implications for Guanylate Cyclase." EMBO J. 2000, 19, 5661-5671.

J.P. Hannan, S.L. Davy, G.R. Moore, R.R. Eady and C.R. Andrew "Effect of Nickel(II) Substitution on the Resonance Raman and NMR Spectra of *Alcaligenes xylosoxidans* Azurin II: Implications for Axial-Ligand Bonding Interactions in Cupredoxin Active Sites." Biol. Inorg. Chem. 1998, 3, 282-291.

C.R. Andrew, J. Han, T. den Blauuwen, G. van Pouderoyen, E. Vijgenboom, G.W. Canters and J. Sanders-Loehr, "Cysteine Ligand Vibrations are Responsible for the Complex Resonance Raman Spectrum of Azurin." Biol. Inorg. Chem. 1997, 2, 98-107.

C.R. Andrew and J. Sanders-Loehr, "Copper-Sulfur Proteins: Using Raman Spectroscopy to Predict Coordination Geometry" [Review]. Acc. Chem. Res. 1996, 29, 365-372.

KEITH D. GARLID

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M.D., The Johns Hopkins
University School
of Medicine, 1961
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Physical Chemistry
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RESEARCH INTERESTS

The structure-function of the mitochondrial ATP-sensitive K^+ channel (mitoK_{ATP}) and its role in cardioprotection and cardiac physiology; the structure-function of uncoupling proteins; mitochondrial and cellular bioenergetics.

REPRESENTATIVE PUBLICATIONS

R. Bajgar, S. Seetharaman, A.J. Kowaltowski, K.D. Garlid and P. Paucek, "The ATP-Sensitive Potassium Channel of Brain Mitochondria." J. Biol. Chem. 2001, 276, 33369-33374.

A.J. Kowaltowski, S. Seetharaman, P. Paucek and K.D. Garlid, "Bioenergetic Consequences of Opening the ATP-Sensitive K^+ Channel of Heart Mitochondria." Am. J. Physiol. Heart Circ. Physiol. 2001, 280, H649-H657.

K.D. Garlid, M. Jaburek, P. Jezek and M. Varecha, "How Do Uncoupling Proteins Uncouple?" Biochim. Biophys. Acta 2000, 1459, 383-389.

G.J. Grover and K.D. Garlid, "ATP-Sensitive Potassium Channels: A Review of Their Cardioprotective Pharmacology." J. Mol. Cell. Cardiol. 2000, 32, 677-695.

K.D. Garlid, P. Paucek, V. Yarov-Yarovoy, H.N. Murray, R.B. Darbenzio, A.J. D'Alonzo, N.J. Lodge, M.A. Smith and G.J. Grover, "Cardioprotective Effect of Diazoxide and its Interaction with Mitochondrial ATP-Sensitive K^+ Channels. Possible Mechanism of Cardioprotection." Circ. Res. 1997, 81, 1072-1082.

MICHAEL H. GOLD

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RESEARCH INTERESTS

Biochemistry; molecular biology; genetics of fungi; fungal degradation of lignin and environmental pollutants; structure and function of novel peroxidases; structure expression and regulation of fungal genes; biotechnology.

REPRESENTATIVE PUBLICATIONS

G.V.B. Reddy and M.H. Gold, "Purification and Characterization of Glutathione Conjugate Reductase: A Component of the Tetrachlorohydroquinone Reductive Dehalogenase System from *Phanerochaete chrysosporium*." Arch. Biochem. Biophys. 2001, 391, 271-277.

F.A.J. Rotsaert, B. Li, V. Renganathan and M.H. Gold, "Site-directed Mutagenesis of the Heme Axial Ligands in the Hemoflavoenzyme, Cellobiose Dehydrogenase." Arch. Biochem. Biophys. 2001, 390, 206-214.

H.L. Youngs, M.D. Sollewijn Gelpke, D. Li, M. Sundaramoorthy and M.H. Gold, "The Role of E39 in Mn^{II} Binding and Oxidation by Manganese Peroxidase from *Phanerochaete chrysosporium*." Biochemistry 2001, 40, 2243-2250.

D. Li, H.L. Youngs and M.H. Gold, "Heterologous Expression of a Thermostable Manganese Peroxidase from *Dichomitus squalens* in *Phanerochaete chrysosporium*." Arch. Biochem. Biophys. 2001, 385, 348-356.

B. Ma, M.B. Mayfield and M.H. Gold, "The Green Fluorescent Protein Gene Functions as a Reporter of Gene Expression in *Phanerochaete chrysosporium*." Appl. Environ. Microbiol. 2001, 67, 948-955.

THOMAS M. LOEHR

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RESEARCH INTERESTS

Metallobiochemistry; biological role of transition metals; molecular and electronic structures of metalloenzyme active sites; chemistry of O_2 metabolism; metal-oxo intermediates; resonance and FT Raman, FT-IR, and EPR spectroscopy.

REPRESENTATIVE PUBLICATIONS

J. Hirst, S.K. Wilcox, J. Ai, P. Moënne-Loccoz, T.M. Loehr and D.B. Goodin, "Replacement of the Axial Histidine Ligand with Imidazole in Cytochrome *c* Peroxidase. 2. Effects on Heme Coordination and Function." Biochemistry 2001, 40, 1274-1283.

J. Baldwin, W.C. Voegtli, N. Khidekel, P. Moënne-Loccoz, C. Krebs, B.A. Ley, B.H. Huynh, T.M. Loehr, A. C. Rosenzweig and J.M. Bollinger, Jr., "Rational Reprogramming of the R2 Subunit of *Escherichia coli* Ribonucleotide Reductase into a Self-Hydroxylating Monooxygenase." J. Am. Chem. Soc. 2001, 123, 7017-7030.

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Y. Liu, L. Koenigs Lightning, H.-w. Huang, P. Moënne-Loccoz, D.J. Schuller, T.L. Poulos, T.M. Loehr and P.R. Ortiz de Montellano, "Replacement of the Distal Glycine 139 Transforms Human Heme Oxygenase-1 into a Peroxidase." J. Biol. Chem. 2000, 275, 34501-34507.

L.S. Koo, R.A. Tschirret-Guth, W.E. Straub, P. Moënne-Loccoz, T.M. Loehr and P.R. Ortiz de Montellano, "The Active Site of the Thermophillic cyp119 from *Sulfolobus solfataricus*." J. Biol. Chem. 2000, 275, 14112-14123.

PIERRE MOËNNE-LOCCOZ

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RESEARCH INTERESTS

Structure-function relationships within proteins. Metallo- and heme-proteins. Spectroscopic studies of enzyme-active sites and their cofactors. Reaction intermediates within catalysts.

REPRESENTATIVE PUBLICATIONS

R.A. Ghiladi, K.R. Hatwell, K.D. Karlin, H.-w. Huang, P. Moënne-Loccoz, C. Krebs, B.H. Huynh, L.A. Marzilli, R.J. Cotter, S. Kaderli and A.D. Zuberbuhler, "Dioxygen Reactivity of Mononuclear Heme and Copper Components Yielding a High-Spin Heme-Peroxo-Cu Complex." J. Am. Chem. Soc. 2001, 123, 6183-6184.

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P. Moënne-Loccoz, O.-M.H. Richter, H.-w. Huang, I. Wasser, R.A. Ghiladi, K.D. Karlin and S. de Vries, "Nitric Oxide Reductase from *Paracoccus denitrificans* Contains an Oxo-Bridged Heme/Non-Heme Diiron Center." J. Am. Chem. Soc. 2000, 122, 9344-9345.

A. Wilks and P. Moënne-Loccoz, "Identification of the Proximal Ligand His-20 in Heme Oxygenase (HmuO) from *Corynebacterium diphtheriae*. Oxidative Cleavage of the Heme Macrocycle Does Not Require the Proximal Histidine." J. Biol. Chem. 2000, 275, 11686-11692.

P. Moënne-Loccoz, C. Krebs, K. Herlihy, D.E. Edmondson, E.C. Theil, B.H. Huynh and T.M. Loehr, "The Ferroxidase Reaction of Ferritin Reveals a Diferric mu-1,2 Bridging Peroxide Intermediate in Common with Other O_2-Activating Non-Heme Diiron Proteins." Biochemistry 1999, 38, 5290-5295.

MICHIKO NAKANO

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RESEARCH INTERESTS

Anaerobiosis of *Bacillus subtilis*; oxygen-controlled gene regulation; two-component signal transduction system; transcriptional activation; nitrate/nitrite reductases; flavohemoglobin; anaerobic electron transport; nitric oxide signaling.

REPRESENTATIVE PUBLICATIONS

M.M. Nakano and Y. Zhu, "Involvement of the ResE Phosphatase Activity in Down-Regulation of ResD-Controlled Genes in *Bacillus subtilis* During Aerobic Growth." J. Bacteriol. 2001, 183, 1938-1944.

M.M. Nakano, Y. Zhu, M. LaCelle, X. Zhang and F.M. Hulett, "Interaction of ResD with Regulatory Regions of Anaerobically Induced Genes in *Bacillus subtilis*." Mol. Microbiol. 2000, 37, 1198-1207.

M.M. Nakano, Y. Zhu, J. Liu, D.Y. Reyes, H. Yoshikawa and P. Zuber, "Mutations Conferring Amino Acid Residue Substitutions in the Carboxy-Terminal Domain of RNA Polymerase alpha Can Suppress *clpX* and *clpP* with Respect to Developmentally Regulated Transcription in *Bacillus subtilis*." Mol. Microbiol. 2000, 37, 869-884.

M.M. Nakano, G. Zheng and P. Zuber, "Dual Control of *sbo-alb* Operon Expression by the Spo0 and ResDE Systems of Signal Transduction Under Anaerobic Conditions in *Bacillus subtilis*." J. Bacteriol. 2000, 182, 3274-3277.

C. Jourlin-Castelli, N. Mani, M.M. Nakano and A.L. Sonenshein, "CcpC, a Novel Regulator of the LysR Family Required for Glucose Repression of the *citB* Gene in *Bacillus subtilis*." J. Mol. Biol. 1999, 295, 865-878.

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Dr.Rer.Nat., Biophysics and Chemical Physics
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RESEARCH INTERESTS

Molecular biophysics of mitochondrial cation transporters and channels, with emphasis on the ATP-dependent K^+ channel in cardiac and brain mitochondria; receptor properties and their roles in cellular signaling, bioenergetics and pharmacology.

REPRESENTATIVE PUBLICATIONS

R. Bajgar, S. Seetharaman, A.J. Kowaltowski, K.D. Garlid and P. Paucek, "Identification and Properties of a Novel Intracellular (Mitochondrial) ATP-Sensitive Potassium Channel in Brain." J. Biol. Chem. 2001, 276, 3369-33374.

G.J. Grover, A.J. D'Alonzo, K.D. Garlid, N.J. Lodge, P.G. Sleph, R.B. Darbenzio, T.A. Hess, M.A. Smith, P. Paucek and K.S. Atwal, "Pharmacologic Characterization of BMS-101-05, a Mitochondrial K_{ATP} Opener with No Peripheral Vasodilator or Cardiac Action Potential Shortening Activity." J. Pharmacol. Exp. Ther. 2001, 297, 1184-1192.

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M. Jaburek, V. Yarov-Yarovoy, P. Paucek, W. Li and K.D. Garlid "State-Dependent Inhibition of the Mitochondrial KATP Channel by Glyburide and 5-Hydroxydecanoate." J. Biol. Chem. 1998, 273, 13578.

K.D. Garlid, P. Paucek, V. Yarov-Yarovoy, H.N. Murray, R.B. Darbenzio, A.J. D'Alonzo, N.J. Lodge, M.A. Smith and G.J. Grover. "Cardioprotective Effect of Diazoxide and Its Interaction with Mitochondrial ATP-Sensitive K^+ Channels: Possible Mechanism of Cardioprotection." Circ. Res. 1997, 81, 1072.

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Ph.D., Chemistry
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RESEARCH INTERESTS

Metallobiochemistry; structure-function analysis of metalloenzymes. Spectroscopic characterization of copper transporters such as Wilson's and Menkes disease protein, using extended X-ray absorption fine structure spectroscopy (EXAFS). Cloning, overexpression and characterization of proteins involved in copper transport in the mammalian cell.

REPRESENTATIVE PUBLICATIONS

J.F. Eisses, J.P. Stasser, M. Ralle, J.H. Kaplan and N.J. Blackburn, "Domains I and III of Human Copper Chaperone for Superoxide Dismutase Interact via a Cysteine-Bridged Dicopper(I) Cluster." Biochemistry 2000, 38, 7337-7342.

N.J. Blackburn, M. Ralle, R. Hassett and D.J. Kosman, "Spectroscopic Analysis of the Trinuclear Cluster in the Fet3 Protein from Yeast, a Multinuclear Copper Oxidase." Biochemistry 2000, 39, 2316-2324.

M. Ralle, M.L. Verkhovskaya, J.E. Morgan, M.I. Verkhovsky, M. Wikstrom and N.J. Blackburn, "Coordination of CuB in Reduced and CO-liganded States of Cytochrome *bo3* from *Escherichia coli*. Is Chloride Ion a Cofactor?" Biochemistry, 1999, 38, 7185-7194.

N.J. Blackburn, M. Ralle, E. Gomez, M.G. Hill, A. Pastuszyn, D. Sanders and J.A. Fee, "Selenomethionine-substituted *Thermus thermophilus* Cytochrome ba3: Characterization of the CuA Site by Se and Cu K-EXAFS." Biochemistry, 1999, 38, 7075-7084.

M. Ralle, M.J. Cooper, S. Lutsenko and N.J. Blackburn, "The Menkes Disease Protein Binds Copper via Novel 2-Coordinate Cu(I)-Cysteinates in the N-Terminal Domain." J. Am. Chem. Soc. 1998, 120, 13525-13526.

L.E.L. (BETS) RASMUSSEN
Research Professor
Ph.D., Neurochemistry
Washington University
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betsr@bmb.ogi.edu

RESEARCH INTERESTS

Mammalian chemocommunication: the transport, olfactory and vomeronasal organ reception of (Z)-7-dodecenyl acetate, the sex pheromone of the Asian elephant; the origin and synthesis of (Z)-7-dodecenyl acetate; identification and function of pheromones and chemical signals of the elephant-unique temporal gland.

REPRESENTATIVE PUBLICATIONS

L.E.L. Rasmussen, "Source and Cyclic Release Pattern of (Z)-7-Dodecenyl Acetate, the Preovulatory Pheromone of the Female Asian Elephant." Chem. Senses 2001, 26, 611-623.

L.E.L. Rasmussen and V. Krishnamurthy, "How Chemical Signals Integrate Asian Elephant Society: The Known and the Unknown." Zoo Biol. 2000, 19, 405-423.

L.E.L. Rasmussen, "Elephant Olfaction." ChemoSenses, 1999, 2, 4-5.

L.E.L. Rasmussen and T.E. Perrin, "Physiological Correlates of Musth: Lipid Metabolites and Chemosignal Composition." Physiol. Behav. 1999, 67, 539-549.

L.E.L. Rasmussen, "Chemical Communication: An Integral Part of Functional Asian Elephant (*Elephas maximus*) Society." Ecoscience 1998, 5, 410-426.

MATTHEW S. SACHS
Associate Professor
Ph.D., Biology
Massachusetts Institute of Technology, 1986
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RESEARCH INTERESTS

Mechanisms of translational and transcriptional control that regulate the expression of the *Neurospora crassa arg-2* and *Saccharomyces cerevisiae CPA1* genes; translational control of human proto-oncogenes; fungal genomes.

REPRESENTATIVE PUBLICATIONS

D.D. Perkins, A. Radford and M.S. Sachs, The *Neurospora Compendium: Chromosomal Loci*. Academic Press, 2001.

H.S. Kelkar, J. Griffiths, M.E. Case, S.F. Covert, D.A. Hall, C. Keith, J.S. Oliver, M.J. Orbach, M.S. Sachs, J.R. Wagner, M.J. Weise, J.K. Wunderlich and J. Arnold, "The *Neurospora Crassa* Genome: Libraries Sorted by Chromosome." Genetics 2001, 157, 979-990.

P. Fang, Z. Wang and M.S. Sachs, "Evolutionarily Conserved Features of the Arginine Attenuator Peptide Provide the Necessary Requirements for its Function in Translational Regulation." J. Biol. Chem. 2000, 275, 26710-26719.

A.P. Geballe and M.S. Sachs, "Translational Control by Upstream Open Reading Frames," in *Translational Control of Gene Expression* (N. Sonenberg, J.W. B. Hershey and M.B. Mathews, eds.), Cold Spring Harbor Laboratory Press, New York, 2000, pp. 595-614.

Z. Wang, A. Gaba and M.S. Sachs, "A Highly Conserved Mechanism of Regulated Ribosome Stalling Mediated by Fungal Arginine Attenuator Peptides That Appears Independent of the Charging Status of Arginyl-tRNAs." J. Biol. Chem. 1999, 274, 37565-37574.

JAMES W. WHITTAKER
Associate Professor
Ph.D., Biochemistry
University of Minnesota, 1983
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RESEARCH INTERESTS

Electronic structures and dynamics of metalloenzyme active sites; spectroscopic and computational approaches to biomolecular structure; metalloenzyme mechanisms; enzyme engineering; biology of metal ions.

REPRESENTATIVE PUBLICATIONS

M.M. Whittaker and J.W. Whittaker, "Catalytic Reaction Profile for Alcohol Oxidation by Galactose Oxidase." Biochemistry 2001, 40, 7140-7148.

R.A. Edwards, M.M. Whittaker, J.W. Whittaker, E.N. Baker and G.B. Jameson, "Outer Sphere Mutations Perturb Metal Reactivity in Manganese Superoxide Dismutase." Biochemistry 2001, 40, 15-27.

M.M. Whittaker and J.W. Whittaker, "Expression of Recombinant Galactose Oxidase by *Pichia pastoris*." Protein Expr. Purif. 2000, 20, 105-111.

M.M. Whittaker and J.W. Whittaker, "Recombinant Superoxide Dismutase from a Hyperthermophilic Archaeon, *Pyrobaculum aerophilium*." J. Biol. Inorg. Chem. 2000, 5, 402-408.

M.M. Whittaker, V.V. Barynin, S.V. Antonyuk and J.W. Whittaker, "The Oxidized (3,3) State of Manganese Catalase. Comparison of Enzymes from *Thermus thermophilus* and *Lactobacillus plantarum*." Biochemistry 1999, 38, 9126-9136.

GEBRETATEOS WOLDEGIORGIS

Associate Professor
Ph.D., Nutritional Biochemistry
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RESEARCH INTERESTS

Regulation of carnitine palmitoyltransferase I; regulation of long-chain fatty acid transport and oxidation in mammalian cells; regulation of cell metabolism and signaling by long-chain acyl CoA esters; mitochondrial ion transport and bioenergetics.

REPRESENTATIVE PUBLICATIONS

C. Nicot, F.G. Hegardt, G. Woldegiorgis, D. Haro and P.F. Marrero, "Pig Liver Carnitine Palmitoyltransferase I, with low K_m for Carnitine and High Sensitivity to Malonyl-CoA Inhibition, is a Natural Chimera of Rat Liver and Muscle Enzymes." Biochemistry 2001, 40, 2260-2266.

J. Dai, H. Zhu, J. Shi and G. Woldegiorgis, "Identification by Mutagenesis of Conserved Arginine and Tryptophan Residues in Rat Liver Carnitine Palmitoyltransferase I Important for Catalytic Activity." J. Biol. Chem. 2000, 275, 22020-22024.

J. Shi, H. Zhu, D.N. Arvidson and G. Woldegiorgis, "The First 28 N-Terminal Amino Acid Residues of Human Heart Muscle Carnitine Palmitoyltransferase I are Essential for Malonyl CoA Sensitivity and High-Affinity Binding." Biochemistry 2000, 39, 712-717.

G. Woldegiorgis, J. Shi, H. Zhu and D.N. Arvidson, "Functional Characterization of Mammalian Mitochondrial Palmitoyltransferases I and II Expressed in the Yeast *Pichia pastoris*." J. Nutr. 2000, 130, 310S-314S.

L. Abu-Elheiga, W.R. Brinkley, L. Zhong, S.S. Chirala, G. Woldegiorgis and S.J. Wakil, "The Subcellular Localization of Acetyl-CoA Carboxylase 2." Proc. Natl. Acad. Sci. USA 2000, 97, 1444-1449.

PETER ZUBER

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Ph.D., Microbiology
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RESEARCH INTERESTS

Regulation of prokaryotic gene expression and development in response to stress; signal transduction; regulation and mechanism of peptide antibiotic biosynthesis; regulation of genetic competence in *Bacillus subtilis*.

REPRESENTATIVE PUBLICATIONS

P. Zuber, "Specificity Through Flexibility." Nat. Struct. Biol. 2000, 7, 1079-1081.

J. Liu and P. Zuber, "The ClpX Protein of *Bacillus subtilus* Indirectly Influences RNA Polymerase Holoenzyme Composition and Directly Stimulates Sigma^H-Dependent Transcription *In Vitro*." Mol. Microbiol. 2000, 37, 885-897.

G. Zheng, R. Hehn and P. Zuber, "Mutational Analysis of the *sbo-alb* Locus of *Bacillus subtilis*: Identification of Genes Required for Subtilosin Production and Immunity." J. Bacteriol. 2000, 182, 3266-3273.

M.M. Nakano, Y. Zhu, J. Liu, D.Y. Reyes, H. Yoshikawa and P. Zuber, "Mutations Conferring Amino Acid Residue Substitutions in the Carboxy-Terminal Domain of RNA Polymerase Alpha Can Suppress clpX and clpP with Respect to Developmentally Regulated Transcription in *Bacillus subtilis*." Mol. Microbiol. 2000, 37, 869-884.

M.M. Nakano, G. Zheng and P. Zuber, "Dual Control of *sbo-alb* Operon Expression by the Spo0 and ResDE Systems of Signal Transduction Under Anaerobic Conditions in *Bacillus subtilis*." J. Bacteriol. 2000, 182, 3274-3277.

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THE DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING has an internationally acclaimed research program. The breadth and depth of the research program is evidenced by the research projects and research centers listed below, and by the educational program.

Four degrees are offered: Master of Science in Computer Science and Engineering, Master of Science in Computational Finance, Oregon Master of Software Engineering, and Doctor of Philosophy in Computer Science and Engineering. In addition to these degrees, we offer a Certificate in Computational Finance, Applied Computing, and Oregon Master of Software Engineering.

ADMISSION REQUIREMENTS

Admission requirements are the same as the general requirements of the institution. General aptitude GRE scores are required, except in cases of advanced placement admission for M.S. students (see below). A candidate must hold a bachelor's degree in computer science, mathematics, engineering, one of the biological or physical sciences, or one of the quantitative social sciences. Candidates with a degree in a field other than computer science must have completed courses in the following subject areas:

- An introduction to programming in a high-level language
- Data structures*
- Discrete mathematics*
- Logic design and computer organization
- Calculus or other college-level mathematics

*APC515 Data Structures and Discrete Mathematics may be taken to meet the prerequisite.

ADVANCED PLACEMENT ADMISSIONS FOR MS STUDENTS

Students who are currently studying at OGI and have earned 12 credits in computer science classes are exempt from the GRE and TOEFL requirements. Only two letters of recommendation are required; all other admissions requirements remain the same. The CSE courses must include at least two, preferably three, courses from the MS Core (list follows). Students must earn an overall Grade Point Average of 3.0 and a B or better in each MS Core class to be eligible to apply through Advanced Placement:

CSE500	**Introduction to Software Engineering**
CSE511	**Principles of Compiler Design**
CSE513	**Introduction to Operating Systems**
CSE514	**Introduction to Database Systems**
CSE521	**Introduction to Computer Architecture**
CSE532	**Analysis and Design of Algorithms**
CSE533	**Automata and Formal Languages**
	If a student applies to the Computational Finance program through advanced placement, the 12 credits earned may be from CSE, ECE APC or FIN courses.

DEGREE REQUIREMENTS

A Student Program Committee (SPC) that provides academic advising is assigned for each matriculating student. The student's SPC also approves the application of courses toward the degree requirements.

A maximum of 21 credits earned prior to matriculation at OGI may be applied toward the master's degree. This may include up to 12 credits transferred from other institutions (up to 18 from Portland State University, the University of Oregon or Oregon State University) and credits taken at OGI prior to matriculation.

The program of study for each master's student may be tailored to meet individual needs by the SPC. Students are particularly encouraged to include special-topic courses (CSE 58X) relevant to their interests.

CSE MS PROFESSIONAL INTERNSHIP OPTION

Participation is limited by available industrial internships. Students declaring this option must complete 45 credits of course work and up to an additional 3 credits of a professional internship. (CSE620)

MASTER OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

All M.S. students must complete the M.S. core of 21 credits.

M.S. CSE CORE

The following courses are required of all M.S. CSE students:

CSE500	**Introduction to Software Engineering**	**3 credits**
CSE511	**Principles of Compiler Design**	**3 credits**
CSE513	**Introduction to Operating Systems**	**3 credits**
CSE514	**Introduction to Database Systems**	**3 credits**
CSE521	**Introduction to Computer Architecture**	**3 credits**

Doctoral student Francis Chang (left) and faculty member Wu-chang Feng are working on network support for streaming digital media.

CSE532	Analysis and Design of Algorithms	3 credits
CSE533	Automata and Formal Languages	3 credits

M.S. THESIS OPTION

Students choosing the thesis option must submit and defend a master's thesis and may apply up to 12 credits of thesis research (CSE 700) toward the 45 credit requirement.

1. M.S. CSE CORE (listed above)
2. CSE 700 M.S. THESIS (maximum 12 credits)
3. ELECTIVES (12 credits), as directed by the thesis advisor or SPC

Please note: Students may not receive credit for both CSE504 and OMSE533.

M.S. NONTHESIS OPTIONS

Students choosing the nonthesis M.S. option must complete 15 courses and a minimum of 45 credits; up to six credits of nonthesis research (CSE 610) may be included, with the approval of the student's SPC. Students matriculated prior to Winter Quarter 2002 are exempt from the 15 course requirement. Students pursuing the non-thesis option may choose one of the nine areas of emphasis defined below or consult their SPC to define a custom program.

ADAPTIVE SYSTEMS AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE CORE (listed above)
2. ADAPTIVE SYSTEMS CORE (12 credits):

Required:

CSE547	Statistical Pattern Recognition	3 credits
CSE560	Artificial Intelligence	3 credits

Choose two of:

CSE540	Neural Network Algorithms & Architecture	3 credits
CSE545	Advanced Neural and Adaptive Algorithms	3 credits
CSE546	Data and Signal Compression	3 credits
CSE548	Statistical Computing	3 credits
CSE550	Spoken Language Systems	3 credits
CSE562	Natural Language Processing	3 credits
CSE564	Human-Computer Interaction	3 credits
CSE568	Empirical Research Methods	3 credits
ECE554	Adaptive Signal Processing	4 credits

3. SUGGESTED ELECTIVES (12 credits)

CSE563	Multi-Agent Systems	3 credits
CSE569	Scholarship Skills	3 credits
CSE58X	appropriate special topics course (or) any CSE class not already taken	

Please note: Students may not receive credit for both CSE504 and OMSE533.

COMPUTATIONAL FINANCE AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE Core (listed above)
2. COMPUTATIONAL FINANCE CORE (18 credits):

Required: (Choose 6 of the following:)

FIN541	Principles of Modern Finance	3 credits
FIN544	Investment and Portfolio Management	3 credits
FIN547	Global Markets and Foreign Exchange	3 credits
FIN551	Options and Futures	3 credits
FIN552	Options and Futures II	3 credits
FIN558	Advanced Numerical Computing in Finance	3 credits
FIN561	Risk Management	3 credits
FIN573	Financial Time-Series Analysis	3 credits
FIN576	Financial Markets and Trading	3 credits
FIN585	Topics in Computational Finance	3 credits

3. SUGGESTED ELECTIVES (6 credits)

CSE509	Object-Oriented Programming	3 credits
CSE540	Neural Network Algorithms & Architecture	3 credits
CSE544	Introduction to Probability and Statistical Inference	3 credits
CSE545	Advanced Neural and Adaptive Algorithms	3 credits
CSE546	Data and Signal Compression	3 credits
CSE547	Statistical Pattern Recognition	3 credits
CSE548	Statistical Computing	3 credits
CSE549	Applied Business Forecasting	3 credits
CSE555	Mathematical Methods for Engineering & Finance	3 credits
CSE564	Human-Computer Interaction	3 credits
CSE568	Empirical Research Methods	3 credits
CSE58X	Special Topics	
ECE525	Analytical Techniques in Process & Communication	4 credits
ECE555	Engineering Optimization (or) any CSE class not already taken	4 credits

Please note: Students may not receive credit for both CSE504 and OMSE533

COMPUTER SECURITY AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE CORE (listed above)
2. COMPUTER SECURITY CORE (15 credits)

Required:

CSE503	Software Engineering Processes	3 credits
CSE524	TCP/IP Internetworking Protocols	3 credits
CSE527	Principles and Practices of System Security	3 credits
CSE58X	Cryptography	3 credits
CSE58X	Security Assurance	3 credits

3. SUGGESTED ELECTIVES (9 credits)

CSE515	Distributed Computing Systems (or) any CSE class not already taken.	3 credits

Please note: Students may not receive credit for both CSE504 and OMSE533

DATA-INTENSIVE SYSTEMS AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE Core (listed above)
2. DATA-INTENSIVE SYSTEMS CORE (12 credits)

Four of:

CSE515	Distributed Computing Systems	3 credits
CSE526	Modern Operating System Design	3 credits
CSE541	Database Implementation	3 credits
CSE542	Object Data Management	3 credits
CSE58X	Informational Retrieval and the Internet	3 credits
CSE58X	Any special topics course in the database area	

One course from the System Software Core

One course from the Software Engineering Core or the Software Engineering for Industry Professionals Core

3. SUGGESTED ELECTIVES (12 credits)

Any CSE class not already taken.

Please note: Students may not receive credit for both CSE504 and OMSE533.

HUMAN-COMPUTER INTERFACES AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE CORE (listed above)
2. HUMAN-COMPUTER INTERFACES CORE (18 credits)

Required:

CSE560	Artificial Intelligence	3 credits
CSE564	Human-Computer Interaction	3 credits

Choose four of:

CSE547	Statistical Pattern Recognition	3 credits
CSE551	Structure of Spoken Language	3 credits
CSE552	Hidden Markov Models for Speech Recognition	3 credits
CSE561	Dialogue	3 credits
CSE562	Natural Language Processing	3 credits
CSE563	Multi Agent Systems	3 credits
CSE567	Developing User-Oriented Systems	3 credits
CSE568	Empirical Research Methods	3 credits
CSE58X	Any special topics course appropriate to this area	

3. SUGGESTED ELECTIVES (6 credits)

CSE507	Logic Programming	3 credits
CSE515	Distributed Computing Systems	3 credits
CSE540	Neural Network Algorithms & Architecture	3 credits
CSE569	Scholarship Skills	3 credits
	(or) any CSE class not already taken.	

Please note: Students may not receive credit for both CSE 04 and OMSE533.

SOFTWARE ENGINEERING AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE CORE (listed above)
2. SOFTWARE ENGINEERING CORE (15 credits)

Required:

CSE503	Software Engineering Processes	3 credits
CSE504	Object-Oriented Analysis and Design	3 credits
CSE509	Object-Oriented Programming	3 credits

MST512	**Project Management**	**3 credits**

Choose one of:

CSE564	**Human-Computer Interaction**	**3 credits**
CSE567	**Developing User-Oriented Systems**	**3 credits**

3. SUGGESTED ELECTIVES (9 credits)

Any CSE class not already taken

Please note: Students may not receive credit for both CSE504 and OMSE533.

SOFTWARE ENGINEERING FOR INDUSTRY PROFESSIONALS AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE CORE (listed above)

2. SOFTWARE ENGINEERING FOR INDUSTRY PROFESSIONALS CORE (15 credits)

Required:

OMSE511	**Managing Software Development**	**3 credits**
OMSE521	**Using Metrics & Models**	**3 credits**
OMSE531	**Software Requirements Engineering**	**3 credits**
OMSE533	**Software Design Techniques**	**3 credits**

Choose one of:

CSE564	**Human-Computer Interaction**	**3 credits**
CSE567	**Developing User-Oriented Systems**	**3 credits**

3. SUGGESTED ELECTIVES (9 credits)

Any CSE course not already taken.

Please note: Students may not receive credit for both CSE504 and OMSE533.

SPOKEN LANGUAGE SYSTEMS AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1 M.S. CSE CORE (listed above)

2. SPOKEN LANGUAGE SYSTEMS CORE (12-16 credits)

Three of:

CSE550	**Spoken Language Systems**	**3 credits**
CSE551	**Structure of Spoken Language**	**3 credits**
CSE552	**Hidden Markov Models for Speech Recognition**	**3 credits**
CSE561	**Dialogue**	**3 credits**
CSE562	**Natural Language Processing**	**3 credits**
ECE541	**Speech Processing**	**3 credits**
ECE545	**Speech Systems**	**4 credits**
ECE58X	**Speech Synthesis**	**4 credits**

Choose one of the following or one more from the above list:

CSE540	**Neural Network Algorithms & Architectures *(S)***	**3 credits**
CSE545	**Advanced Neural & Adaptive Algorithms**	**3 credits**
CSE547	**Statistical Pattern Recognititon**	**3 credits**
CSE560	**Artificial Intelligence**	**3 credits**
CSE564	**Human Computer Interaction**	**3 credits**
CSE568	**Empirical Research Methods**	**3 credits**
ECE540	**Auditory & Visual Proc. by Human & Machine**	**4 credits**
ECE544	**Intro to Signals, Systems and Info. Processing**	**4 credits**
ECE551	**Introduction to Digital Signal Processing**	**4 credits**
ECE552	**Digital Signal Processing II**	**4 credits**
ECE554	**Adaptive Signal Processing**	**4 credits**

3. SUGGESTED ELECTIVES (8-12 credits)

Courses in the Spoken Language Systems core, or any CSE classes not already taken.

Please note: Students may not receive credit for both CSE 504 and OMSE 533.

SYSTEMS SOFTWARE AREA OF EMPHASIS NONTHESIS M.S. CSE DEGREE

1. M.S. CSE CORE (listed above)

2. SYSTEMS SOFTWARE CORE (12 credits)

Choose four of:

CSE515	**Distributed Computing Systems**	**3 credits**
CSE524	**TCP/IP Internetworking Protocols**	**3 credits**
CSE526	**Modern Operating System Design**	**3 credits**
CSE527	**Principles and Practices of System Security**	**3 credits**
CSE541	**Database Implementation**	**3 credits**
CSE58X	**Internet Technology**	**3 credits**
CSE58X	**Multi-Media Networking**	**3 credits**
CSE58X	**plus any special topics courses appropriate to this area**	

3. SUGGESTED ELECTIVES (12 credits)

Any course in the Systems Software area core or any CSE class not already taken.

Please note: Students may not receive credit for both CSE 504 and OMSE 533.

MASTER OF SCIENCE IN COMPUTATIONAL FINANCE

The Master of Science in Computational Finance is an interdisciplinary program offering students the flexibility to learn technical skills directly relevant to quantitative or computational work in the financial securities industry. A professional internship track is also available. (see below)

1. M.S. IN COMPUTATIONAL FINANCE CORE (24 credits)

Choose eight of:

FIN541	**Principles of Modern Finance**	**3 credits**
FIN544	**Investment and Portfolio Management**	**3 credits**
FIN547	**Global Markets and Foreign Exchange**	**3 credits**
FIN551	**Options and Futures I**	**3 credits**
FIN552	**Options and Futures II**	**3 credits**
FIN558	**Advanced Numerical Computing in Finance**	**3 credits**
FIN561	**Risk Management**	**3 credits**
FIN573	**Financial Time Series Analysis**	**3 credits**
FIN576	**Financial Markets and Trading**	**3 credits**
FIN585	**Topics in Computational Finance**	

2. BREADTH REQUIREMENT (21 credits)

Breadth requirement courses must come from at least two of the following tracks. The course lists for each track are representative, not exhaustive. Students with strong backgrounds or special interests may request approval to substitute other OGI courses in place of those listed below:

A. APPLIED COMPUTING		
APC500	**Development with Visual Basic for Applications**	**3 credits**
APC501	**Accelerated Development with Visual Basic**	**3 credits**
APC503	**Web Development with Perl 5**	**3 credits**
APC505	**Applications Programming in C++**	**3 credits**
APC506	**Advanced Applications Programming in C++**	**3 credits**
APC508	**Web Development with Java 2**	**3 credits**
APC511	**Computational Tools for Engineering and Finance**	**3 credits**
APC515	**Data Structures and Discrete Math**	**3 credits**
B. COMPUTER SCIENCE		
CSE500	**Principles of Software Engineering**	**3 credits**
CSE503	**Software Engineering Processes**	**3 credits**
CSE504	**Object-Oriented Analysis and Design**	**3 credits**
CSE509	**Object-Oriented Programming**	**3 credits**
CSE514	**Introduction to Database Systems**	**3 credits**
CSE532	**Analysis and Design of Algorithms**	**3 credits**
C. APPLIED MATHEMATICS, STATISTICS, AND MACHINE LEARNING		
CSE540	**Neural Network Algorithms and Architectures**	**3 credits**
CSE544	**Introduction to Probability and Statistical Inference**	**3 credits**
CSE545	**Advanced Neural and Adaptive Algorithms**	**3 credits**
CSE547	**Statistical Pattern Recognition**	**3 credits**
CSE548	**Modern Applied Statistics**	**3 credits**
CSE549	**Applied Business Forecasting**	**3 credits**
CSE555	**Mathematical Methods for Science and Engineering**	**3 credits**
CSE556	**Simulation and Optimization**	**3 credits**
D. ENGINEERING		
ECE525	**Analytical Techniques in Statistical Signal Processing**	**4 credits**
ECE544	**Introduction to Signals, Systems and Information Processing**	**4 credits**
ECE550	**Linear Systems**	**4 credits**
ECE551	**Introduction to Digital Signal Processing**	**4 credits**
ECE554	**Adaptive Signal Processing**	**4 credits**
ECE555	**Engineering Optimization**	**3 credits**
E. MANAGEMENT SCIENCE		
MST501	**Managerial & Financial Accounting**	**4 credits**
MST502	**Financial Management**	**4 credits**
MST512	**Project Management**	**3 credits**
MST520	**Managing in Science and Technology**	**4 credits**
MST540	**International Management in Science & Technology**	**3 credits**

F. FINANCE	
	Finance core courses beyond the 8-course core requirement.

MASTER OF SCIENCE, COMPUTATIONAL FINANCE PROFESSIONAL INTERNSHIP PROGRAM

Participation in this program option is limited by available industrial internships. For students declaring this option, the breadth requirement courses must come from at least one of the tracks previously listed, plus FIN620 Professional Internship in Finance.

OREGON MASTER OF SOFTWARE ENGINEERING (OMSE)

OGI School of Science and Engineering, Portland State University, Oregon State University, and the University of Oregon jointly offer the Oregon Master of Software Engineering (OMSE) degree to meet the needs of software professionals. The curriculum emphasizes the technical and leadership aspects of software engineering, teamwork and communication skills, and the business aspects of developing industrial-strength software. Admission requirements include a B.S. with pre-foundation courses in programming, discrete mathematics, data structures, operating systems, and computer architecture as well as two years of working experience. Courses may be taken on non-admitted basis. For additional information, see www.omse.org.

Oregon Master of Software Engineering students will take the following courses:

OMSE500	Principles of Software Engineering	3 credits
OMSE511	Managing Software Development	3 credits
OMSE512	Understanding the Software Business	3 credits
OMSE513	Professional Communication Skills for Software Engineers	3 credits
OMSE521	Using Metrics and Models to Support QuantitativeDecision Making	3 credits
OMSE522	Modeling and Analysis of Software Systems	3 credits
OMSE525	Software Quality Analysis 3 credits	
OMSE531	Software Requirements Engineering	3 credits
OMSE532	Software Architecture and Domain Analysis	3 credits
OMSE533	Software Design Techniques	3 credits
OMSE535	Software Implementation and Testing	3 credits
OMSE551	Strategic Software Engineering	3 credits
OMSE555	Software Development Practicum I	3 credits
OMSE556	Software Development Practicum II	3 credits
	Any two CSE or OMSE classes not already taken. 6 credits	

The courses on software development in context provide instruction in the basic areas of software development: requirements, architecture, design, implementation, and testing. The course material in each of these areas provides instruction in underlying principles, development methods and tools, and analytic methods and tools with a focus on applying principles, techniques and tools. Course material focuses on applying techniques and skills from the foundation courses to realistic examples of the products of each development phase. Course emphasis is on understanding the application and effect of the techniques covered in the context of real software development.

OMSE 531	Software Requirements Engineering	3 credits
OMSE 532	Software Architecture and Domain Analysis	3 credits
OMSE 533	Software Design Techniques	3 credits
OMSE 535	Software Implementation and Testing	3 credits
PART 3:	PROGRAM INTEGRATION AND STRATEGIC DEVELOPMENT SKILLS (9 Credits)	

Courses in this area focus on integrating the skills taught in the OMSE program and on the ability to think abstractly about the processes and products of software engineering. Students must have completed Part 1 and Part 2 of the OMSE program before beginning Part 3. (Exception: A student may begin taking courses in Part 3 in the same term as taking any remaining courses in the first two parts.) In OMSE 551, Strategic Software Engineering students learn the skills necessary to understand, model, and adapt their software engineering processes to meet emerging needs. In OMSE 555/556, the Software Development Practicum, students participate in the end-to-end development of a significant software product and apply the personal competencies and development skills learned throughout the program in a development context that includes the essential characteristics of real commercial software development.

OMSE 551	Strategic Software Engineering	3 credits
OMSE 555	Software Development Practicum I	3 credits
OMSE 556	Software Development Practicum II	3 credits
PART 4:	ELECTIVES (6 credits)	
	Any CSE or OMSE class not already taken.	

OREGON GRADUATE ENGINEERING INTERNSHIP PROGRAM

For information and availability regarding the OGI School's Department of Computer Science Internships, please contact the department.

COOPERATIVE COMPUTER SCIENCE PROGRAMS

OGI has established undergraduate/graduate cooperative programs with Lewis & Clark College, Pacific University, Reed College, and Willamette University. These programs allow selected undergraduate students to enter the master's program in computer science and engineering at the beginning of their senior year. In two years of residence at OGI, the student can simultaneously fulfill requirements for the bachelor's degree at the undergraduate institution and the master's degree at OGI.

PH.D. PROGRAM

The Ph.D. program is strongly oriented toward preparation for research. Each student has the opportunity to work closely with a faculty research advisor throughout his or her residency at OGI. A student must satisfy the institutional requirements for the Ph.D.

Candidacy is satisfied in three parts:

FOUNDATION REQUIREMENTS: Students are required to take six foundation courses. Particularly well-prepared students can waive some of these courses by passing an examination on the course material.

AREA REQUIREMENTS: Students choose three courses within one area and three courses out of that area, as outlined below.

RESEARCH SKILLS ASSESSMENT: Students are required to take CSE 569 Scholarship Skills and to pass the research proficiency examination (RPE), which requires a written and oral presentation of a research paper. The RPE normally takes place in the spring quarter of the second year of residence.

Ph.D. students must obtain a grade of 'B' or better on each required course. Required courses should be completed by the end of the second year. The doctoral dissertation will document a significant, original research contribution and must be of publishable quality, both in content and presentation.

The faculty strongly recommends that students prepare a formal thesis proposal between 9 and 18 months before the Ph.D. defense. The proposal is not a candidate screening tool, but instead a means to ensure an acceptable level of intellectual vigor and maturity. Starting in the second year, the faculty strongly recommends that students deliver yearly research talks. The RPE, presentation at the student research symposium, the thesis proposal, and talks at refereed conferences satisfy this requirement. Practice talks for conference papers should be open for commentary.

The program of study for each Ph.D. student is tailored to meet individual needs and interests. Each student's Student Program

Committee provides academic advisement and is in direct control of each student's program of study. The SPC will work with the student to set and review goals on a twice-yearly basis. Students must write a progress report for all SPC meetings except the first one.

FOUNDATION REQUIREMENTS (18 credits)		

Required:

CSE513	**Introduction to Operating Systems**	**3 credits**
CSE521	**Introduction to Computer Architecture**	**3 credits**
CSE532	**Analysis and Design of Algorithms**	**3 credits**
CSE533	**Automata and Formal Languages**	**3 credits**

Choose one programming language course:

CSE502	**Functional Programming**	**3 credits**
CSE507	**Logic Programming**	**3 credits**
CSE509	**Object-Oriented Programming**	**3 credits**
CSE531	**Foundations of Semantics**	**3 credits**

Choose one interactive and adaptive systems course:

CSE540	**Neural Network Algorithms and Architectures**	**3 credits**
CSE560	**Artificial Intelligence**	**3 credits**
CSE564	**Human-Computer Interaction**	**3 credits**

DISTRIBUTION REQUIREMENTS (18 credits)		

Three courses from one of the following six areas, and three other courses not from that area not already taken:

Adaptive Systems and Applications		
CSE540	**Neural Network Algorithms and Architectures**	**3 credits**
CSE545	**Advanced Neural and Adaptive Algorithms**	**3 credits**
CSE546	**Data and Signal Compression**	**3 credits**
CSE547	**Statistical Pattern Recognition**	**3 credits**
CSE568	**Empirical Research Methods**	**3 credits**
FIN573	**Financial Time Series Analysis**	**3 credits**
ECE540	**Auditory and Visual Processing by Human and Machine**	**4 credits**
ECE553	**Control Systems: Classical, Neural and Fuzzy**	**4 credits**
ECE554	**Adaptive Signal Processing**	**4 credits**
Human-Computer Interactive Systems		
CSE550	**Spoken Language Systems**	**3 credits**
CSE551	**Structure of Spoken Language**	**3 credits**
CSE552	**Hidden Markov Models for Speech Recognition**	**3 credits**
CSE560	**Artificial Intelligence**	**3 credits**
CSE561	**Dialogue**	**3 credits**
CSE562	**Natural Language Processing**	**3 credits**
CSE563	**Multi-Agent Systems**	**3 credits**
CSE564	**Human-Computer Interaction**	**3 credits**
CSE567	**Developing User-Oriented Systems**	**3 credits**
CSE568	**Empirical Research Methods**	**3 credits**
CSE58X	**Special Topics: Computer Graphics**	**variable**
ECE540	**Auditory and Visual Processing by Human and Machine**	**4 credits**
Programming Languages and Software Engineering		
CSE500	**Introduction to Software Engineering**	**3 credits**
CSE502	**Functional Programming**	**3 credits**
CSE503	**Software Engineering Processes**	**3 credits**
CSE504	**Object-Oriented Analysis and Design**	**3 credits**
CSE507	**Logic Programming**	**3 credits**
CSE509	**Object-Oriented Programming**	**3 credits**
CSE511	**Principles of Compiler Design**	**3 credits**
CSE512	**Compiling Functional Languages**	**3 credits**
CSE518	**Software Design and Development**	**3 credits**
CSE530	**Introduction to Mathematical Logic**	**3 credits**
CSE531	**Foundations of Semantics**	**3 credits**
CSE567	**Developing User-Oriented Systems**	**3 credits**
Systems Software		
CSE509	**Object-Oriented Programming**	**3 credits**
CSE510	**Software Tools**	**3 credits**
CSE514	**Introduction to Database Systems**	**3 credits**
CSE515	**Distributed Computing Systems**	**3 credits**
CSE524	**TCP/IP Internetworking Protocols**	**3 credits**
CSE526	**Modern Operating System Design**	**3 credits**
CSE527	**Principles and Practices of System Security**	**3 credits**
CSE541	**Database Implementation**	**3 credits**
CSE542	**Object Data Management**	**3 credits**
Theory		
CSE530	**Introduction to Mathematical Logic**	**3 credits**
CSE531	**Foundations of Semantics**	**3 credits**
CSE534	**Computability and Intractability**	**3 credits**
CSE535	**Categories in Computer Science**	**3 credits**
RESEARCH SKILLS REQUIREMENT (3 credits)		
CSE569	**Scholarship Skills**	**3 credits**
	Research Proficiency Exam	

COURSE DESCRIPTIONS

CSE500 Introduction to Software Engineering

Software engineering is concerned with the ways in which people conduct their work activities and apply technology to produce and maintain software products and software-intensive systems. Issues of concern include specification, design, implementation, verification, validation, and evolution of software artifacts. Related topics include software metrics, project management, configuration management, quality assurance, peer reviews, risk management, and process improvement. This course presents an integrated view of these topics and related issues. It is an essential course for anyone working in development, maintenance, management, or related areas in a software organization. 3 credits

CSE502 Functional Programming

In functional programming, we shift our focus from data objects and their representations to functions that act on data. Programs are formulated as compositions of functions, rather than as sequences of statements. This leads to a programming methodology that is quite different from that learned in using statement-oriented languages. This course introduces the student to functional notation, recursion, higher-order functions, reasoning about functions, and polymorphic type systems. Functional programming languages are known for their increased productivity and reliability, due in part to the higher levels of abstraction provided by functional languages. Course is taught by lecture with small weekly programming assignments. Experience is gained by programming in the functional language Haskell or one of its close derivatives. Recent advances in functional programming languages allow them to use updatable state in a safe manner and to cause effects on the real world. Students gain experience by writing programs using these features to program interactive window-based programs using an embedded "widget" library. 3 credits

CSE503 Software Engineering Processes

This course is concerned with examining and improving the software development processes, including the technical, managerial, and cultural processes, used by organizations to develop and maintain high quality software systems in a timely and economical manner. Various process models, including the SEI Capability Maturity Models, the ISO SPICE model, the Team Software Process, and the Personal Software Process are studied and contrasted. Tailoring of process models to fit local situations and various approaches to software process improvement are presented. Students select and complete term projects that address topics in software process improvement. 3 credits

CSE504 Object-Oriented Analysis and Design

This course presents an integrated set of techniques for software analysis and design based on object-oriented concepts. The techniques focus on producing the artifacts and work products, expressed in UML, appropriate for the analysis and design phases of the software development lifecycle. We adopt a use case model for requirements and a responsibility-driven approach for the development of object models. Design patterns and frameworks are also emphasized. Note that CSE 509 Object-Oriented Programming is intended as a follow-on course for CSE 504. 3 credits

CSE507 Logic Programming

Logic programming is an attempt to construct computer languages with completely declarative semantics: The programmer only states "what" should be done; the interpreter or compiler must decide "how." This course examines existing logic programming languages, notably Prolog; provides the foundations in logic and theorem proving for such languages; and covers implementation of logic programming languages. Other topics may include an introduction to modal logic and intuitionistic logic. 3 credits

CSE509 Object-Oriented Programming

This course provides a rigorous introduction to the concepts behind object-oriented programming. It is

for students who are already familiar with the concept of object-orientation and with object-oriented analysis and design techniques. One way to learn this background material is by taking CSE 504 Object-Oriented Analysis and Design. In CSE 509, students gain a thorough understanding of incremental programming, type-safety, polymorphism, encapsulation, and set-based abstraction, and apply these concepts through a variety of programming projects. We study several programming languages, including Java and Smalltalk, so students are exposed to different realizations of these concepts and gain an appreciation for the programming language design space. We also look at published object-oriented design patterns and see how they can be implemented in different object-oriented programming languages. Students are required to read appropriate research papers, complete several short programming assignments, complete a substantial programming project, and write some short essays. Prerequisite: CSE 504 or equivalent.
3 credits

CSE511 Principles of Compiler Design
This course introduces the student to the basics of building a compiler using a multi-phase translation process. It covers lexical analysis, parsing, and translation to abstract syntax using modern parser generator technology. It discusses binding of identifiers and symbol table organization, and a variety of intermediate representations that are suitable for back end analysis. It investigates back end transformations and optimizations for a number of languages. Other topics include type checking, static analysis, and basic runtime support. Compiling is essentially a process of symbolically manipulating program representations represented by tree and graph-like data structures. Because of this, we will use tools that facilitate symbolic manipulation and definition of such structures as parser and lexical generators, and tools for generating code from pattern-based descriptions. Prerequisite: CSE 533.
3 credits

CSE512 Compiling Functional Languages
A project-oriented course on the theory and design of a compiler for a typed, functional programming language. Topics include understanding a formal definition of programming language semantics, compiling pattern analysis, lifting abstractions, continuation-passing style of implementation, abstract machines, code generation and address assignment, register allocation and assignment on general-register machines, run-time storage administration, data-flow analysis, and code improvement. Prerequisite: CSE 511. 3 credits

CSE513 Introduction to Operating Systems
A study of the design and implementation of modern operating systems. The course concentrates on operating system kernel design, and includes the following topics: concurrent processes, interprocess communication, synchronization, scheduling, resource allocation, memory management, the concept of virtual memory and the required underlying hardware support, secondary storage management, file systems, and security. We will use the Linux operating system to ground the discussion of abstract concepts. Interested students will be encouraged to read the Linux source code for discussions in class. 3 credits

CSE514 Introduction to Database Systems
A survey of database fundamentals emphasizing the use of database systems. Topics include database design, data dependencies and normalization, secondary storage structures, query languages, query processing, query optimization, transactions, recovery, and embedded SQL. This course focuses on relational database systems and the SQL query language. Students participate in a project to design, populate, and query a database. Prerequisites: Data structures, discrete mathematics, and mathematical logic. 3 credits

CSE515 Distributed Computing Systems
This course concentrates on distributed computing from a systems software perspective. Major topics include communications middleware (remote procedure call, remote method invocation and causal broadcast), operating system support, distributed file systems, distributed transaction processing, load balancing, distributed programming languages and systems, fault-tolerance and replication algorithms, distributed timing issues, and distributed algorithms. Prerequisites: CSE513 Introduction to Operating Systems. (Also a basic understanding of computer communications problems and protocols.)
3 credits

CSE518 Software Design and Development
Contemporary, object-oriented software design, using the Java programming language. An introduction to the eXtreme Programming software development methodology, which is based upon the principle that change is inevitable and successful software designs undergo continual evolution. Techniques that will be taught in the course include program refactoring, automated unit testing, pair programming, participatory design and managing short product development cycles. These principles and techniques will be illustrated in a term-length project that provides members of the class with design and implementation experience. 3 credits

CSE521 Introduction to Computer Architecture
This course provides a broad introduction to computer architecture. The course covers a large amount of material in moderate depth, giving the student a good understanding of the basic issues in computer system design. Specifically, the course covers instruction set design, pipelining, the memory heirarchy, I/O systems, networking issues, and multiprocessors. Example systems include the Intel x86, MIPS, and DEC Alpha processors. Prerequisites: Experience writing software, preferably with some C or assembler programming. NOTE: Computer architecture has become a quantitative science, so there will be considerable algebraic manipulation involved in the performance analysis component of the course. 3 credits

CSE522 Advanced Computer Architecture
This course covers new architectural trends in designing high-performance clusters with examples. Topics to be covered include I/O & IPC interconnects (routing, switch designs, virtual lanes, etc.); single system image and scheduling; lightweight messaging and use-level networking; suitable I/O architectures; commercial cluster interfaces and systems; and presence of clusters in data centers. Commercial and academic examples will be covered for each of the above topics, such as InfiniBandTM, Virtual Interface Architecture (VIA), ServerNet, Beowulf, Memory Channel, etc. Prerequisite: CSE 521.
3 credits

CSE524 TCP/IP Internetworking Protocols
This course provides an overview of the structure and algorithms used in the TCP/IP networking protocols that make up the foundation of the Internet. Protocols and technologies covered will include an introduction to the link layer, ARP, IP, ICMP, UDP, TCP, routing protocols, and application protocols and systems like the DNS, NFS, SMTP, FTP, HTTP, and multicasting protocols and applications. To provide architectural insight into protocol design issues and operating system implementation techniques, typically in terms of the Berkeley UNIX socket programming model. To provide socket programming experience with the client/server model. To provide experience reading Internet RFC's and/or drafts. Prerequisites: familiarity with the functions of a modern multiuser operating system such as is covered in CSE 513 or in PSU's CS 533; familiarity with C programming on modern UNIX computers.
3 credits

CSE526 Modern Operating System Design
This course includes an in-depth study of modern operating system design. The course is based on a collection of recent research papers, and includes an emphasis on evaluating the papers in addition to understanding the systems they describe. Topics include micro-kernel operating systems, lightweight interprocess communication, extensible operating systems, file systems, mobile computing, workstation clusters, adaptive resource manage-ment, and OS support for multimedia systems. Prerequisites: CSE 513 and CSE 521. 3 credits

CSE527 Principles and Practices of System Security
In the Internet age, host system security is essential and difficult. This course will educate students in the principles and practices of securing host systems. Students learn the principles of how to build secure systems and how various real systems succeed and fail in living up to these principles. We will study various security enhancing technologies, in each case relating the security enhancement to the principles of secure systems. Prerequisite: CSE 513. 3 credits

CSE530 Introduction to Mathematical Logic
Provides a theoretical foundation for the logic of computation. Propositional and first-order predicate calculi, soundness and completeness, incompleteness and incomputability, the Church-Turing thesis, term-rewriting systems, and application to program verification. 3 credits

CSE531 Foundations of Semantics
Formal semantics aims to answer two important questions: 1) when are two programs equal? And 2) when does a program faithfully implement a mathematical specification? The course explores denotational semantics, operational semantics, and program logic, studying how they are related and how they can answer the motivating questions.

Programming language concepts, such as imperative programming, functional programming, call-by-name, call-by-value, and continuations, are contrasted and explained in terms of their semantic foundations. Key concepts include full abstraction and the use of least fixed point constructions to solve recursive equations. The course is designed for students interested in the mathematical foundations of programming languages and programming logics. Prerequisite: Discrete mathematics. 3 credits

CSE532 Analysis and Design of Algorithms
An introduction to the design and analysis of algorithms. The course covers design techniques, such as dynamic programming and greedy methods, as well as fundamentals of analyzing algorithms for correctness and time and space bounds. Topics include advanced sorting and searching methods, graph algorithms and geometric algorithms. Other areas vary from year to year, and may include computational geometry, matrix manipulations, string and pattern matching, set algorithms, polynomial computations, and the fast Fourier transform. Prerequisite: Data structures and discrete mathematics. 3 credits

CSE533 Automata and Formal Languages
Automata theory introduces fundamental models that are used over and over again in computer science for programming languages, in compiler construction, and in algorithms. These models are a valuable part of the repertoire of any computer scientist or engineer. This course introduces progressively more powerful models of computation, starting with finite automata and moving through counter, stack, and Turing machines. It also presents the regular, context-free, recursive, and recursively enumerable languages, and shows how they correspond to the various models of computation and to generation mechanisms such as regular expressions and grammars. The emphasis is on understanding the properties of these models, the relationships among them, and how modifications such as nondeterminism and resource bounds affect them. The course includes application of these concepts to problems arising in other parts of computer science. Prerequisite: Discrete mathematics. 3 credits

CSE534 Computability and Intractability
Computability and complexity theory identify classes of languages based on characteristics of machines that recognize them. The course presents elementary results from recursive function theory, including recursive and recursively enumerable sets, and degrees of undecidability. Using recursion theory as a model, it develops the classical results of complexity theory, including time and space complexity classes, hierarchy theorems, and elementary results from parallel complexity. The course concludes by studying classes of problems that are provably intractable, with a particular emphasis on NP-complete problems. Prerequisites: CSE 532 or CSE 533. 3 credits

CSE535 Categories in Computer Science
Category theory provides a powerful and concise notation for abstract properties of functions. Originally developed for algebraic topology, it has found widespread application in computer science. This course introduces the basic notions of category theory, including functors, natural transformations, products, sums, limits, colimits, monads, and adjunctions. These concepts are illustrated with examples from computer science and mathematics, including the relationship between cartesian closed categories and the lambda-calculus. Familiarity with discrete mathematics is an essential prerequisite. 3 credits

CSE540 Neural Network Algorithms and Architectures
This course introduces the fundamentals of connectionist and neural network models. Paradigms for both unsupervised and supervised learning are covered. Topics include introduction to neural processing elements, Hebbian learning, LMS and back propagation algorithms, competitive learning, computational capability, and elements of statistical pattern recognition. Specific architectures covered include Hopfield nets, single and multilayer Perceptrons, and Kohonen maps. Programming projects involve network simulations and application problems. Prerequisites: Some knowledge of linear algebra and calculus is required. Programming experience is necessary. 3 credits

CSE541 Database Implementation
This course provides hands-on experience implementing high-performance database management systems. The goal of the course is to implement database software and to understand techniques used to provide maximum performance and functionality on modern architectures. Typical topics discussed include benchmarking, transaction processing, file and index implementation, buffer management, concurrency control, recovery, query optimization, and a variety of query processing algorithms. The data model to be implemented, and the computer architecture to be used, will change between offerings. Prerequisite: CSE 514. This course is offered at Portland State University as CS 545. 3 credits

CSE542 Object Data Management
A variety of products for managing object data have emerged in the marketplace. Object-oriented database systems and persistent programming languages have been joined by object-relational databases and middleware component technologies, such as Enterprise Java Beans. Other storage engines, such as LDAP and XML servers, have an object flavor. This course begins with the concepts in types, data models, and languages that underlie object data management. It then looks at example prototype and commercial systems, and examines design dimensions such as data model, persistence, encapsulation, hierarchies, query languages, and transactions. It touches on application development and data management issues and concludes with treatment of software architecture and implementation techniques. Students will do a project using a commercial product. 3 credits

CSE544 Introduction to Probability and Statistical Inference
This course provides a comprehensive introduction to probability, statistical inference and stochastic processes. The topics include the elements of exploratory data analysis, sampling distribution theory, confidence intervals, hypothesis testing, linear regression, goodness-of-fit, ANOVA, maximum likelihood estimation, Bayesian inference, cross-validation, nonparametric tests, random walks, martingales, stochastic processes and stochastic differential equations. The goal of the course is to provide a comprehensive review of essential concepts in probability and statistics. The primary analysis tools for this course are S-PLUS and MATLAB. 3 credits

CSE545 Advanced Neural and Adaptive Algorithms
An advanced treatment of architectures and algorithms for pattern recognition, regression, timeseries prediction, and datamining. Typical topics include convergence, effects of noise, optimization methods, probabilistic framework (including Bayesian estimation), generalization ability and regularization and pruning, Hebbian learning, and clustering and density modeling. Prerequisites: CSE 540 or instructor permission. 3 credits

CSE546 Data and Signal Compression
The need for signal and data compression is ubiquitous in image, video, and speech processing, finance, and computational science. Where data stores become very large (e.g. video, finance, earth science), the need is not met by simple lossless file compression schemes, and we must turn to sophisticated coding techniques.This course addresses both the theoretical basis and practical algorithms for data and signal compression. Topics include lossless entropy based coding including Huffman and Lempel-Ziv, and lossy compression techniques including: scalar quantizers, transform coding (Karhunen-Loeve, DCT, and nonlinear transform codes), predictive coding, vector quantization, adaptive codes, and wavelets. The relation between compression schemes and probabilistic data modeling is emphasized in conjunction with each technique. Application to speech, image, and video coding are discussed. Students will have the opportunity to design compression schemes for such diverse applications as earth science data, finance, speech, or video depending on their specific interests. Prerequisites: Undergraduate calculus, introductory probability and statistics, some programming experience. 3 credits

CSE547 Statistical Pattern Recognition
Theory and practice of statistical pattern recognition. Students will learn fundamental theory and practices that are common to a broad range of pattern recognition applications and technologies, and apply principles to real-world examples.The emphasis is on developing tools, both theoretical and practical, that provide grounding in pattern recognition problems and methods; rather than on showcasing particular technologies. The course will benefit those whose work may use any of a variety of recognition technologies in broad-ranging applications such as speech and image processing, data mining, finance. Topics include: random vectors, detection problems (binary decision problems), likelihood ratio tests, ROC curves, parametric and non-parametric density estimation, classification models, theoretical error bounds and practical error

estimation through cross-validation. Maximum likelihood and Bayesian parameter estimation. Feature extraction for dimensionality reduction, and for classification. Prerequisites: The course is designed to be self-contained. Familiarity with undergraduate probability and statistics is useful. 3 credits

CSE548 Statistical Computing
This course provides an introduction to modern applied statistics. The topics include distributions and data summaries, density estimation, generalized linear models, modern nonlinear regression, robust statistics, factor analysis, linear and nonlinear classifiers, Bayesian classifiers, cluster analysis, decision trees, ensemble learning methods, validation techniques and Bootstrap and Monte Carlo methods. The goal of the course is to provide a solid understanding of practical statistical inference methods and proficiency in using modern statistical tools. The primary analysis tool for this course is S-PLUS. Prerequisite: CSE544 Introduction to Probability and Statistical Inference or equivalent. 3 credits

CSE549 Applied Business Forecasting
This course is taught over the World Wide Web using WebCT; enrollment limitations may apply. An applied course in business forecasting, the course emphasizes generating and implementing business forecasts. Designed for those wishing to understand the basics of modern forecasting, the course emphasizes modern statistical methods widely used to generate business forecasts. Specific applications to business include forecasting sales, production, inventory, macroeconomic variables such as interest rates and exchange rates, and other applications related to business planning, both short- and long-term. Topics include data considerations and model selection, applied statistics, moving averages and exponential smoothing, regression analysis, time-series decomposition, Box-Jenkins (ARIMA) models, bootstrapping, optimal forecast combination, and forecast implementation. The course is based upon the FORECASTX™ integrated econometric and statistical analysis language for Windows 95 and NT, which accompanies Wilson and Keating's Business Forecasting, McGraw Hill-Irwin, 4th Edition. Knowledge of basic statistics and regression analysis is highly recommended, but not required.
3 credits

CSE550 Spoken Language Systems
In the not too distant future, spoken language systems will revolutionize human-computer interaction by enabling natural conversations between people and machines. In addition to telephony applications, such as voice browsing of the web, these systems also will support face-to-face communication with intelligent animated agents. These animated human-like agents will combine acoustic information with the speaker's facial cues and gestures to understand speech, and produce natural and expressive speech with accurate facial movements and expressions. This course reviews the state of the art in human language technology, and explains how key technologies are combined to produce spoken language systems. The course combines lectures by experts in the field with hands-on experience using and building spoken language systems using the CSLU Toolkit. The course materials are included in http://www.cse.ogi.edu/ CSLU/hltsurvey/hltsurvey.html.
3 credits

CSE551 Structure of Spoken Language
This course provides a foundation for subsequent learning and research in computer speech recognition. We examine the structure of spoken English through selected readings in speech perception and acoustic phonetics and examination of visual displays of speech. The goals are to understand the acoustic cues for each major phonetic category, understand how these cues are affected by context, understand the perceptual strategies that listeners use to understand speech, and evaluate the assumption that speech can be described as anordered sequence of phonetic segments. 3 credits

CSE552 Hidden Markov Models for Speech Recognition
Hidden Markov Model-based technology is used widely in today's speech recognition systems. This course is an introduction to speech recognition using HMM technology. Topics include the theory of Hidden Markov Models (discrete, semi-continuous, and continuous) and their applications to speech recognition, along with the basic mathematics (probability theory, statistics, stochastic process, information theory, and signal processing) that are necessary for speech recognition. The course is focused on understanding the theory behind these fundamental technologies, and applying the technology to develop speech recognition systems. Prerequisite: Some knowledge of engineering mathematics (calculus and linear algebra) is required; C programming experience is necessary. 3 credits

CSE555 Mathematical Methods for Engineering and Finance
This course explores the essential mathematical methods required for quantitative analysis in engineering and finance. The course examines a selection of topics from multivariate calculus, differential equations, stochastic calculus and mathematical optimization. Advanced topics include partial differential equations, Ito calculus, martingales, stochastic control and constrained optimization. The focus is on explaining the key Mathematical results and, by means of examples and assignments, showing how they may be applied in engineering and finance. Prerequisites: Knowledge of calculus, linear algebra and basic differential equations. 3 credits

CSE556 Simulation and Optimization
This course introduces modern, advanced numerical methods for quantitative work in engineering, finance and operations research, focusing on Monte Carlo Simulation and Optimization techniques. In Monte-Carlo simulation we will cover pseudo-random and quasi-random number generators, generation of stochastic processes, variance reduction techniques, bootstrapping and other statistical techniques. In Optimization we will briefly review classical methods, and study in detail new techniques such as genetic algorithms, differential evolution, simulated annealing and ant colony optimization. Students will be introduced to mathematical modeling, and learn the science and art of effectively applying these techniques. Grading will be based on assignments and a group project, and these will involve programming in Matlab. The assignments, project and examples in class will be drawn from practical problems in engineering and finance. Prerequisites: Programming experience, linear algebra, calculus, CSE544 Introduction to Probability and Statistical Inference (or equivalent).
3 credits

CSE560 Artificial Intelligence
This course surveys the foundations and applications of symbolic approaches to artificial intelligence. The approach emphasizes the formal basis of automated reasoning and includes an introduction to programming in Prolog. Fundamentals covered include search, knowledge representation, automated inference, planning, nonmonotonic reasoning, and reasoning about belief. Applications include expert systems, natural language processing and agent architectures. 3 credits

CSE561 Dialogue
This course provides an in-depth treatment of the major theories of dialogue, including finite-state, plan-based, and joint action theories. Dialogue is examined at a level general enough to encompass conversations between humans, between human and computer, and among computers, while at the same time being precise enough to support implementations. The course introduces basic speech act theory, planning, and reasoning through a number of classic papers. Plan-based theories are examined in detail, including their incorporation into spoken dialogue systems, and their potential effects upon speech recognition components. Students will develop dialogue components and integrate them into working systems. Prerequisite: CSE 560.
3 credits

CSE562 Natural Language Processing
An introduction to artificial intelligence techniques for machine understanding of human language. The course introduces key aspects of natural language, along with the analyses, data structures and algorithms developed for computers to understand it. Computational approaches to phonology, morphology, syntax, semantics, and discourse are covered. Programming assignments are written in Prolog. Prerequisite: CSE 560 or equivalent. 3 credits

CSE563 Multi-Agent Systems
This course covers the emerging theory and practice of multi-agent systems: semi-autonomous, semi-intelligent distributed computing systems that can be organized ad hoc to meet the immediate needs of a user. The course covers a variety of individual and multi-agent architectures, including the Contract Net protocol, distributed blackboard systems, and mobile agents. Also discussed are principles for building networks of heterogeneous agents, ranging from simple rule-based systems to databases and humans. In order to collaborate to solve a user's problem, agents need to communicate. We examine agent communication languages, including KQML and FIPA, as well as the underlying general speech act theories. Students learn how to model these systems formally, and will develop and program individual agents that can participate in a multi-agent system. 3 credits

CSE564 Human-Computer Interaction
This course emphasizes the experience of computing, which centers on an understanding of real users and the specific tasks they need to accomplish when computing. In the pursuit of optimal user support, an interdisciplinary approach to system design and evaluation is stressed. The course reviews current research viewpoints and activities in the field of human-computer interaction, surveys key research challenges that exist, and discusses trends in next-generation system design. Students gain hands-on experience by critiquing existing interfaces, as well as hearing reports from experts in industry on the state of the field. An introduction to this topic is essential for everyone working in the field of computer science. 3 credits

CSE567 Developing User-Oriented Systems
This course explores a range of issues and methods needed to design and evaluate user-oriented software applications. Topics focus on field and ethnographically based design studies, participatory design methods, user laboratory studies, and usability testing. The purpose is to have access to a range of methods that help uncover opportunities, breakdowns, and interactions that affect the design and use of developing systems. Students are challenged to evaluate the underlying perspectives of the approaches and decide which approach or combination of approaches works best for particular problems. They apply the methods in field and classroom exercises and produce a real-world project or paper using course methods. The intended result is to make students more effective not only at gathering relevant user-based information, but also at integrating it into the development process. 3 credits

CSE568 Empirical Research Methods
This course introduces principles of experimental design and data analysis for empirical research. Topics include the goals and logic of experimental design, hypothesis formation and testing, probability and sampling theory, descriptive statistics, correlation and regression, basic parametric and nonparametric tests of statistical significance (e.g., Binomial, t-test, chi-square, analysis of variance), standard designs for single- and multi-factor experiments, and strategies of scientific investigation (e.g., Exploratory vs. Directed). The course is fundamental for anyone who plans to conduct independent research in the future or needs to critically evaluate the research of others. Students participate in designing and analyzing data in order to answer scientific questions and present the results of these activities both orally and in writing. 3 credits

CSE569 Scholarship Skills
Scientific results have little value if they are not communicated clearly or are disconnected from prior work in a field. This course teaches students to research, write, present, and review effectively for the computer sciences. It emphasizes learning by doing, and students have frequent writing and presentation assignments. Students learn how to locate and organize background materials, how to write clearly about technical topics, organizing web content, the structure and stylistic conventions of scientific documents (such as conference abstracts, journal papers, theses, and proposals), how to prepare and deliver short and long presentations, the refereeing process, and how to prepare and respond to a review. This course is required for Ph.D. students and strongly recommended for master's students, especially those pursuing the thesis option. It also is useful for professionals who must write or speak to a technical audience. 3 credits

CSE58X Special Topics
Under this number, we offer courses of particular relevance to the research interests of faculty or in state-of-the-art subjects of interest to the community.

CSE600 Research
Supervised research activity.
Variable and repetitive credit.

CSE610 Nonthesis Research
Supervised research for up to six credits as a component of the nonthesis master's degree. Students are required to produce concrete research deliverables, including a final report equivalent to a CSE technical report.

CSE620 Professional Internship
These courses provide the student with an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for their future careers in computer science. A written report must be submitted to the CSE faculty advisor at the end of the experience.

Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
1 to 3 credits per quarter

CSE700 M.S. Thesis Research
Research toward the thesis for the M.S. degree.
Variable and repetitive credit.

CSE800 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree.
Variable and repetitive credit.

FIN541 Principles of Modern Finance
This course examines the theory and practice of modern corporate finance stressing the six central concepts in finance: Net Present Value, Capital Asset Pricing Model, Efficient Capital Markets, Value Additivity (Capital Structure Theory), Option Theory and Agency Theory.

Topics include discounted cash flow analysis, capital budgeting, capital structure theory, mean-variance portfolio theory, arbitrage-pricing theory, Black-Scholes option pricing, and real options theory. In addition, students will learn the nuances of evaluating an Ebusiness. The principal goal of the course is to provide students with an intuitive foundation of modern finance upon which the student can apply advanced computational techniques. This will be accomplished through interaction between the text, instructor, case studies, MATLAB assignments, and student presentations/discussions. This course fulfills all or part of the prerequisite requirements for FIN576 Financial Markets and Trading. 3 credits

FIN544 Investment and Portfolio Management
This course provides students with an overall introduction to practical and theoretical aspects of investment analysis and portfolio management. Specifically, the course surveys various models of asset valuation and their use in constructing effective investment portfolios. Topics include investment vehicles and asset classes, market structure and market efficiency, security valuation models, financial statement analysis, setting investment goals and policies, designing investment portfolios, equity and fixed-income portfolio strategies, measuring investment performance, and managing investment risk. To help students integrate the course knowledge into their actual investment practice, the course includes team projects to analyze actual investment securities and design investment portfolios. Students have access to investment data and analytics provided by Barra and Standard and Poor's Micropal. 3 credits

FIN547 Global Markets and Foreign Exchange
This course surveys the modern paradigms in international finance. Specifically, the course examines the theory linking the world's various foreign exchange, money, and securities markets, emphasizing global investment and risk management. Topics include spot and forward FX markets, FX options, interest rate parity, purchasing power parity, exchange rate theory, global investing, global FX risk management, and emerging markets and currency crises. Course assignments make use of MATLAB's-Plus and Barra on campus. 3 credits

FIN551 Options and Futures I
This course introduces the trading, pricing and risk-management applications of financial derivatives including futures, swaps, and option contracts. Emphasis is given to pricing models including arbitrage pricing theory, risk-neutral valuation, and Black-Scholes analysis. Topics covered include futures and swap pricing, methods for pricing American style options, hedging and speculation using derivatives, Ito calculus, portfolio insurance, option trading strategies, dynamic hedging strategies, and numerical models. Course assignments require use of MATLAB. 3 credits

FIN552 Options and Futures II
A continuation of FIN551 Options and Futures I, this course examines derivative pricing models since Black-Scholes, models for the term structure of interest rates and relevant numerical methods. The course begins with a review of stochastic calculus and stochastic differential equations. Specific topics include arbitrage pricing, equivalent martingale measures, risk neutrality, and optimal stopping times as applied to American options. Equilibrium and no-arbitrage term structure models are presented, from Vasicek through Heath-Jarrow-Morton. In addition, emphasis is given to pricing fixed-income derivatives, credit derivatives, and exotics using numerical solution methods such as the Crank-Nicholson, finite difference methods, and Monte Carlo search. Prerequisite: FIN551 Options and Futures I or permission from instructor.
3 credits

FIN558 Advanced Numerical Computing in Finance
This course introduces the major numerical methods needed for quantitative work in finance, focusing on derivatives pricing and fixed income applications. Topics include binomial and trinomial methods, finite difference solution of partial differential equations, Crank-Nicholson methods for various exotic options, treatment of discrete dividends, projected-SOR method for American options, numerical methods for stochastic differential equations, random number generators, Monte-Carlo methods for European and least-squared Monte-Carlomethods for American options. The course is lab oriented. Prerequisite: FIN552 Options and Futures II or permission from instructor. 3 credits

FIN561 Risk Management
This course explores various aspects of management of risk associated with operating a multinational enterprise. Emphasis is on evaluating and hedging financial risks (fixed-income, equity, commodity, and foreign exchange risk exposures), with emphasis on value-at-risk (VAR) models. Topics include sources and measurement of risk and exposure, value at risk, hedging linear and nonlinear derivatives risk, delta-normal VAR, historical simulation VAR, Monte Carlo approaches to VAR, and implementation and evaluation of risk management systems. Course assignments make use of MATLAB and BARRA On Campus. 3 credits

FIN573 Financial Time-Series Analysis
This course reviews advanced time-series techniques and their application to the analysis and forecasting of financial time-series. Emphasis is given to multivariate and nonlinear methods applied to high-frequency financial data. Topics covered include ARIMA models, GARCH models, martingales and random walks, stochastic trends, co-integration and error-corrections models. The primary analysis tool for this course is S-PLUS. Prerequisite: CSE548 Modern Applied Statistics. 3 credits

FIN576 Financial Markets and Trading
This course provides a survey of the structure and dynamics of financial markets, the behavior of financial price series, and trading techniques. Topics include market microstructure, market efficiency and documented anomalies, noise traders and bounded rationality, properties of high frequency data, nonlinear price behavior, speculative bubbles and crashes, market psychology, and technical trading systems. The course draws upon the academic literature and the practitioners' lore. Students use MATLAB, S-PLUS, and extensive data resources to analyze price behavior and build and test simple technical trading systems. Prerequisites: FIN541 Principles of Modern Finance and FIN573 Financial Time-Series Analysis. 3 credits

FIN620 Professional Internship in Finance
This course provides the student with an opportunity to earn credit for relevant work experience in finance and related industries. It enables students to enhance their understanding of the practical realities of modern finance, including such areas as corporate treasury operations, investment analysis, portfolio management, risk management, derivatives pricing, forecasting and trading. Students gain valuable industrial experience that both allows them to learn to apply their knowledge gained in the classroom and to better prepare for their future careers in finance. Enrollment requires the permission of the instructor and is limited by the number of internship opportunities available. 1-3 credits

APPLIED COMPUTING COURSES

These courses may be applicable to the Master in Computational Finance or as a prerequisite for the Master in Computer Science and Engineering or the Oregon Master of Software Engineering.

APC500 Development with Visual Basic for Applications
This course introduces Visual Basic for Applications as a tool for rapid application development, customization and system integration in Windows environments. The course focuses on combining VBA with Microsoft Office. Topics covered include the structure of the VBA programming language and built-in functions, enhancing recorded macros using VBA code, applying the MS Office object models and accessing relational databases using ActiveX Data Objects (ADO). Students will gain expertise in advanced analysis and data manipulation, developing and customizing applications, and integrating them with existing systems. Prerequisites: experience with MS Excel and Access, and knowledge of a programming language. 3 credits

APC501 Accelerated Development with Visual Basic
This course uses Visual Basic 6.0 and Visual Basic for Applications as tools to introduce the concepts of rapid application development, systems integration and customization on Windows platforms. While studying Visual Basic, students will gain an understanding of the architecture of Windows applications and create COM components, ActiveX controls and executable programs. Students will also learn how to apply basic analysis and design techniques, and how to make their user interfaces friendly and efficient. Assignments involve practical work with these software tools, using applications from industry/business as case studies. This fast-paced course is intended for experienced programmers wishing to augment their skills with knowledge of Visual Basic. Prerequisites are programming experience with C, C++ or Java. APC500 is not a prerequisite for this course. 3 credits

APC503 Web Development with Perl 5
This course uses "Perl 5" technology to introduce the essential concepts needed to develop web applications with server side scripting. Topics include the structure and elements of the Perl 5 language (variables, control structures, file I/O, regular expressions, objects and built-in functions), important Perl libraries, writing CGI scripts, building dynamic web pages and extracting data from databases using basic SQL queries. Important issues, such as the security of web applications, will be addressed and additional topics, such as XML, may be introduced, time permitting. On completion, students will understand the conceptual architecture of web applications with server side automation and be in a position to contribute to their design and development. Assignments include writing programs and a project to develop a web application. Prerequisites: knowledge of a programming language and basic HTML. 3 credits

APC505 — Applications Programming in C++
This course provides an introduction to programming in C++, which is used widely for developing engineering and business applications. This course introduces students to C++ language constructs, data structures and classes. The student will also be shown how access class and template libraries, including the standard template library (STL). The course is suitable for students in engineering, management and finance who wish to gain an understanding of the language. On completion, students will be in a position to contribute to the design and development of systems using C++. Assignments include writing programs and a programming project. Prerequisites are knowledge of a programming language. 3 credits

APC506 Advanced Applications Programming in C++
This course explores advanced topics concerning applications programming in C++. The course will focus on writing efficient, extensible and reusable programs, and introduce concepts in software engineering, program analysis and design, and data modeling. Students will develop class libraries, and learn how to apply design patterns. The course is suitable for students in science, engineering and finance who wish to further their understanding of the language. On completion, students will be in a position to the design and develop systems using C++. Assignments include writing programs and a programming project. Prerequisites: APC 505 or equivalent knowledge of C++. 3 credits

APC508 Web Development with Java 2
This course uses "Java 2" technology to introduce the essential concepts needed to develop web applications with client side scripting. Topics include the structure and elements of Java, Java Foundation Classes (JFC), Java applets and servlets, Java Beans and Remote Method Invocation (RMI). Other topics, such as JDBC and XML may be introduced, time permitting. On completion, students will understand the conceptual architecture of web applications with client side automation and be in a position to contribute to their design and development. Assignments include writing programs and a project to develop a web application. Prerequisites: knowledge of a programming language. 3 credits

APC511 Computational Tools for Engineering and Finance
This course provides an introduction to essential programming skills needed for engineering and finance. The course reviews key topics in linear algebra, explores basic numerical methods, and provides a comprehensive introduction to computing in Matlab. Mathematical topics include vector spaces, matrix computation, solution of linear systems, interpolation, regression, approximation, numerical precision, convergence and algorithm complexity. Matlab topics include language features, handling vectors, matrices and cells, programming in Matlab (functions and script files), 2D and 3D graphics, using key toolboxes, developing a graphical user interface, and other advanced features.

Programming assignments focus on the practical use of Matlab. Prerequisites: knowledge of a programming language. 3 credits

APC515 Data Structures and Discrete Math
This course covers fundamental topics in data structures and discrete mathematics. The topics are presented in an integrated manner that provides the discrete math foundations for data structures and computing applications of discrete mathematics concepts. Topics covered include stacks, queues, linked lists, trees, algorithms for searching and sorting, finite state automata, and concepts of computability and decidability. Topics from discrete math include sets and various types of relations (functions, graphs, trees, lattices), recursion and inductive proofs, boolean logic, relational algebra, predicate calculus, series and limits, and asymptotic behavior of searching and sorting algorithms. Programming exercises are assigned throughout the course. Prerequisites: APC505 or equivalent knowledge of C or C++. 3 credits

OREGON MASTER OF SOFTWARE ENGINEERING COURSE OFFERINGS

OMSE500 Principles of Software Engineering
This course serves as an introduction to software engineering. The course's focus is on understanding the software engineering process and its attendant problems as manifest in real development projects. The course compares and contrasts different models of the software engineering process and approaches to process improvement. It includes the analysis of where and how things go wrong motivated by case studies. This course is intended as a leveling course for entering students who have not had prior instruction in software engineering and may be waived for students with an equivalent senior-level or master's-level course or equivalent work experience. Prerequisite: Knowledge of programming. Relevant work experience recommended but not required. 3 credits

OMSE 511 Managing Software Development
This course provides the knowledge and skills needed to plan, organize, lead, and control software projects. Topics include planning and estimating, measuring and controlling, and achieving results in environments that include a great deal of ambiguity and contradictory information. Quantitative measures and risk management will be emphasized throughout the course. Students will prepare project plans for real or hypothetical software projects, to include effort, cost, and schedule estimates and risk management plans. Prerequisite: OMSE 500. 3 credits

OMSE512 Understanding the Software Business
This course provides a familiarity with the business and economic aspects of software companies and other high-technology companies that develop software. Topics include fundamental macro-economic concepts, basic accounting and financial principles and methods, basic business law, and the functions and role of marketing in enterprises that develop software products or products that include software. Prerequisite: OMSE 500. 3 credits

OMSE513 Professional Communication Skills for Software Engineers
This course covers the skills necessary for appropriate professional conduct and effective communication in a professional setting. It includes technical writing, making effective presentations, conducting effective meetings, conflict resolution, team and decision-making skills, and professional ethics. Prerequisite: OMSE 500. 3 credits

OMSE521 Using Metrics and Models to Support Quantitative Decision Making
This course provides the knowledge and skills needed to apply quantitative tools based on metrics and models of the software product and development process to make decisions under uncertainty. Topics covered will include measurement concepts, decision-making under uncertainty, and model and metric development for the software development enterprise. Prerequisite: OMSE 500. 3 credits

OMSE522 Modeling and Analysis of Software Systems
Abstract models are used to formalize specifications of software systems. Formalized reference specifications serve as a basis for the design of software implementations and for validating critical properties of software systems. This course provides the fundamental mathematical concepts needed to understand abstract models of software and to reason about them as well as examples showing how they are applied. Prerequisite: OMSE 500. 3 credits

OMSE525 Software Quality Analysis
This course covers processes, methods, and techniques for developing quality software, for assessing software quality, and for maintaining the quality of software. Course material emphasizes the tradeoffs between software cost, schedule time, and quality; the integration of quality into the software development process; formal review and inspection methods; principles of testing and test planning; module design for testability; and maintaining quality while supporting existing software. Prerequisite: OMSE 500. 3 credits

OMSE531 Software Requirements Engineering
This course covers the principles, tools, and techniques for requirements elicitation, specification, and analysis. The course focus is on understanding the role of requirements in system development and maintenance, goals of the requirements phase, essential difficulties of specifying requirements for real systems, and effective methods tools and techniques. The course covers techniques for formally modeling and specifying software requirements with hands-on experience as well as the role of prototyping in validating requirements. Prerequisites: OMSE 500, OMSE 522, and the Formal Inspections part ofQuality Analysis. 3 credits

OMSE532 Software Architecture and Domain Analysis
This course covers the principles and methods of the architectural design of complex software systems. It includes a survey of the major architectural styles, strengths and weaknesses of each style, and tradeoffs among them; application of domain analysis to identifying and capturing common architecture in software domains (e.g., Product lines); the impact of platform dependence and independence on architectural decisions; and the relation of software architecture to requirements and its effects on downstream design. Students will examine domain analysis and the architectural design process and products in context including the effect of decisions on function, quality, cost, and schedule. Prerequisites: OMSE 500, OMSE 522. 3 credits

OMSE533 Software Design Techniques
This course covers the principles of software design and a survey of design methods, techniques, and tools. In-depth and hands-on study of at least one method such as object-oriented design as applied to a realistic industrial problem. It examines the effects ofdesign decisions on the functional and non-functional properties of the software (e.g., Ease of understanding, maintainability, reuse) and how software engineering principles are applied to make appropriate trade-offs. Students also examine the design process and products in context including the effect of design decisions on function, quality, cost, and schedule. Prerequisites: OMSE 500, OMSE 522. CSE students may not receive credit for both CSE 504 and OMSE 533 because there is significant overlap in content. 3 credits

OMSE535 Software Implementation and Testing
This course covers the principles of implementing and verifying computer software. Implementation topics include coding style, packaging principles, reuse, testability, and maintainability. Verification topics include structural (white box) testing and techniques for code verification. Also included will be verification and integration of foreign code, testing techniques and how to apply them, including code-based and specification-based testing, hands-on application of the testing process, including test case generation, and test adequacy, test validation, test execution, and automation. Prerequisites: OMSE 500, OMSE 522, OMSE 525. 3 credits

OMSE551 Strategic Software Engineering
Where traditional software engineering focuses on the development and maintenance of individual systems strategic software engineering addresses the development of multiple systems over time. Recent work has shown that significant gains in productivity, cost, and schedule can result from systematic improvement of a company's overall software development process and systematic reuse of life-cycle products over multiple developments. This course covers the principles, methods, and tools for such strategic software development including long-term process modeling and improvement, developing programs as instances of families of systems, and systematic approaches to code generation and the reuse of non-code products including requirements and design. Prerequisites: OMSE Foundation and Context courses. 3 credits

OMSE555 Software Development Practicum I
3 credits

OMSE556 Software Development Practicum II
The development practicum provides an opportunity for students to apply the knowledge and skills gained in other courses as they synthesize a solution to a significant, realistic, and practical problem. Students work in teams to analyze a problem, develop a software concept, plan a software development effort, define requirements, and implement a solu-

tion. Each offering of the practicum will include at least one hour of lecture per week. Students will work closely with OMSE program faculty and, where possible, reviewers from industry to apply advanced software engineering techniques to a disciplined development of a realistic product and evaluate the results. Software development artifacts created as part of the practicum will become part of the student's professional portfolio. Contents of the portfolio include such products as the concept definition, cost estimate, project plan and schedule, formal requirements specification, test plan, software quality assurance plan, software architecture, software design, implementation artifacts, test results, and metrics collected. The portfolio contents provide examples of the student's professional capabilities. 3 credits

RESEARCH PROGRAMS

The specific research projects under way at any given time depend upon current interests and obligations of faculty, students, and research sponsors.

Agent-Based Systems

This project will design a new agent communication language (AGENTTALK) and multiagent architecture. Unlike DARPA's current language (KQML), the language offers a true semantics, and provably correct dialogue protocols, based on joint intention theory. The Adaptive Agent Architecture, a successor to our earlier Open Agent Architecture, offers platform and application interoperability, facilitated communication, proper concurrent operation, dynamic reconfigurability of facilitators, and separation of data and control. Quickset has been reimplemented to use this architecture, gaining a more robust capability for supporting human-human collaboration, multimedia, and dynamic adaptation to processing environments. *Cohen*

Autonomix: Component, Network, and System Autonomy

Autonomix pragmatically seeks to provide autonomic defenses for commodity information systems. Our contribution is in three complementary areas: Component Autonomy, to make existing individual components more robust to attack, Network Autonomy, to allow existing components to access CIDF capabilities via current Internet standard protocols, and Systemic Autonomy, to model, analyze and implement coordinated, adaptive responses of multiple components. Component autonomy is developing a family of tools (StackGuard, PointGuard, FormatGuard, and RaceGuard) that make applications *vulnerability tolerant by* making broad classes of vulnerabilities (buffer overflows, printf format string bugs, and temporary file races) *unexploitable.* Network and Systemic Autonomy are providing a family of tools to enable *large-loop* intrusion tolerant responses, where in a distributed network of machines can adaptively respond to intrusions. Component Autonomy work is being done at WireX Communications, Inc., and Network and Systemic Autonomy work is being done at OGI. *Cowan, Maier, Delcambre*

Constructing Software from Specifications

Research in formal methods for software engineering has been concerned primarily with software specification. This research explores the next step: given a declarative specification, to generate practical and efficient software by the technologies of program transformation and specialization.

We have demonstrated a new software development method in which software components are constructed from executable specifications by typed, staged functional programs and a translation directed by an interface specification that determines data representations. Systematic techniques for proving the semantic validity of representations for data types are explored. *Kieburtz, Hook, Sheard, Launchbury*

Digital Government

DOT is collaborating with the US Forest Service, Bureau of Land Management, Fish and Wildlife Service and other government agencies to build a forest information portal for the Adaptive Management Area (AMA) program. The AMAs develop and test innovative approaches to forest management. We are developing an information model called Metadata++ to locate documents and document fragments along several dimensions and to search for documents based on ìsimilarity search between locations. The Forest project also includes participants from the MST and ESE departments at OGI, from UNLV and from the private sector. *Delcambre, Maier, Toccalino, Phillips, Steckler, Tolle, Landis, Palmer*

Domain Specific Languages

A domain-specific language can provide a declarative programming interface for specialists in an application domain who are not primarily software engineers. A well-designed domain-specific language improves productivity, reduces the incidence of programming errors and furnishes an easily understood medium for documentation of a software artifact. A barrier to the widespread adoption of domain specific languages is the inherent difficulty of language design and implementation. We are developing semantics combinators to allow rapid implementation of declarative, domain-specific languages. We are also pursuing staged implementations as a means of efficiently embedding a domain specific language into a broad-spectrum functional language framework. *Sheard, Hook, Kieburtz, Launchbury*

Functional Programming Languages

Functional programming languages are based upon the idea that programs can be designed as mathematical functions with logical properties. Functional abstraction is a powerful and flexible means of constructing concise programs. PacSoft faculty have a continuing interest in techniques for analysis and efficient implementation of functional programming languages including ML and Haskell. These techniques include staged programming, partial evaluation, effects encapsulation with monads, automatic program transformation, and advanced type systems. *Black, Hook, Jones, Kieburtz, Launchbury, Sheard*

Machine Learning and Adaptive Systems

Machine learning, neural computation and adaptive systems are studied from both theoretical and practical standpoints. Research in theory, architectures, and algorithm design includes learning algorithms (supervised, unsupervised, and reinforcement), generalization theory (including model selection and pruning, invariant learning), deterministic and stochastic optimization, context-sensitive learning, signal processing, time series analysis, and control. Practical application domains include adaptive signal processing, pattern recognition, speech recognition, image processing, medical screening technology, control systems, macroeconomics, and finance. *Hermansky, Leen, Moody, Pavel, Song, Wan*

Multimodal Systems

Multimodal interfaces enable more natural and efficient interaction between humans and machines by supporting multiple coordinated channels through which input and output can pass. The Center for Human-Computer Communication is engaged in empirical investigation of multimodal interaction. This informs our research and development of architectures for multimodal language processing, work which draws on a range of fields such as cognitive science, natural language processing, multimedia, user interface design, speech recognition, gesture recognition, and visual parsing. The Quickset system developed at CHCC supports multimodal pen/voice interaction with complex visual/spatial displays such as maps. *Cohen, Oviatt*

Natural Language Dialogue

The performance of speech recognition systems improves significantly when the spoken language understanding system can predict the next utterance. Accordingly, we are performing perceptual studies of dialogue and building models of human-human and human-computer dialogue in order to develop computational models of conversation that can be used to track and predict spoken language. This work is based on speech-act theory, multi-agent architectures, and models of spontaneous speech. *Cohen, Heeman, Oviatt*

Net Data Management

We believe that data management systems of the future must stress data movement over data storage. NIAGARA is an initial effort, conducted with the University of Wisconsin, to move beyond disk-centric data management to net-centric systems. Current work includes algebras and special operators for XML, exploiting stream semantics for efficient processing, and data-query hybrids for distributed query evaluation. *Maier, DeWitt, Naughton*

Operating Systems

Our operating systems-related research focuses primarily on adaptive systems software and its application in distributed, mobile, and multimedia computing environments. Several large projects are currently under way in the areas of quality of service control, adaptive resource management and dynamic specialization for enhanced performance, survivability and evolvability of large software systems. *Black, Steere, Walpole*

Query Optimization

Our work on query optimization and evaluation deals with both general frameworks and specific techniques for different data model and query language features. Columbia is a C++-based, top-down framework for construction of cost-based query optimizers. We are currently examining pruning techniques for searching, transforms for collection-valued attributes and nested queries, and ìmultiplex query optimization for efficiently optimizing groups of queries. Columbia is a joint project with Portland State University. *Maier, Shapiro*

Speech Recognition

The goal of Large Vocabulary Continuous Speech Recognition research is to enable normal human speech as an input device in next generation computers alongside today's keyboard and mouse input. This technology can be used for dictation and command control applications when used by itself. It can also form part of a powerful information processing system when used together with information retrieval and natural language understanding systems. The research focuses include accurate acoustic modeling, speaker adaptation, confidence measure and rejection, and modeling spontaneous speech. *Yan, Heeman*

Spoken Language Systems

Spoken language systems make it possible for people to interact with computers using speech, the most natural mode of communication. A spoken language system combines speech recognition, natural language understanding and human interface technology. It functions by recognizing the person's words, interpreting the words in terms of the context and goals of the task, and providing an appropriate response to the user. We are involved in the analysis and development of various components of such systems, ranging from empirical studies of human dialogues through the construction of interactive systems to the development of abstract models of behavior. *Cohen, Oviatt, Heeman, van Santen*

Superimposed Information and Superimposed Applications

We are interested in providing typical database system capabilities in an environment where we do not own or manage the underlying, base information. We seek to develop a superimposed layer of information that can reference selected information from the base layer and can also add new information to highlight, interconnect, elaborate, or annotate the selected information. We have defined an architecture for building superimposed applications and have implemented our first tool: SLIMPad, a scratchpad application that allows users to easily create "scraps" that reference selected items from the base layer and organize scraps into bundles. The tendency to use scraps and bundles to organize our thoughts is common practice, as confirmed by our observational research team that is studying how clinicians seek and use information in a hospital intensive care unit. *Observational team: Gorman, Ash,Lavelle; computer science team: Delcambre, Maier*

Tracking Footprints through an Information Space: Leveraging the Document Selections of Experts

The goal of this project is to help expert problem solvers find needed information in a large, complex information space. The focus is on one example of expert problem solving; the physician seeking to diagnose and treat a patient while using the medical record. Sorting through a heterogeneous collection of electronic and other media materials to find needed information, sometimes under time pressures, can be formidable. This project proposes to capture the trace of information used by experts-to monitor the paths taken and collection resources used by physicians, in moving from observation, to information gathering, to solution of a given health care problem. By capturing the trace information artifacts associated with information seeking and selection, it is hypothesized that greater insight can be gained into behaviors of users and patterns of usage. This knowledge can then be fed-back into the design and development of new information environments. The work is conducted by a cross-disciplinary team comprised of an MD focusing on information seeking behaviors of physicians, and a group of computer scientists focusing on extracting and using regularly structured information. The usefulness of the approaches will be tested in domains other than health care, in particular the aircraft design industry through the active support of the Boeing Corp. *Delcambre, Maier, and Dr. Paul Gorman, Oregon Health & Science University*

RESEARCH CENTERS

CENTER FOR HUMAN-COMPUTER COMMUNICATION

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The Center for Human-Computer Communication is dedicated to realizing a vision of transparent information and service access. Research projects are broadly interdisciplinary, and include collaborations with numerous universities, federal research laboratories, and the Data-Intensive Systems Center at OGI.

Research activities focus on:

- Multimodal human-computer interaction that allows people to state their needs using speech, writing, and gestures, and that provides multimedia output.
- User-centered design of next-generation interface technology, including spoken language and multimodal interfaces, and interfaces for mobile and multimedia technology.
- Intelligent agent technologies - software systems that assist users in accomplishing tasks and can reason about how and where to carry out the users' requests in a worldwide distributed information environment.
- Collaboration technologies to support human-human communication, and collaborative decision making among groups of people.

CHCC organizes an annual Distinguished Lecture Series on the Future of Human-Computer Interaction. World-class researchers are invited to share current topics.

Dr. Philip Cohen and Dr. Sharon Oviatt are co-directors of the center. Other center faculty include Dr. Peter Heeman, and Dr. Misha Pavel. For more information, visit CHCC's web pages at www.cse.ogi.edu/CHCC/.

PACIFIC SOFTWARE RESEARCH CENTER

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The Pacific Software Research Center (PacSoft) is a team of faculty, students and professional research staff who study mathematically based techniques for the specification, development and validation of complex computer software. Our goals are to explore and test new techniques that can support the development of software products in which clients can have high confidence.

PacSoft's approach to software specification and development is grounded in functional programming, type theory, and formal semantics of programming languages. Our research methods extend from theoretical investigation through prototype software tool development to experimental validation.

Much of our work during the past decade has focused on techniques for the design and implementation of domain-specific languages. A domain-specific language is able to express the abstractions and operations used in a particular engineering domain, in terms familiar to domain experts. One domain in which this work has demonstrated considerable success is the design of complex microarchitectures for high-performance microprocessors.

The Hawk project has exploited abstraction and equational specification techniques from functional programming languages to produce a new kind of hardware specification language. A microarchitecture specification written in Hawk can be directly executed as a simulation, symbolically manipulated as a hardware algebra, or submitted to formal verification of its properties by model checking or by a theorem prover.

Among current PacSoft projects is *Programatica*, an exploration of computer-supported techniques for developing property-certified programs (ìprogramming as if properties matteredî). Project *Timber* is developing new means of programming embedded applications that involve both time-critical and critical-rate tasks.

Dr. Tim Sheard is the current Director of the Center. Dr Richard Kieburtz is the founding Director. Other faculty members of PacSoft are Dr. James Hook, Dr. Mark Jones and Dr. John

Launchbury of OHSU/OGI and Dr. Andrew Tolmach of Portland State University. The Center employs six postdoctoral researchers and has numerous visitors each year.

Research by PacSoft scientists is supported by grants and contracts from the National Science Foundation, DARPA, the National Security Agency, Intel Corp. and Compaq.

For additional information, visit the PacSoft web site, http://www.cse.ogi.edu/PacSoft/.

THE SYSTEMS GROUP

Database and Object Technology Laboratory
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Systems Software Laboratory
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The Systems Group consists of two research laboratories — the Systems Software Laboratory and the Database and Object Technology Laboratory.

The Database and Object Technology Lab (DOT) conducts theoretical and applied research related to database management and object-oriented systems. Query processing is a long-term focus, particularly query optimization frameworks as well as design, optimization and evaluation of object-oriented query languages. Another area of interest is scientific data management, most recently in support of multi-disciplinary studies in forest canopy science.

DOT research includes conceptual modeling, including semantic and object-oriented database models, models for object-oriented analysis and design, and models for superimposed information. Other topics include data dissemination, focusing particularly on information utility and superimposed information management. Superimposed information enhances the utility and value of existing data sources by layering small amounts of information over them. We are examining superimposed information in connection with improving accessibility of medical records. Finally, we are investigating architectures for adaptable software and middleware support for application building, especially object-oriented approaches.

Dr. Dave Maier of OGI is the director of DOT. Additional DOT-affiliated faculty members are Dr.Crispin Cowan, Dr. Lois Delcambre, and Dr. Dylan McNamee of OGI, and Dr. Leonard Shapiro of Portland State University.

The Software Systems Lab (SySL) is a center for research spanning the areas of distributed and mobile computing, operating systems, networking, and wide-area-network based information management systems. SySL focuses on the development of adaptive systems that utilize techniques such as feedback-control, specialization, domain-specific languages, and quality of service management to enable them to operate effectively in today's rapidly evolving and widely heterogeneous distributed environments. We emphasize the real-world applicability of our research results and we continue to build distributed and scalable prototype systems for application areas such as multimedia computing and communications, active networks, Internet-based information management, and survivable distributed systems. We collaborate closely with industry sponsors such as Intel and IBM, and have strong federal funding from DARPA and NSF. Dr. Jonathan Walpole is the director of SySL. Additional SySL-affiliated faculty are Drs. Wu-chi Feng, Wu-chang Feng, Andrew Black and David Steere of OGI, and Dr. Molly Shor of OSU.

FACILITIES

OGI's Department of Computer Science and Engineering provides a state-of-the-art computing environment designed to support the needs of research and education. The computing facilities staff has a wide range of skills that allows the computing environment at CSE to be flexible and responsive in meeting the changing needs of the department.

Support for central services such as mail, dial-up access, video conferencing, database access, and file and printer sharing as well as access to Internet and Internet2 services are distributed across a group of Sun computers and a Network Appliance file server that comprise the core support environment.

While Sun computers are highly visible at CSE, both Intel and Alpha based machines running Windows or Linux are mainstays of our research activities. The generous support of our industry and government research partners allows CSE to maintain a high-quality computing infrastructure capable of supporting a high degree of heterogeneity as required for high-quality research.

In all, a facilities staff of nine supports almost 400 computer systems, X terminals, and peripheral devices spanning multiple networks using a variety of automated techniques, many developed internally, to cope with the high degree of complexity inherent in such a heterogeneous environment.

JAMES HOOK

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RESEARCH INTERESTS

Domain-specific languages, formal methods, and functional programming.

REPRESENTATIVE PUBLICATIONS

J. Hook, E. Meijer, & D. Leijen, "Client-side web scripting in Haskell", in proceedings of Practical Applications of Declarative Languages, January 1999.

J. Hook, E. Meijer, & D. Leijen, "Haskell as an Automation Controller", in "Advanced Functional Programming", Swierstra, Henriques and Oliveira (Eds.), Springer Verlgan, LNCS Vol. 1608.

T. Widen &J. Hook, "Software Design Automation: Language Design in the Context of Domain Engineering," Sere 98, June 1998.

J. Bell, F. Bellegarde & J. Hook, "Type-driven Defunctionalization," ICFP '97, June 1997.

R. Kieburtz, F. Bellegarde, et al., "Calculating Software Generators from Solution Specifications," TAPSOFT '95, Springer-Verlag, LNCS, May 1995.

F. Bellegarde & J. Hook, "Substitution: A Formal Methods Case Study using Monads and Transformations," Science of Computer Programming, 22(2-3), 287, 1994.

J. Bell, J. Hook, et al., "Software Design for Reliability and Reuse: A Proof-of-Concept Demonstration," TRI-Ada '94 Proceedings, ACM Press, November 1994.

F. Bellegarde & J. Hook, "Monads, Indexes, and Transformations," Proceedings of the Colloquium on Formal Approaches to Software Engineering (TAPSOFT '93), LNCS, April 1993.

DAVID BASTERFIELD

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University of Manchester, 1984
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RESEARCH INTERESTS

Numerical computing, simulation, optimization, genetic algorithms, information systems, time series analysis and computational finance.

REPRESENTATIVE PUBLICATIONS

D. Basterfield, "Error bounds on Tree methods for Calculating Options Prices", Paper Presented at Computational Finance 2000, June 2000.

D. Basterfield, T. Bundt and G.Murphy, "The Stable Paretian Hypothesis and the Asian Currency Crisis", Paper Presented at Computational Finance 2000, June 2000.

ANDREW P. BLACK

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RESEARCH INTERESTS

Programming languages; distributed systems; streaming infrastructure for wide-area networks; object-oriented languages and systems; programming environments; and the ways in which all of these areas interrelate.

REPRESENTATIVE PUBLICATIONS

A. P. Black, J. Huang and J. Walpole, "Reifying Communication at the Application Level". Oregon Graduate Institute, Department of Computer Science & Engineering, Beaverton, OR, Technical Report CSE-01-006, May 2001.

C. Pu, A. Black, C. Cowan, J. Walpole, & C. Consel, "Microlanguages for Operating System Specialization," Proc. First ACM SIGPLAN Workshop on Domain-Specific Languages, Paris, France, p. 49-57, January 1997.

C. Pu, T. Autrey, A.P. Black, C. Consel, C. Cowan, J. Inouye, L. Kethana, J. Walpole & K. Zhang, "Optimistic Incremental Specialization: Streamlining in a Commercial Operating System," Proceedings of the 15th ACM Symposium on Operating Systems Principles, December 1995.

A.P. Black & M.P. Immel, "Encapsulating Plurality," Proceedings of European Conference on Object-Oriented Programming, July 1993.

R.K. Raj, E.D. Tempero, H.M. Levy, A.P. Black, N.C. Hutchinson & E. Jul, "Emerald, A GeneralPurpose Programming Language," Software Practice & Experience, 21(1), 91, January 1991.

A.P. Black & Y. Artsy, Digital Equipment Corp., "Implementing Location Independent Invocation," IEEE Trans. On Parallel and Distributed Systems, 1(1), 107, January 1990.

THOMAS BUNDT

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RESEARCH INTERESTS

International monetary theory and empirical models of exchange rate determination, time series analysis and forecasting and pedagogical tools in finance. Professor Bundt has also written instructional manuals (distance learning courses) in Managerial Economics, Business Forecasting and Ebusiness Valuations.

REPRESENTATIVE PUBLICATIONS

T. Bundt, T.F. Cosimano & J.A. Halloran, "DIDMCA and Bank Market Risk: Theory and Evidence," Journal of Banking and Finance, 16, 1179-1193, 1992.

T. Bundt & J.H. Bergstrand, "Currency Substitution and Monetary Autonomy: The Foreign Demand for U.S. Demand Deposits," Journal of International Money and Finance, 9, 325-334, 1990.

T. Bundt & R. Schweitzer, "Deregulation, Deposit Markets, and Banks' Costs of Funds," The Financial Review, 24(3), 417-430, August 1989.

T. Bundt, J.S. Chiesa & B.P. Keating, "Common Bond Type and Credit Union Behavior," Review of Social Economy, 47(1), 27-42, Spring 1989.

T. Bundt & A. Solocha, "Debt, Deficits and the Dollar," Journal of Policy Modeling, 10(4), 581-600, October 1988.

PHIL COHEN

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Center for Human-Computer Communication
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RESEARCH INTERESTS

Multimodal interfaces, human-computer interaction, natural language processing, dialogue, delegation technology, cooperating agents, communicative action, applications to mobile computing, information management, network management, manufacturing.

REPRESENTATIVE PUBLICATIONS

Oviatt, Sharon & Cohen, Philip. "Multimodal Interfaces That Process What Comes Naturally", Communications of the ACM, Vol. 43, No. 3, pp. 45-53, March 2000.

D. McGee, P. Cohen, & L. Wu, (2000) "Something from nothing: Augmenting a paper-based work practice with multimodal interaction," in Proceedings of the Designing Augmented Reality Environments Conference, ACM Press, pp. 71-80, Copenhagen, Denmark, April 12-14, 2000.

S. Kumar, & P. Cohen, "Towards a Fault-Tolerant Multi-Agent System Architecture." To appear in The Fourth International Conference on Autonomous Agents (Agents 2000), Barcelona, Spain, June 3-7, 2000.

L. Wu, S.L. Oviatt, & P. Cohen, "Multimodal Integration — A Statistical View," IEEE Transactions on Multimedia, Vol. 1, No. 4, pp. 334-341, December 1999.

P. Cohen, D. McGee, S.L. Oviatt, L. Wu, J. Clow, R. King, S. Julier, & L. Rosenblum, "Multimodal Interactions for 2D and 3D Environments," IEEE Computer Graphics and Applications, pp.10-13, July/August 1999.

S. Kumar, P. Cohen, & H. Levesque, "The Adaptive Agent Architecture: Achieving Fault-Tolerance Using Persistent Broker Teams." To appear in The Fourth International Conference on Multi-Agent Systems (ICMAS 2000), Boston, MA, USA, (Acceptance rate 20%), July 7-12, 2000.

CRISPIN COWAN

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RESEARCH INTERESTS

System security and survivability, operating systems, distributed systems, computer architecture, optimism, programming languages.

REPRESENTATIVE PUBLICATIONS

C. Cowan, S. Beattie, C. Wright, & G. Kroah-Hartman, "RaceGuard: Automatic Adaptive Detection and Prevention of Buffer-Overflow Attacks," Tenth USENIX Security Conference 2001.

C. Cowan, M. Barringer, S. Beattie, G. Kroah-Hartman, M. Frantzen, & J. Lokier, "FormatGuard: Automatic Adaptive Detection and Prevention of Buffer-Overflow Attacks," Tenth USENIX Security Conference 2001.

D. McNamee, J. Walpole, C. Cowan, C. Pu, C. Krasic, P. Wagle, C. Consel, G. Muller & R.Marlet, "Specialization Tools and Techniques for Systematic Optimization of Systems Software," ACM Transactions on Computer Systems, Volume 19, No. 2, May 2001.

C. Cowan, C. Pu, D. Maier, H. Hinton, J. Walpole, P. Bakke, S. Beattie, A. Grier, P. Wagle, & Q. Zhang, "Stackguard: Automatic Adaptive Detection and Prevention of Buffer-Overflow Attacks," Seventh USENIX Security Conference, 1998.

C. Cowan & H. Lutfiyya, "A Wait-Free Algorithm for Optimistic Programming: HOPE Realized," 16th International Conference on Distributed Computing Systems (ICDCS'96), Hong Kong, 1996.

C. Cowan, T. Autrey, C. Krasic, C. Pu, & J. Walpole, "Fast Concurrent Dynamic Linking for an Adaptive Operating System," in The International Conference on Configurable Distributed Systems (ICCDS'96), Annapolis, MD, 1996.

C. Pu, T. Autrey, A. Black, C. Consel, C. Cowan, J. Inouye, L. Kethana, J. Walpole, & K. Zhang, "Optimistic Incremental Specialization: Streamlining a Commercial Operating System," in Proceedings of the 15th ACM Symposium on Operating Systems Principles (SOSP'95), Copper Mountain, Colorado, 1995.

LOIS DELCAMBRE

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RESEARCH INTERESTS

Superimposed information, database system data models, scientific data management.

REPRESENTATIVE PUBLICATIONS

S. Bowers and L. Delcambre. A generic representation for exploiting model-based information. To appear, ETAI Journal, 2001.

L. Delcambre, D. Maier, S. Bowers, L. Deng, M. Weaver, P. Gorman, J. Ash, M. Lavelle, and J. Lyman. Bundles in captivity: An application of superimposed information." Proceedings of the IEEE International Conference on Data Engineering, Heidelberg, Germany, April 2001.

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L. Delcambre & E. Ecklund, "A Behaviorally Driven Approach to Object-Oriented Analysis and Design with Object-Oriented Data Modeling," in Object-Oriented Data Modeling, M. Papazouglu, S. Spaccateria, & Z. Tari (Eds), MIT Press, 1999.

RICHARD E. (DICK) FAIRLEY

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Ph.D., Computer Science
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RESEARCH INTERESTS

All aspects of software engineering, including but not limited to systems engineering of software-intensive systems, software process modeling and process improvement, software requirements engineering, software design, software quality engineering, software metrics, software project management, software cost and schedule estimation, software risk management, and software engineering policies, procedures, standards, and guidelines.

REPRESENTATIVE PUBLICATIONS

Software Project Management, Encyclopedia of Computer Science, Groves Dictionaries, 2001.

"Software Estimation Risk," Encyclopedia of Software Engineering, Volume 2, John Wiley and Sons, 2000.

R. Fairley, "A Process-Oriented Approach to Software Product Improvement," PROFES'99 Conference Proceedings, Oulu, Finland, June 1999.

R. Fairley, "The Concept of Operations-The Bridge from Operational Requirements to Technical Specifications," Annals of Software Engineering, Vol. 3, Baltzer Publishers, Amsterdam, The Netherlands, September 1997.

R. Fairley, "Standard for Concept of Operations Documents," IEEE Standard Vol. 1362, IEEE Computer Society, 1997.

R. Fairley, "Standard for Software Project Management Plans," IEEE Standard, Vol. 1058, IEEE Computer Society, 1997.

R. Fairley, "Risk-Based Cost Estimation," Proceedings of the 11th COCOMO Users Group, Los Angeles, CA, November 1996.

R. Fairley, "Some Hard Questions for Software Engineering Educators," keynote presentation, CSEE 95 Proceedings, ACM Conference on Software Engineering Education, New Orleans, March 1995.

WU-CHANG FENG

Assistant Professor
Ph.D., Computer Science
University of Michigan, 1999
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RESEARCH INTERESTS

Scalable Internet systems, Internet congestion control and queue management, wireless networking, programmable network infrastructure.

REPRESENTATIVE PUBLICATIONS

W. Feng, D. Kandlur, D. Saha, K. Shin, "Blue: An Alternative Approach to Active Queue Management," NOSSDAV 2001, June 2001.

W. Feng, D. Kandlur, D. Saha, K. Shin, "Stochastic Fair Blue: A Queue Management Algorithm for Enforcing Fairness," INFOCOM 2001, April 2001.

W. Feng, D. Kandlur, D. Saha, K. Shin, "A Self-Configuring RED Gateway," INFOCOM 1999, May 1999.

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Ph.D., Computer Science
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RESEARCH INTERESTS

Networking, multimedia systems, multimedia networking, video coding, middleware services, and massively scalable streaming infrastructures.

REPRESENTATIVE PUBLICATIONS

Guohong Cao, Wu-chi Feng, Mukesh Singhal, Online VBR Video Traffic Smoothing, to appear Computer Communications.

Wu-chi Feng, Ming Liu, Extending Critical Bandwidth Allocation Techniques for Stored Video Delivery Across Best-Effort Networks, to appear International Journal of Communication Systems.

Ali Saman Tosun, Wu-chi Feng, Lightweight Security Mechanisms for Wireless Video Transmission, in Proceedings of the IEEE International Conference on Information Technology: Coding and Computing 2001, Las Vegas, Nevada, April 2001.

Ali Saman Tosun, Wu-ch Feng, On Improving Quality of Video for H.263 over Wireless CDMA Networks, in Proceedings of the IEEE Wireless Communications and Networking Conference, Chicago, Illinois, September 2000.

Amit Agarwal, Wu-chi Feng, Christine Wolfe, A Multi-Differential Video Coding Algorithm for Robust Video Conferencing, in Proceedings of the SPIE Voice, Video, and Data Communications Conference, Boston, Massachusetts, November 2000.

Ali Saman Tosun, Amit Agarwal, Wu-chi Feng, Providing Efficient Support for Lossless Video Transmission and Playback, in 10th International Workshop on Network and Operating Systems Support for Digital Audio and Video, Chapel Hill, North Carolina, June 2000.

PETER A. HEEMAN

Assistant Professor and
Ph.D., Computer Science
University of Rochester, 1997
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RESEARCH INTERESTS

Spontaneous speech recognition, modeling disfluencies and intonation, dialogue management, collaboration, spoken dialogue systems, natural language processing.

REPRESENTATIVE PUBLICATIONS

P. Heeman & J. Allen, "Improving Robustness by Modeling Spontaneous Speech Events," in J. Junqua and G. van Noord (Ds.), Robustness in language and speech technology, Kluwer Academic Publishers, 2000.

K. Ward & P. Heeman, "Acknowledgments in Human-Computer Interaction," in Proceedings of the 1st Conference of the North American Chapter of the Association for Computational Linguistics, Seattle, May 2000.

P. Heeman, "Modeling Speech Repairs and Intonational Phrasing to Improve Speech Recognition," in IEEE Workshop on Automatic Speech Recognition and Understanding, Keystone, Colorado, December 1999.

P. Heeman & J. Allen, "Speech Repairs, Intonational Phrases and Discourse Markers: Modeling Speakers' Utterances in Spoken Dialog," Computational Linguistics, Vol. 25-4, 1999.

P. Heeman, "POS Tags and Decision Trees for Language Modeling," in Proceedings of the Joint SIGDAT Conference on Empirical Methods in Natural Language Processing and Very Large Corpora, College Park, Maryland, June 1999.

P. Heeman, M. Johnston, J. Denney & E. Kaiser, "Beyond Structured Dialogues: Factoring Out Grounding," in Proceedings of the Internatial Conference on Spoken Language Processing (ICSLP-98), Sydney, Australia, December 1998.

P. Heeman & G. Damnati, "Deriving Phrase-based Language Models," IEEE Workshop on Speech Recognition and Understanding, Santa Barbara, California, December 1997.

MICHAEL JOHNSTON
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RESEARCH INTERESTS

Natural language processing, human-computer interaction, multimodal interfaces, spoken dialogue systems, syntax, semantics, and pragmatics of human language, computational models of phonology, morphology, and the lexicon, natural language understanding and computational semantics.

REPRESENTATIVE PUBLICATIONS

M. Johnston, P. Cohen, D. Mcgee, S.L. Oviatt, J.A. Pittman, I. Smith, "Unification-based Multimodal Integration," Proceedings of the 35th Annual Meeting of the Association for Computational Linguistics, Madrid, Spain, 281-288, 1997.

P. Cohen, M. Johnston, D. Mcgee, S.L. Oviatt, J.A. Pittman, I. Smith, L. Chen, & J. Clow, "quickset: Multimodal interaction for distributed applications," Proceedings of the Fifth ACM International Multimedia Conference, CM Press, New York, 1997.

M. Johnston, "The Telic/Atelic Distinction and the Individuation of Quantificational Domains," in Empirical Issues in Formal Syntax and Semantics: Selected Papers from the Colloque de Syntaxe et de Sémantique de Paris (CSSP 95), Daniéle Godard and Francis Corblin (Eds.). Peter Lang, Bern, 269-290, 1997.

J. Pustejovsky, B. Boguraev, M. Verhagen, P. Buitelaar & M. Johnston, "Semantic Indexing and Typed Hyperlinking," in Proceedings of the AAAI Spring Symposium on Natural Language Processing for the World Wide Web, American Association for Artificial Intelligence, 1997.

M. Johnston & F. Busa, "Qualia Structure and the Compositional Interpretation of Compounds," in Proceedings of ACL SIGLEX Workshop 1996: Breadth and Depth of Semantic Lexicons, Association for Computational Linguistics, 1996.

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RESEARCH INTERESTS

Programming language design and implementation; programming paradigms; module and component systems; type theory; semantics; program transformation and analysis.

REPRESENTATIVE PUBLICATIONS

Mark P. Jones , Type Classes with Functional Dependencies, in Proceedings of the 9th European Symposium on Programming, ESOP 2000, Berlin, Germany, March 2000, Springer-Verlag LNCS 1782.

M.P. Jones, "First-class Polymorphism with Type Inference," in Proceedings of the Twenty Fourth Annual ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages, Paris, France, Jan. 15-17, 1997.

M.P. Jones, "Using Parameterized Signatures to Express Modular Structure," in Proceedings of the Twenty Third Annual ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages, St. Petersburg Beach, Florida, Jan. 21-24, 1996.

M.P. Jones, "Simplifying and Improving Qualified Types," in proceedings of FPCA '95: Conference on Functional Programming Languages and Computer Architecture, La Jolla, CA, June 1995.

M.P. Jones, "A system of constructor classes: overloading and implicit higher-order

polymorphism," Journal of Functional Programming, 5, 1, Cambridge University Press, January 1995.

S. Liang, P. Hudak, & M.P. Jones, "Monad Transformers and Modular Interpreters," in Conference Record of POPL'95: 22nd ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages, San Francisco, CA, January 1995.

M.P. Jones, Qualified Types: Theory and Practice, Cambridge University Press, November 1994.

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RESEARCH INTERESTS

Functional programming, program transformation, domain-specific languages, program verification, high-confidence software

REPRESENTATIVE PUBLICATIONS

R. B. Kieburtz, Real-time Reactive Programming for Embedded Controllers, (QAPL 2001) September 2001.

R. B. Kieburtz, A Logic for Rewriting Strategies, (Strategies ë01) June 2001.

R. B. Kieburtz, Defining and Implementing Closed Domain-Specific Languages, (SAIG 00), September 2000.

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R. B. Kieburtz, Reactive Functional Programming, in PROCOMET'98, pp. 263-284, Chapman and Hall, June 1998.

R.B. Kieburtz, L. McKinney, J. Bell, J. Hook, A. Kotov, J. Lewis, D. Oliva, T. Sheard, I. Smith & L.Walton, "A Software Engineering Experiment in Software Component Generation," in Proceedings of the 18th International Conference on Software Engineering, Berlin, March 1996.

R.B. Kieburtz, F. Bellegarde, J. Bell, J. Hook, J. Lewis, D. Oliva, T. Sheard, L. Walton & T. Zhou," Calculating Software Generators from Solution Specifications," TAPSOFT '95, Springer-Verlag, series LNCS, 915, 546, 1995.

R.B. Kieburtz, "Programming with Algebras," Advanced Functional Programming, E. Meijer & J.Jeuring (Eds.), Springer-Verlag, Series LNCS, Vol. 925, 1995.

R.B. Kieburtz, "Results of the SDRR Validation Experiment," Pacific Software Research Center Software Design for Reliability and Reuse: Phase I Final Scientific and Technical Report, Vol. VI, CDRL No. 0002.11, February 1995.

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RESEARCH INTERESTS

Functional programming languages, semantics-based program analysis, program transformation, and partial evaluation.

REPRESENTATIVE PUBLICATIONS

J. Lewis, M. Shields, E. Maijer, & J.Launchbury, "Implicit Parameters," Implicit Parameters, ACM Principles of Programming Languages, 2000.

J. Matthews & J. Launchbury, " Elementary Microarchitecture Algebra," Computer Aided Verification, 1999.

J. Launchbury, J. Lewis, & B. Cook. " On embedding a microarchitecture design language within Haskell," International Conference on Functional Programming. ACM, 1999.

J. Launchbury & A. Sabry, "Axiomatization and Type Safety of Monadic State," Proc. ACM International Conference on Functional Programming, 1997.

J. Launchbury & R. Paterson, "Parametricity and Unboxing with Unpointed Types," Proc. European Symposium on Programming, Linkoping, 1996.

J. Launchbury & S.P. Jones, "State in Haskell," J. Of Lisp and Symbolic Computation, December 1995.

J. Launchbury & S.P. Jones, "Lazy Functional State Threads," in Proc. SIGPLAN Programming Languages Design and Implementation, Orlando, FL, 1994.

A. Gill, J. Launchbury & S.P. Jones, "A Short Cut to Deforestation," in Proc. SIGPLAN/SIGARCH Functional Programming and Computer Architecture, Copenhagen, Denmark, 1993.

J. Launchbury, "A Natural Semantics for Lazy Evaluation," in Proc. SIGPLAN Principles of Programming Languages, Charleston, SC, 1993.

J. Hughes & J. Launchbury, "Projections for Polymorphic First-Order Strictness Analysis," in Mathematical Structures in Computer Science, 2, 301, C.U.P., 1992.

J. Hughes & J. Launchbury, "Relational Reversal of Abstract Interpretation," in Journal of Logic and Computation, 2(4), 465, O.U.P., 1992.

TODD K. LEEN

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Ph.D., Physics
University of Wisconsin, 1982
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RESEARCH INTERESTS

Machine learning including: neural networks, local and mixture models, stochastic learning, model complexity, and invariance; applications to signal compression, sensor fusion, and anomaly detection, adaptation in biological systems.

REPRESENTATIVE PUBLICATIONS

R. Sharma, T.K. Leen, and M. Pavel, "Bayesian Image Sensor Fusion Using Local Generative Models," Optical Engineering, 2001, in press.

C. Archer and Todd K. Leen, "The Coding Optimal Transform," in Data Compression Conference 2001, IEEE Computer Society Press, 2001.

C. Archer and T.K. Leen, "From Mixtures of Mixtures to Adaptive Transform Coding," in T. Leen, T. Dietterich, and V. Tresp (eds.), Advances in Neural Information Processing Systems 13, The MIT Press, 2001.

R. Sharma, T.K. Leen & M. Pavel, "Probabilistic Image Sensor Fusion," in Advances in Neural Information Processing Systems 11, Kearn, Solla, Cohn (Eds.), The MIT Press, 1999.

W. Wei, T. Leen & E. Barnard, "A Fast Histogram-Based Post-processor that Improves Posterior Probability Estimates," Neural Computation, Vol. 11, No. 5, 1999.

T.K. Leen, B. Schottky, & D. Saad, "Optimal Asymptotic Learning Rates: Macroscopic Versus Microscopic Dynamics," Physical Review, E-59, 985-991, 1999.

T.K. Leen, "Exact and Perturbation Solutions for the Ensemble Dynamics," in Online Learning in Neural Networks, The Newton Institute Series, D. Saad (Ed.), Cambridge University Press, Cambridge, 1998.

T.K. Leen, B. Schottky & D. Saad, "Two Approaches to Optimal Annealing," in Advances in Neural Information Processing Systems 10, The MIT Press, 1998.

DAVID MAIER

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Princeton University, 1978
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RESEARCH INTERESTS

Database systems (including object-oriented database management systems, query processing, scientific information management, superimposed information and net data management), object-oriented and logic programming languages, algorithms, survivability of information systems, and health information technology.

REPRESENTATIVE PUBLICATIONS

J. Shanmugasundaram, K. Tufte, D. DeWitt, J. Naughton, D. Maier. Architecting a Network Query Engine for Producing Partial Results. In *The World Wide Web and Databases* (Third International Workshop WebDB 2000), Lecture Notes in Computer Science, Vol. 1997, Springer-Verlag, 2001.

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Gorman, J. Ash, M. Lavelle, J. Lyman, L. Delcambre, D. Maier, S. Bowers and M. Weaver. ìBundles in the wild: Tools for managing information to solve problems and maintain situation awareness. Library Trends 49(2), Fall 2000.

L. Fegaras and D. Maier. Optimizing object queries using an effective calculus. ACM Transactions on Database Systems 25(4), December 2000.

Q. Wang, D. Maier and L. Shapiro. The hybrid technique for reference materialization in object query processing. Proceedings of the 4th International Conference on Database Engineering and Applications (IDEAS2000), Tokyo, Japan, September 2000.

JOHN E. MOODY

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Ph.D., Theoretical Physics
Princeton University, 1984
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RESEARCH INTERESTS

Computational finance, time series analysis, analysis of financial markets, forecasting, and statistical learning theory and algorithms. Applications of machine learning to problems in finance, economics and the sciences.

REPRESENTATIVE PUBLICATIONS

Learning to Trade via Direct Reinforcement, John Moody and Matthew Saffell, IEEE Transactions on Neural Networks, Vol. 12, No. 4, July 2001.

Term Structure of Interactions of Foreign Exchange Rates, John Moody and Howard Yang, in Computational Finance 1999, edited by Y. S. Abu-Mostafa, B. LeBaron, A. W. Lo, and A. S. Weigend, Cambridge, MA: MIT Press, 2000.

Predicting Blood Glucose Metabolism in Diabetics -- A Machine Learning Solution, Volker Tresp and John Moody, IEEE Transactions on BioMedical Engineering, 1999.

Performance Functions and Reinforcement Learning for Trading Systems and Portfolios, John Moody, Lizhong Wu, Yuansong Liao and Matthew Saffell, Journal of Forecasting, vol. 17, pp. 441-470, 1998.

High Frequency Foreign Exchange Rates: Price Behavior Analysis and `True Price' Models, John Moody and Lizhong Wu, Chapter 2 of Nonlinear Modelling of High Frequency Financial Data, Christian Dunis and Bin Zhou, editors, Wiley Financial Publishing, London, 1998.

Stochastic Manhattan Learning: Time-evolution Operator for the Ensemble Dynamics, Todd Leen and John Moody, Physical Review E, 1997.

Smoothing Regularizers for Projective Basis Function Networks, John Moody and Thorsteinn Rognvaldsson, in Advances in Neural Information Processing Systems 9, M.C. Mozer, M.I. Jordan and T. Petsche, eds, MIT Press, Cambridge, 1997.

SHARON L. OVIATT

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Human-Computer Communication
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RESEARCH INTERESTS

Multimodal and spoken language systems, modality effects in communication (speech, writing, keyboard, etc.), communication models, telecommunications and technology-mediated communication, mobile and interactive systems, human-computer interaction, empirically based design and evaluation of human-computer interfaces, cognitive science, and research methodology.

REPRESENTATIVE PUBLICATIONS

S. L. Oviatt, ìMultimodal Input and Output, Handbook of Human-Computer Interaction, (ed. By J. Jacko & A. Sears), Lawrence Erlbaum Assoc: Mahwah, New Jersey, invited book chapter to appear in 2002.

S. L. Oviatt, P. R. Cohen, L. Wu, J. Vergo, L. Duncan, B. Suhm, J. Bers, T. Holzman, T. Winograd, J. Landay, J. Larson, & D. Ferro. ìDesigning the user interface for multimodal speech and gesture applications: State-of-the-art systems and research directions. Human Computer Interaction, 15(4), 263-322, 2000. (to be reprinted in J. Carroll (Ed.) Human-Computer Interaction in the New Millennium, Addison-Wesley Press: Boston, 2001).

S. L. Oviatt, ìMultimodal System Processing in Mobile Environments, Proceedings of the Thirteenth Annual ACM Symposium on User Interface Software Technology (UIST'2000), 21-30, ACM: New York, N.Y., 2000.

S. L. Oviatt, ì Multimodal Signal Processing in Naturalistic Noisy Environments. In B. Yuan, T. Huang & X. Tang (Eds.), Proceedings of the International Conference on Spoken Language Processing (ICSLP'2000), Vol. 2, (pp. 696-699). Beijing, China: Chinese Friendship Publishers.

S. L. Oviatt, ìTaming Recognition Errors with a Multimodal Architecture, Communications of the ACM, 43 (9), 45-51, September 2000 (special issue on "Conversational Interfaces").

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RESEARCH INTERESTS

Transaction processing, distributed databases, scientific databases, parallel and distributed operating systems.

REPRESENTATIVE PUBLICATIONS

L. Liu & C. Pu, "An Adaptive Object-Oriented Approach to Integration and Access of Heterogeneous Information Sources," International Journal on Distributed and Parallel Databases, 5(2), April 1997.

K.L. Wu, P.S. Yu & C. Pu, "Divergence Control for Epsilon-Serializability," IEEE Transactions on Knowledge and Data Engineering, 9(2), March/April 1997.

J. Biggs, C. Pu, A. Groeninger & P.E. Bourne, "pdbtool: An Interactive Browser and Geometry Checker for Protein Structures," Journal of Applied Crystallography, 29(4), 1996.

L. Liu, C. Pu, R. Barga & T. Zhou, "Differential Evaluation of Continual Queries," Proceedings of the 16th International Conference on Distributed Computing Systems, Hong Kong, May 1996.

K. Ramamrithan & C. Pu, "A Formal Characterization of Epsilon Serializability," IEEE Transactions on Knowledge and Data Engineering, 7(6), December 1995.

C. Pu, T. Autrey, A.P. Black, C. Consel, C. Cowan, J. Inouye, L. Kethana, J. Walpole & K. Zhang, "Optimistic Incremental Specialization: Streamlining a Commercial Operating System," Proceedings of the Fifteenth Symposium on Operating Systems Principles, December 1995.

R. Barga & C. Pu, "A Practical and Modular Implementation Technique of Extended Transaction Models," Proceedings of the 21st International Conference on Very Large Data Bases, Zurich, Switzerland, September 1995.

K. Ramamrithan & C. Pu, "A Formal Characterization of Epsilon Serializability," IEEE Transactions on Knowledge and Data Engineering, 7(3), June 1995.

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RESEARCH INTERESTS

Functional programming, software specification, program generation, meta-programming and staging.

REPRESENTATIVE PUBLICATIONS

T. Sheard. "Accomplishments and Research Challenges in Meta-Programming." Invited talk, Second International Workshop on Semantics, Applications, and Implementation of Program Generation (SAIG 2001). LNCS 2196. Florence, Italy, September 2001.

T. Sheard. "Generic Unification via Two-Level Types and Parameterized Modules." Sixth ACM SIGPLAN International Conference on Functional Programming (ICFP'01). ACM Press. Florence, Italy, September 3-5, 2001.

T. Sheard, Z. Benaissa, & E. Pasalic. "DSL Implementation Using Staging and Monads," Usenix, Second Conference on Domain Specific Languages. Austin, Texas. October 3-5, 1999.

W. Taha, Z. Benaissa, & T. Sheard. "Multi-Stage Programming: Axiomatization and Type Safety," 25th International Colloquium on Automata, Languages and Programming, July 1998.

M. Shields, T. Sheard, & S. Peyton Jones, "Dynamic Typing as Staged Type Inference," ACM-SIGPLAN-SIGACT Symposium on Principles of Programming Languages (POPL '98), San Diego, CA, January 1998.

T. Sheard, "A Type-Directed, On-Line, Partial Evaluator for a Polymorphic Language," ACM-SIGPLAN Conference on Partial Evaluation and Semantics-Based Program Manipulation, Amsterdam, June 1997.

W. Taha & T. Sheard, "Multi-Stage Programming with Explicit Annotations," ACM-SIGPLAN Conference on Partial Evaluation and Semantics-Based Program Manipulation, Amsterdam, June 1997.

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Carnegie Mellon University, 1997
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RESEARCH INTERESTS

Operating systems, mobile computing, distributed information systems.

REPRESENTATIVE PUBLICATIONS

D.C. Steere, A. Goel, J. Gruenberg, D. McNamee, C. Pu, & J. Walpole, "A Feedback-driven Proportion Allocator for Real-Rate Scheduling," Operating Systems Design and Implementation, February 1999.

J. Walpole, C. Krasic, L. Liu, D. Maier, C. Pu, D. McNamee, & D.C. Steere, "Quality of Service Semantics for Multimedia Database Systems," to appear in Proceedings Data Semantics 8: Semantic Issues in Multimedia Systems IFIP TC-2 Working Conference, Rotorua, New Zealand, January 1999.

D. McNamee, D. Revel, D.C. Steere, & J. Walpole, "Adaptive Prefetching for Device Independent File I/O," in Proceedings of Multimedia Computing and Networking 1998 (MMCN98), January 1998.

D.C. Steere, "Exploiting the Non-Determinism and Asynchrony of Set Iterators to Reduce Aggregate File I/O Latency," in Proceedings of the 16th acmsymposium on Operating Systems Principles, October 1997.

D.C. Steere & J. Wing, "Specifying Weak Sets," in Proceedings of the 15th International Conference on Distributed Computing Systems, 414-421, Vancouver, BC, June 1995.

M. Satyanarayanan, H.H. Mashburn, P. Kumar, D.C. Steere & J.J. Kistler, "Lightweight Recoverable Virtual Memory," ACM Transactions on Computer Systems, 12(1), 33-57, February 1994. Corrigendum: ACM Transactions on Computer Systems, 12(2), 165-172, May 1994.

M. R. Ebling, L.B. Mummert & D.C. Steere, "Overcoming the Network Bottleneck in Mobile Computing," in Proceedings of the First Workshop on Mobile Computing Systems and Applications, 34-36, Santa Cruz, CA, December 1994.

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RESEARCH INTERESTS

Adaptive systems software and its application in distributed, mobile, and multimedia computing environments and environmental observation and forecasting systems. Quality of service specification, adaptive resource management and dynamic specialization for enhanced performance, survivability and evolvability of large software systems.

REPRESENTATIVE PUBLICATIONS

K. Li, C. Krasic, J. Walpole, M. Shor, C.Pu, The Minimal Buffering Requirements of Congestion Controlled Interactive Multimedia Applications, in Proceedings of the 8th International Workshop on Interactive Distributed Multimedia Systems, iDMS 2001, Lancaster, UK, September 2001. Also published in Springer Verlag's Lecture Notes in Computer Science Series.

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J. Huang, A. Black, J. Walpole, C. Pu, ìInfopipes ñ An Abstraction for Information Flow, in proceedings of the ECOOP Workshop on the Next 700 Distributed Object Systems, Budapest, Hungary, June 2001.

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Intel Corporation

DR. TED BRUNNER
Tektronix Inc.

DR. SHANWEI CEN
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Oregon Health &
Science University

DR. EARL ECKLUND
Objective Technology Group

MS. ANNIE GROENINGER
Performance Logic, Inc.

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DR. DAVID HANSEN
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Intel Corporation

DR. HOLLY JIMISON
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The primary mission of the DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING is to provide quality graduate education, research and technology transfer in the areas of Intelligent Signal Processing, Semiconductor Materials and Devices, Computer and Systems Engineering, and Biomedical Engineering.

We currently have a very successful and well-focused program in Intelligent Signal Processing, which includes speech recognition and synthesis, image processing, adaptive filtering and control, and anthropomorphic signal processing. The department has two centers in this area, the Center for Information Technology (CIT) and the Center for Spoken Language Understanding (CSLU). Close interaction with the high-tech industry is a critical element of the activities reflected in numerous collaborative projects funded by industrial organizations including Intel, Qualcomm, and many others.

The Semiconductor Materials and Devices program has many new people and is in the middle of a rebuilding process. We have an excellent group, and investment includes a 5-year, $1 million Intel grant. We are creating a number of new laboratories. Although some semiconductor processing will be done, most of the effort and laboratory space will be devoted to education and to semiconductor materials and device characterization, including high-speed devices. These, plus our existing electron microscopy facility, are of value to local industry.

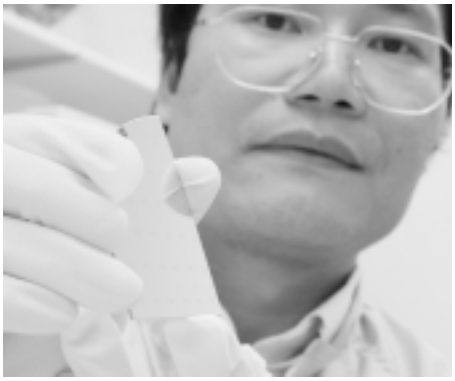
Computer and Systems Engineering is focused primarily on research into hardware and systems for implementing intelligent signal processing and robotic control. This process also includes the VLSI design of specialized devices for computation and intelligent sensing. Computational neuroscience plays an important part of this work. A new laboratory with 8 stations for DSP and FPGA programming is available, with help from Intel and Altera, to support education and research in this area. This area has several adjunct faculty from companies such as Intel, RadiSys, IDT, Cypress, Maxim and Triquint. There is one center in this area, the Center for Biologically Inspired Information Engineering (CBIIE).

The Biomedical Engineering (BME) program concentrates on Biomedical Optics, Tissue Engineering, and Medical Informatics. Biomedical Optics develops optical technologies for imaging and characterizing tissues and laser-tissue interactions for machining tissues and surgical techniques. Faculty are emphasizing tissue engineering with research at the affiliated Oregon Medical Laser Center (OMLC). Several people are also faculty at Oregon Health & Science University (OHSU) with a laboratory at OGI where students conduct research that interfaces with medical clinicians and investigators.

The department offers a wide variety of formal courses in core areas as well as in specific research areas. The curriculum for each student is determined in part by his or her academic background and interest, and is set after discussion with a faculty advisor.

The major fields of research activity in the department are:

- Advanced Lithography
- Atmospheric Optics
- Biomedical Engineering
- Biosensors
- Digital Signal Processing
- Display Technology including Thin Film Transistors and Phosphors
- Electro-Optic Systems
- Human Information Processing
- Image and Video Processing
- Man-Machine Interfaces
- MEMS
- Neural Networks
- Optical Remote Sensing
- Pattern Recognition
- Processing for Ultra Shallow Device Technology
- Semiconductor Electronic Devices
- Semiconductor Materials and Processing
- Speech Recognition, Enhancement, and Synthesis
- Systems Dynamics
- Technology Transfer



Jinshan Huo is a Ph.D. student and Intel intern whose interests involve copper interconnects for microelectronic device and materials characterization.

- Transient Thermal Processing
- VLSI/FPGA Design
- VLSI Architecture for Intelligent Computing

Students may become involved in relatively fundamental investigations (such as atmospheric effects on laser beams, and semiconductor materials characterization and processing) or in advanced engineering applications (such as video display technology or signal/image processing). In all cases, the emphasis is on scientific and engineering investigations having well-defined goals and real utility in an atmosphere resembling that of a working research and development laboratory. The academic program, while rigorous, is innovative and individually planned to meet each student's needs. The limited number of students in residence assures close attention to each student and progress at a rate determined by the student's ability and effort.

DEPARTMENT SEMINARS

The department and other local educational and corporate organizations host invited talks and seminars on topics of interest in the field of electrical engineering. M.S. students are required to obtain at least three credits of seminar to graduate. Seminar schedules are posted each quarter. Additionally, the ECE Department in conjunction with Portland State University's Department of Electrical and Computer Engineering sponsor the Portland Area Semiconductor Seminar Series (PASSS). These seminars offer an opportunity to meet leading local and nationally recognized EE professionals and learn about the latest technical advancements in the high-technology industry.

ADMISSIONS REQUIREMENTS

Admission requirements are the same as the general requirements of the institution. The GRE is not required for the part-time program or the twelve-month M.S. program. It is recommended for M.S. students who may want to apply for the Ph.D. at a later date. The GRE is required for all applicants to the Ph.D. program. The TOEFL is required of all international student applicants for both the M.S. and Ph.D. programs.

Prerequisite: B.S. or M.S. in physics, applied physics, engineering physics, electrical engineering, or equivalent. Since modern electrical engineering programs are broad and diverse, students with undergraduate degrees in applied mathematics as well as other branches of engineering are encouraged to apply.

OGI offers the Ph.D. in Electrical Engineering. Students must have a Master of Science degree acceptable to the ECE Department to be considered for the Ph.D. program. The M.S. degree may be from OGI or another institution of higher education.

DEGREE REQUIREMENTS

MASTER OF SCIENCE (M.S.) PROGRAM

The M.S. program in Electrical Engineering is designed to enable professionals or recent graduates to adapt quickly to the changing needs of their fields. ECE's M.S. program offers three degree options for full-time and part-time students. The M.S. degree requires successful completion of 48 credits and may be obtained with a non-thesis option, a non-thesis project option, or a thesis option. All courses, non-thesis research, and thesis research must be taken for graded credit to be counted towards the ECE M.S. degree. Courses taken outside of the ECE Department must also be taken for graded credit; Pass/No Pass is not acceptable. A minimum grade point average of 3.0 must be maintained throughout the degree program. Students' course of study should be reviewed and approved by a faculty advisor. Students are limited to 12 credits per quarter unless a waiver is obtained from their advisor.

NON-THESIS OPTION

The non-thesis option requires completion of a minimum of 48 credits of graded course work. While students are strongly encouraged to focus on courses in ECE, students may take up to 24 credits of course work in other OGI academic departments provided the courses fall within the curriculum standards set by the ECE Department. For students seeking an M.S. degree in Electrical Engineering, a minimum of 24 credits must be taken from the OGI's ECE department curriculum. All courses, regardless of OGI department, must be taken for graded credit.

NON-THESIS PROJECT OPTION

The non-thesis project option requires completion of a minimum of 48 graded credits, comprising 40 credits of course work and a minimum of 8 credits of research (ECE610). The research project is more limited in scope than a thesis and may include experimental work, a critical literature review, or a specific contribution to a larger project. Completion of the non-thesis project requires the submission of a written report to satisfy the research grade requirements. The student is encouraged to work with a faculty advisor in formulating an appropriate project.

THESIS OPTION

The M.S. thesis option requires successful completion of a minimum of 32 credits of graded course work and a minimum of 16 credits of graded research (ECE700). The thesis is an original independent work resulting in publication. The student will work with a faculty member to select courses and design an appropriate thesis research program. A thesis committee is assigned to guide and advise the research program. Completion of the M.S. thesis requires the submission of the written thesis and a successful oral defense. Thesis research credits earned towards an M.S. degree must be graded.

SUMMER PROJECTS

Although not required, students should seriously consider taking at least one project course for the M.S. degree. Because most faculty use the summer to do research, it is an ideal time to do a project. In addition, there are often summer internships available at local companies, which also qualify. The department is not required to provide projects for students, but usually there are many opportunities. Projects can involve real implementation and often are done in a team setting, which make them an ideal preparation for a career in engineering. Projects are done as Special Topics courses, ECE 580, and they are graded. The specifics of a project are the responsibility of the sponsoring faculty member. Industrial adjunct faculty may also advise projects.

TRANSFER CREDITS

Up to 12 credits from accredited institutions may be transferred to OGI. Students may petition for transfer of up to 18 credits from the following institutions: Portland State University, Oregon State University, and University of Oregon. Students petitioning for acceptance of transfer credits should provide

(1) written request, (2) detailed course descriptions from institution catalogs and/or website, and (3) original transcript verifying credit hours and grades earned.

Upon approval from the department head, students may apply to their ECE degree a maximum of 21 credits from other OGI departments towards their ECE degree. Acceptance of all transfer credits will be subject to review and approval by the ECE department's Curriculum Committee. Transfer credits will not replace the degree/credit requirement of 24 credits from OGI's ECE department curriculum. Cross-listed courses may not be used as part of these 24 credits.

PH.D. PROGRAM

OGI offers a PhD degree program in Electrical Engineering. Admission to the PhD program generally requires a prior M.S. in Electrical Engineering, Computer Engineering or related field, whether from OGI or from another institution. Upon entry into the program a Student Program Committee (SPC) of three faculty members is formed. The student discusses feasible research areas and eventual research directions with the committee and together they chart an individualized course of study to prepare the student for the Qualifying Exam.

The Qualifying Exam may be written or oral or both, at the discretion of the SPC, and may additionally involve a formal research proposal. It is normally taken within 12 months of enrolling in the program, and is scheduled at any time during the year. The amount of course work to be completed before taking the Qualifying Exam is dependent on the individual's level of preparation at entry. At minimum, 3 graded courses from OGI's ECE department must be successfully completed before taking the exam.

After the Qualifying Exam is passed, student and Committee then work closely together to develop a research plan specifically for the dissertation. Ph.D. students are required to make annual reports to the SPC on the status of their research, and may be called upon to deliver timely research presentations as the work progresses. The dissertation itself must constitute a significant research contribution and must be of publishable quality. The Ph.D. degree is granted following the presentation of an acceptable dissertation and successful oral defense.

ECE CURRICULUM FOCUS AREAS

Students can elect to focus exclusively within one area of specialization or may combine two or more of these focus areas into a broader course of study.

- Biomedical Engineering
- Communications & Networking
- Computer Engineering & Design
- Materials, Semiconductors & Devices
- Signal Processing, Speech & Imaging

Students should refer to the ECE Department's 12-month Curriculum Plan for the scheduled offering of courses in the 2001/2002 academic year.

BIOMEDICAL ENGINEERING

Biomedical engineering is a rapidly developing broad field of study comprising basic biology and medicine, bioinformatics, biomedical signal processing, imaging, biomaterials, information technology and many other areas. Within the biomedical engineering program the ECE Department, in conjunction with other departments in the OGI School of Science and Engineering as well as departments at the OHSU Schools of Medicine, Dentistry, and Nursing, offers students a variety of opportunities to acquire breadth and depth of knowledge and expertise in this field. The research efforts are expanding to cover an increasing number of areas, including biomedical sensors and instrumentation, biomechanics (including laser-tissue interaction and tissue engineering), intelligent biomedical signal processing and analysis, computational neuroscience, biomedical image analysis, data-mining, and technology in healthcare delivery. Current research topics also include intelligent rehabilitation and assistive technologies for future healthcare delivery in smart homes (home health) using wearable sensors and networked devices, exploiting intelligent data fusion and incorporating the latest results in functional genomics.

Because of the diversity of the field, each student is encouraged to devise a program tailored to his or her specific career objectives. The available courses include introductory courses in biology and medicine, biomedical sensors and instrumentation, laser-tissue interactions, biomaterials, biomechanics, neuroscience, molecular engineering, audio and video processing by humans and machines, biomedical signal processing, biological pattern recognition and datamining, bioinformatics, and medical informatics. To be prepared for the challenge, students are expected to take, in addition to specific biomedical engineering courses, a number of basic engineering courses in statistical signal analysis and recognition, digital signal processing, image processing, pattern recognition, databases, and information retrieval.

ECE500	**Introduction to Electronics and Instrumentation**
ECE525	**Analytical Techniques in Statistical Signal Processing & Communications**
ECE529*	**Optical Fibers**
ECE532*	**Biomedical Optics I: Tissue Optics**
ECE533*	**Biomedical Optics II: Laser Tissue Interactions**
ECE534*	**Biomedical Optics III: Engineering Design**
ECE551	**Introduction to Digital Signal Processing**
ECE552	**Digital Signal Processing II**
ECE554	**Adaptive Signal Processing**
ECE540	**Auditory and Visual Processing by Human and Machine**
ECE541	**Speech Processing**
ECE542	**Introduction to Image Processing**
ECE580-PGO	**Physical and Geometric Optics**
ECE580-CLT	**Computational Approaches to Light Transport in Biological Tissues**
ECE580-CLI	**Computational Approaches to Laser Interaction with Biological Tissues**
ECE580 -ONDE	**Optical Non-Destructive Evaluation**
Other OGI School Courses	
CSE514	**Introduction to Database Systems**
CSE540	**Neural Network Algorithms and Architectures**
CSE544	**Probability and Statistical Inference**
CSE547	**Statistical Pattern Recognition**
CSE548	**Statistical Computing**
CSE564	**Human-Computer Interaction**
BMB534	**Instrumental Methods in Biophysics I & II**
BMB540	**Advanced Molecular Biology**
BMB541	**Molecular Genetics of Development**
ESE500	**Numerical Methods**
ESE506	**Environmental Systems Analysis**
ESE550	**Environmental Microbiology**
ESE570	**Principles of Toxicology and Risk Assessment**
Oregon Health & Science University School of Medicine Courses	
CON621	**Molecular and Cell Biology I: Topics in Biochemistry**
CON622	**Molecular and Cell Biology II: Molecular Genetics**
CON627	**Systems Neurophysiology**
BMB610	**Medical Biochemistry**
BCH611/612	**Biochemistry**
BCH511	**Advanced Biochemistry**
BMB618	**Biochemical Properties of Proteins and Protein Engineering**
BMB620	**Biochemical & Biophyiscal Properties of Membranes**
CBA610	**Gross Anatomy**
AN611	**Gross Anatomy**
CBA611	**Histology**
AN613	**General Histology**
CBA607	**Seminar: Cancer Biology**
PHC610	**Pharmacology**
PHY610	**Human Physiology**

PHY611	Physiology - Nervous and Cardiovascular Systems
PHY612	Physiology Respiratory, Renal, and Alimentary Systems
PHY615	Physiological Instrumentation and Techniques
PHY607	Seminar: Biophysical Physiology
PHY617	Advanced Cardiovascular Physiology
MED791	Electrocardiology
NEU792	Experimental Neurology
PTH610	General Pathology

* May be offered in alternating years, beginning FY03

COMMUNICATIONS AND NETWORKING

Job opportunities in communications and computer networking are exploding. This field is enjoying a renaissance due to the rapid progress of optical fiber technology and digital signal processing techniques, and the need to move larger and larger amounts of information on a global basis.

ECE525	Analytical Techniques in Statistical Signal Processing & Communications
ECE526	Analog and Binary Digital Communications Systems
ECE540	Auditory and Visual Processing by Human and Machine
ECE541	Speech Processing
ECE542	Introduction to Image Processing
ECE543	Introduction to Digital Video Processing
ECE544	Introduction to Signals, Systems and Information Processing
ECE550	Linear Systems
ECE551	Introduction to Digital Signal Processing
ECE552	Digital Signal Processing II
ECE554	Adaptive Signal Processing
ECE557*	Computer-Aided Analysis of Circuits (alternating years, FY03)
ECE580-DDC	Design of Digital Communication Circuits
ECE580-CN	Introduction to Computer Networks
ECE580-DCS	Digital Fiber-Optic Communication Systems
ECE580-IE	Internet Engineering
ECE580-IVC	Information Visualization and Computer Graphics
ECE580 -WCSI	Wireless Communications Systems
ECE580-MC	Multimedia Communications
ECE580-SSY	Speech Synthesis

* May be offered in alternating years, beginning FY03

COMPUTER ENGINEERING AND DESIGN

Computer engineering is a hybrid program utilizing electrical engineering and computer science courses. It involves the engineering aspects of hardware, including logic design, integrated circuit design, and computer architecture.

ECE500	Introduction to Electronics and Instrumentation
ECE551	Introduction to Digital Signal Processing
ECE557*	Computer-Aided Analysis of Circuits (alternating years-FY03)
ECE558	High Speed Interconnect Design
ECE559	Design with Programmable Logic
ECE571	Analog Integrated Circuit Design
ECE572	Digital Integrated Circuit Design
ECE573	Introduction to Computer Logic Design
ECE574	CMOS Digital VLSI Design I
ECE575	CMOS Digital VLSI Design II
ECE580 -COD	Introduction to Computer Organization and Design
ECE580-AIC	Analog CMOS IC Design
ECE580-ACD	Special Topics in Analog IC Design4 credits
Other OGI School courses	
CSE521	Introduction to Computer Architecture 3 credits
CSE522	Advanced Computer Architecture 3 credits
Portland State University	
PSU ECE510	Design for Test
PSU ECE672	Advanced Logic Synthesis
Oregon State University	
OSU ECE619	Low Power IC Design
OSU ECE527	VLSI System Design

* May be offered in alternating years, beginning FY03

MATERIALS, SEMICONDUCTORS & DEVICES

ECE offers a broad spectrum of courses in semiconductor synthesis, processing, device physics, and integrated circuits. Courses are designed to prepare the student for growth areas in semiconductor-based technology. Specific groups of courses are designed to provide a strong, cohesive, and marketable body of knowledge in device processing, device physics and design, and integrated circuit design. Course selections can be tailored to create unique specializations that will prepare students for careers in this important technology field.

ECE507	Introduction to Electromagnetics for Modern Applications
ECE508	Electromagnetics for Modern Applications II
ECE509	Electromagnetics for Modern Applications III
ECE510*	Introduction to Quantum Mechanics for Electrical and Computer Engineers
ECE511*	Advanced Quantum Mechanics for Electrical and Computer Engineers
ECE512	Operation of Semiconductor Devices: Diodesand Bipolar Transistors
ECE513	Operation of Semiconductor Devices: MOS Transistors
ECE514	MOSFET Modeling for VLSI Circuit Design
ECE515	Introduction to Semiconductors
ECE516	Fundamental Semiconductor Device Structures
ECE517	Advanced Semiconductor Devices: Structures & Materials
ECE520*	Transmission Line Theory
ECE521*	Microwave Engineering Concepts
ECE535*	Thin Film Deposition and Applications in Semiconductor Fabrication
ECE558	High Speed Interconnect Design
ECE560	Microelectronic Device Fabrication I
ECE561	Microelectronic Device Fabrication II
ECE562	Microelectronic Device Fabrication III
ECE563	Plasma Processing of Semiconductors I
ECE565	Analytical Scanning Electron Microscopy
ECE566	Focused Ion Beam Technology
ECE567	Transmission Electron Microscopy
ECE568	Failure and Reliability in Microelectronics
ECE569	Electronic Materials and Device Characterization
ECE571	Analog Integrated Circuit Design
ECE572	Digital Integrated Circuit Design
ECE580-FSM	Fundamentals of Sensors & MEMS Fabrication
ECE580-ISM	Introduction to Sensor Microfabrication (Lab Only)
ECE580-MPE	Modern Photolithographic Engineering
ECE580 -SMVI	Simulation & Modeling of VLSI Interconnect
ECE580-SSE	Semiconductor Sensors
ECE580-TP	Technology of Photoresists
ECE580-CP	Copper Plating
ECE580 -MEM	Microelectromechanical Systems (MEMS)
ECE580-RFD	Reliability and Failure of Device Packaging
ECE580-CCM	Capstone Course: MEMS & Microsensors Project
ECE580-MTF	Mechanics and Thin Films

* May be offered in alternating years, beginning FY03

SIGNAL PROCESSING, SPEECH & IMAGING

With rapid advances in technology, we are experiencing a paradigm shift toward information-intensive systems for sophisticated multimedia telecommunication and human-machine interaction. This master-level program represents a unique combination of traditional engineering signal processing with human information processing that prepares students for the information-intensive society of the coming century. Multimodal communication is an emerging engineering area that comprises multiple disciplines extending from human factors and algorithm development to network protocols and designing electronic devices. Existing and future multimedia applications combine audio and video (and other possible modalities) to extend the capabilities of a human operator. Students benefit from exposure to real problems through partnerships with industry and government.

ECE525	Analytical Techniques in Statistical Signal Processing & Communications
ECE540	Auditory and Visual Processing by Human and Machine
ECE541	Speech Processing
ECE542	Introduction to Image Processing

ECE543	**Introduction to Digital Video Processing**	
ECE544	**Introduction to Signals, Systems and Information Processing**	
ECE545	**Speech Systems**	
ECE551	**Introduction to Digital Signal Processing**	
ECE552	**Digital Signal Processing II**	
ECE553*	**Control Systems: Classical, Neural and Fuzzy**	
ECE554	**Adaptive Signal Processing**	
ECE555	**Engineering Optimization**	
ECE580-SSY	**Speech Synthesis**	
ECE580-SSL	**Structure of Spoken Language**	
Other OGI School courses		
CSE540	**Neural Network Algorithms and Architectures**	**3 credits**
CSE546	**Data and Signal Compression**	**3 credits**
CSE547	**Statistical Pattern Recognition**	**3 credits**
CSE550	**Spoken Language Systems**	**3 credits**
CSE551	**Structure of Spoken Language**	**3 credits**
CSE552	**Hidden Markov Models**	**3 credits**

* May be offered in alternating years, beginning FY03

COURSE DESCRIPTIONS

ECE500 Introduction to Electronics and Instrumentation
Review of fundamental electronics components and design: passive components, transistor circuits, op amps, RC circuits, frequency domain, and time domain response. Feedback theory, op amp limitations, precision op amp circuits. Noise, interference, grounding, and shielding. Phase-locked loops, lock-in amplifiers. Practical advice on component selection and circuit design. Equipment and circuit demonstrations in class. Homework includes Pspice circuit simulation problems. 4 credits

ECE507 Introduction to Electromagnetics for Modern Applications
This series (ECE507-509) cover essentials of electromagnetic theory for modern practitioners in such areas of engineering and applied science as semiconductor devices; IC design; optics, lasers, and optoelectronics; wireless and optical communications; electronic displays; electron and ion beam technology; vacuum electronic devices; and various biomedical applications. The course is practically oriented, and presents both analytical and numerical methods. The first course introduces basic experimental laws and theoretical concepts. Laplace and Poisson equations for static electric and magnetic potentials. Basic properties of electromagnetic materials. Maxwell equations for static and time-varying fields. Wave equations and Poynting theorem. Finite-difference numerical solution of boundary-value problems. Prerequisite: Some undergraduate electromagnetism, calculus through ordinary and partial differential equations, some vector calculus, or consent of instructor. 4 credits

ECE508 Electromagnetics for Modern Applications II
This course introduces additional mathematical tools and covers topics basic to circuit design, semiconductor device operation, IC design, optics, transmission lines, and antenna design. Covered are waves in conductors and skin effect.Retarded potentials for time-varying fields. Electromagnetics of lumped-element circuit theory. Plane wave propagation, reflection, and refraction. Polarization states and Stokes parameters. Analytical methods for boundary-value problems and numerical solution by boundary-element method. Introductory (TEM) field theory of transmission lines, and its relation to circuit model. Prerequisite: ECE507 and some linear algebra or consent of instructor. 4 credits

ECE509 Electromagnetics for Modern Applications III
This course covers advanced transmission line and waveguide field theory for high speed interconnects, microwave and optical waveguides; resonant cavities for frequency control and lasers; and radiation basics for communications and optics. Topics include TE and TM transmission-line and waveguide modes. Field theory of multiple-conductor transmission lines: Modes, coupling, crosstalk, and termination. Dielectric waveguides. Resonant cavities. Radiation from antennas and apertures. Additional topics as time permits, chosen from: electromagnetic properties of materials; variational formulation of field problems and finite element numerical solution; analytical and numerical calculation of charged-particle motion in electromagnetic fields; suggestions of students. Prerequisite: ECE508 and some linear algebra or consent of instructor. 4 credits

ECE510 Introduction to Quantum Mechanics for Electrical and Computer Engineers
Courses ECE510-511 present basic quantum theory for understanding practical applications such as solid state devices, lasers and other optoelectronic devices, properties of electronic materials, bandgap engineering, quantum effects due to shrinking IC feature sizes, quantum-dot and quantum-well devices, and quantum computing. The first course introduces basic concepts and results essential to understanding solid-state band structure, devices based on tunnelling, and quantum-well devices. Topics include a review of classical mechanics. The Schroedinger equation, postulates of Quantum Mechanics, and basic Hilbert-Dirac formalism. The free particle. One-dimensional quantum-well bound states and tunneling through potential barriers. Bloch functions in periodic potentials and the origin of solid-state band structure. Prerequisite: Calculus through ordinary and partial differential equations, or consent of instructor. 4 credits

ECE511 Advanced Quantum Mechanics for Electrical and Computer Engineers
This course covers two- and three-dimensional applications, and introduces new physical phenomena, mathematical formulations, and tools essential for understanding materials science, lasers, solid state devices, quantum optics, and quantum computing. Covered are two- and three-dimensional quantum wells. The simple harmonic oscillator and algebraic methods. Angular momentum and spin. Matrix formulation of Quantum Mechanics. Atomic structure. Approximation methods, including perturbation theory. Interaction of matter and electromagnetic waves. Prerequisite: ECE510 plus some linear algebra, or consent of instructor. 4 credits

ECE 512 Operation of Semiconductor Devices: Diodes and Bipolar Transistors.
Short review of semiconductor basics; metal-semiconductor contacts and Schottky diodes; pn junction diodes: Depletion approximation, capacitance/voltage behavior and current/voltage characteristics, role of minority carrier diffusion and storage, ideal and nonideal behavior, Shockley-Hall-Read recombination. Fundamentals of bipolar transistors: Ideal Shockley model, current gain, low- and high-level injection effects, transit-time concepts. Ebers-Moll and Gummel-Poon models. Device parameter extraction for SPICE models. 4 credits

ECE 513 Operation of Semiconductor Devices: MOS Transistors.
Fundamentals: Contact potentials and semiconductor surfaces, analysis of the MOS capacitor, the role of oxide charge. MOSFET modeling, one-dimensional approaches based on depletion and charge sheet approximations: Threshold voltage and body effect, sub-threshold behavior based on concepts of weak, moderate, and strong inversion; ion implanted channels; short and narrow channel effects, such as channel length modulation, velocity saturation, effective threshold variations, series resistance effects, breakdown and punch-through; device parameter extraction for SPICE models, device scaling.4 credits

ECE 514 MOSFET modeling for VLSI circuit design
A comprehensive study of compact models used in circuit simulators for VLSI design. Topics covered include modeling of small geometry effects, high speed and frequency (non-quasistatic) models, quantum effects, substrate and gate current models for reliability simulation and device scaling issues. In-depth study of parameter extraction, optimization and device characterization techniques required for developing compact models. Development of statistical, mismatch and noise models for analog circuit design. Review of state of the art models used in industry. Implementation algorithms for MOSFET models in circuit simulators. 4 credits

ECE515 Introduction to Semiconductors
The fundamental properties and concepts needed to understand semiconductors are introduced in this course. We begin with semiconductor crystals, their structure and bonding, and thermal properties. We then examine electron interactions in semiconductor crystals. The physics behind the energy bandgap in semiconductors are examined, and used to ultimately derive the energy band structure, effective mass, and equilibrium carrier statistics. Next, we use these statistics to define carrier transport in semiconducting materials. Finally, we study and understand the dielectric and optical response of semiconductors.. This course is recommended if you have never taken a semiconductor device course (or if you need a refresher). The materials covered will provide you with background for other semiconductor device, processing, and characterization courses offered at OGI. Although not required, you will achieve a more advanced understanding of the concepts discussed in this class if you have taken quantum mechanics. 4 credits

ECE516 Fundamental Semiconductor Device Structures
Semiconductor bulk, junction and surface properties. We develop the fundamentals of semiconductor structures; bulk defects; mechanisms affecting electron/hole transport at low and high electric fields; junction formation/stability (p-n, metal-semiconductor, and metal-insulator); and relationships between semiconductor properties and device performance. The underlying concepts of minority carrier and majority carrier devices are expounded and clarified. 4 credits

ECE517 Advanced Semiconductor Devices: Structures and Materials
The complex interplay between materials properties, fabrication technologies, and device performance will be examined in the context of elucidating such current technology developments as silicon on insulator (SOI), high-K dielectrics, SiGe heterojunctions, heterojunction bipolar transistors (HBT), pseudomorphic high electron mobility transistors (PHEMT), Vertical Cavity Surface Emitting Lasers (VCSEL), quantum dots, single electron transistors, and organic semiconductors. 4 credits

ECE520 Transmission-Line Theory
Maxwell's equations; Field analysis of transmission-lines; Circuit analysis of transmission-lines (telegrapher's equations, equivalent circuit models); Microstrip; Stripline; Signal integrity (transient response, impedance mismatch, reflections, bounce diagrams); Skin effect; Dispersion; Discontinuities (bends, vias); Multi-conductor transmission-lines in multi-layered dielectric systems ([L] and [C] matrices). Numerical analysis of multi-conductor transmission-line networks (method of moments technique); Crosstalk. 4 credits

ECE521 Microwave Engineering Concepts
Traveling waves and transmission-line concepts; Time harmonic transmission-line equations; Smith chart (construction and applications); Impedance matching networks; Impedance transformation; Matrix representation of multi-port transmission-line networks ([S], [Z], [Y], and chain matrices); [S] parameters properties; Matrix conversions ([Z] to [S] and vice-versa); Numerical analysis of transmission-line discontinuities at microwave engineering frequencies (Finite Difference Time Domain, FDTD technique). 4 credits

ECE525 Analytical Techniques in Statistical Signal Processing and Communications
Development of the mathematical techniques needed to analyze systems involving random variables and/or stochastic processes with particular application to communications and instrumentation. Topics include Bayes Theorem (discrete and continuous forms), Tchebycheff inequality, Chernoff Bound, Central Limit Theorem, stationary processes and linear systems, mean square estimation, Poisson process, Gaussian process, Markoff process, and series representations. MATLAB and the MATLAB Statistics Tool Box are used in this course. 4 credits

ECE526 Analog and Binary Digital Communications Systems
Mathematical descriptions of signals and noise, bandwidth requirements, sampling theorem, intersymbol interference, digital multiplexing, line encoding, pulse code modulation, quantizing, quantization and noise error in PCM, bandpass random processes, quadrature representation, Wiener-Hopf filter, amplitude modulation systems (AM, DSB, SSB, VSB), angle modulated systems (PM, FM) preemphasis/de-emphasis. MATLAB and the MATLAB Statistics Tool Box are used in this course. 4 credits

ECE527 M-ary Communication Systems, Information Theory, and Coding
Often times in communication systems, the bandwidth available for the system is fixed. This constrains the communication rate to a maximum of twice the bandwidth if a binary digital system is used. However, in many modern systems such as wireless communications and computer communications, communication rates in excess of twice the bandwidth are needed. This problem has been solved by using M-ary communication systems where the digital system has M distinct states rather than just two. Using M-ary communication in conjunction with long sequences for communication efficiency and coding for error correction allows for modern communication systems that meet the requirements of such systems. This course covers topics that relate to modern communication systems, including Optimum threshold detection, geometrical representation of signals, optimum M-ary Communication (MASK, MPSK, MFSK) systems, Gram-Schmidt orthogonalization procedure, measure of information, source encoding, channel capacity, error-correcting codes (linear block, cyclic, burst-error detecting and correcting, interlaced, convolutional), Viterbi's Algorithm. MATLAB and the MATLAB Statistics Tool Box are used in this course. 4 credits

ECE529 Fiber Optics
An introductory course in fiber optics aimed at scientists and engineers from widely varying backgrounds. Topics include light propagation in dielectric media, attenuation in optical fibers, step- and index-graded fibers, photon generation and detection devices used in fiber optics, and integration of fiber optics with the photon devices.4 credits

ECE532 Biomedical Optics I: Tissue Optics
Light propagation in tissue: This course treats light transport in scattering and absorbing media such as biological tissue. Light transport is modeled using a variety of theories and computational techniques, including Monte Carlo simulations and approximate solutions of the radiative transport equation. Steady-state and time-dependent problems are treated. Spectroscopy and fluorescence measurements are introduced. Optical imaging techniques Are presented. Students learn the basics required for design of optical devices for therapy and diagnostics. 4 credits
Course offered every other year; next session, Fall 02/03

ECE533 Biomedical Optics II: Laser-Tissue Interactions
Physics of laser-tissue interactions: The course treats the immediate physical processes that accompany the absorption of light by biological tissues, including photochemical reactions, heating and tissue coagulation, vaporization, creation of plasmas, and production of stress waves in tissue. Such processes are modeled using finite-difference techniques. Applications in medicine and biology are discussed. Prerequisites: ECE 532 or permission of instructor. 4 credits
Course offered every other year; next session, Winter 02/03

ECE534 Biomedical Optics III: Engineering Design
The students work as a team in preparing five business plans throughout the quarter. Each business plan is devoted to a potential medical device or protocol using optical technologies. The team is divided into a CEO, scientific officer, marketing manager, regulatory affairs manager, and manufacturing manager. The roles are rotated amongst the students for each business plan. Feasibility studies are conducted in a laboratory exercise designed by the students. The team formally presents a business plan every two weeks. Prerequisites: ECE 532 and ECE 533, or permission of instructor. 4 credits
Course offered every other year; next session, Spring 02/03

ECE535 Thin Film Deposition and Applications in Semiconductor Fabrication
Covers thin film deposition topics, such as thermal evaporation, plasma deposition, chemical vapor deposition (CVD and MOCVD), molecular beam epitaxy (MBE), atomic layer epitaxy (ALE), electrochemical deposition, and electroless deposition. Thin film deposition forms the basis for manufacture of modern integrated circuits; a knowledge of methods available for thin film deposition is essential for IC process engineers. Course is designed to cover the theory and applications of main deposition techniques in use or being considered for future IC fabrication processes. 4 credits

ECE536 Surface Science for Semiconductor Technology
The study of gas-solid surface science with emphasis on understanding semiconductor systems and the mechanisms of epitaxial growth of semiconductor films by molecular beam epitaxy (MBE), metal-organic molecular beam epitaxy (MOMBE), atomic layer epitaxy (ALE), etc. The study of thermal desorption, surface diffusion. Surface electronic properties such as work function. Physical absorption, the growth of multilayer films and the application of this phenomena to the study of the BET equation as a tool for the determination of surface area. 4 credits

ECE537 Characterization of Thin Films for Semiconductor Technology
An introduction to the techniques of surface analysis, such as Auger analysis, X-ray photoelectron spectroscopy, energy dispersive X-ray analysis, X-ray wavelength dispersive spectroscopy, secondary ion mass spectroscopy, Rutherford Back scattering Spectroscopy, together with their interpretations. Particular emphasis on semiconductor technology applications. 4 credits

ECE540 Auditory and Visual Processing by Human and Machine
Interaction between humans and machines could be greatly enhanced by machines that could communicate using human sensory signals such as speech and gestures. Knowledge of human information processing including audition, vision, and their combination is, therefore, critical in the design of

effective human-machine interfaces. The course introduces selected phenomena in auditory and visual perception, and motor control. Students learn how to interpret empirical data, how to incorporate these data in models, and how to apply these models to engineering problems. The anthropomorphic (human-like) signal processing approach is illustrated on engineering models of perceptual phenomena. 4 credits

ECE541 Speech Processing
Speech is one of the most important means of communication. This course teaches theory of human speech production, properties of speech signal and techniques for its processing in speech coding, and automatic speech and speaker recognition. Emphasis is on active research in auditory modeling that exploits special properties of speech to improve performance of speech technology in practical applications. Prerequisites: ECE 540, ECE 551, or consent of instructor. 4 credits

ECE542 Introduction to Image Processing
Course covers basic image processing principles and techniques with a brief introduction to machine vision. Students acquire theoretical and working knowledge of image processing approaches including image representation, transform methods, image filtering, multi-resolution representation, edge detection, texture characterization, and motion analysis. Course demonstrates application of these methods to image enhancement, image restoration, and image compression, with emphasis on image quality metrics based on human visual perception. Selected areas in machine vision include image segmentation, elementary techniques in pattern recognition, and object representation. Application of these techniques is illustrated in numerous examples. Prerequisite: ECE 551. 4 credits

ECE543 Introduction to Digital Video Processing
Course provides introduction to digital video processing for multimedia systems. The course first introduces video capture, image formation, analog and digital video signal and standards, and spatio-temporal sampling. Subsequent topics include motion estimation, segmentation and tracking,video filtering, and video standards conversion. Students are familiarized with video compression techniques and standards (JPEG, MPEG2, H.261, H.263), and model-based video quality estimation. Students gain working knowledge of these video techniques through class projects. Familiarity with digital signal processing and transform methods is desirable. 4 credits

ECE544 Introduction to Signals, Systems and Information Processing
This course provides the essential mathematical tools and analytical techniques needed for the analysis of continuous-time and discrete-time systems. Basic signal and system characteristics — linearity, time-invariance, convolution and correlation — are first examined from the time domain perspective. We then proceed to study a family of Transforms - Fourier Series, Fourier Integral Transform, Laplace Transform, Discrete Time Fourier Transform (DTFT), Discrete Fourier Transform (DFT) and z-Transform — which take the study of these systems to a deeper level and introduce a host of useful properties which the time perspective alone does not reveal. Basic applications taken from the areas of information processing, communication and control will serve to fill out the mathematically derived results.

A greater portion of the syllabus in ECE 544 is allotted to continuous time signals/systems than to discrete time signals/systems, for reason that the latter are taken up in detail in other information processing courses, particularly ECE 551. A goal of the presentation in ECE 544 is to impart the essential unity of all the Transforms and the almost perfect correspondence of approach in continuous-time and discrete-time contexts. You then become a well equipped practitioner who knows the way around the entire territory. This course is a useful prerequisite or co-requisite to ECE 551 and all other courses in the information processing area. 4 credits

ECE545 Speech Systems
Speech is one of the most natural means for communication and carries information from many sources. The explosive growth of communications and computer technologies puts new demands on techniques for machine extraction of information content of speech signals, for its storage or transmission, and for reconstruction of the speech signal from its parametric representation. Course covers techniques for processing of speech signal used for speech coding and synthesis, enhancement of degraded speech, speech recognition, speaker recognition, and language identification. 4 credits

ECE547 Signals for Multimedia Engineering
The course discusses concept of signal as a carrier of information, basic principles of signal analysis in engineering, and fundamentals of human auditory and visual perception. It is intended for those who have a good undergraduate-level of basic knowledge in mathematics and physics but who need an introduction to or refreshing of fundamental concepts of signals, systems, and human information processing, necessary for further mastering specialized multi-media topics in speech and image processing, classification, and transmission. 4 credits

ECE550 Linear Systems
This course introduces the State Variable representation of linear dynamical systems and studies a large body of State Space techniques to reveal both inner structure and external behavior of the systems modeled in this way. A general framework for treating time-varying linear systems is developed and utilized. Major emphasis is placed, however, on the time-invariant systems, whose structure and dynamics are investigable and knowable to the very utmost detail. Both continuous-time and discrete-time linear systems are explicitly studied. The course provides a strong body of foundational material, which is utilized either explicitly or implicitly in virtually all applications-specific areas pertaining to system analysis/design and signal/information processing. The major topics covered are: canonical realizations, equivalent systems, canonical transformations, canonical decompositions, solution of state equations, stability, controllability and observability, design of asymptotic observers, state-feedback compensation schemes. Linear Quadratic Regulator and Kalman Filter are also introduced. The Linear Algebra material required for this study — matrices as linear operators , solutions of sets of linear equations, eigenvalues and eigenvectors, eigenstructure factorizations and spectral decompositions — will be presented and developed concurrently, as needed. The relevant Differential Equations material will also be concurrently reviewed. 4 credits

ECE 551 Introduction to Digital Signal Processing
The representation and processing of signals and systems in the discrete or digital domain is the preferred mode in todayís computer and information driven technologies. DSP provides the core building block from cell phones to modems, HDTV to video conferencing, or from speech recognition to MP3 audio.This classes covers the fundamental concepts and mathematics including representation and analysis of discrete time signals and systems, Z-Transforms, Discrete-Time Fourier Transform (DTFT), and the Discrete Fourier Transform (DFT), sampling and windowing techniques pertaining to discrete time processing of continuous signals, analysis and design of recursive (IIR) and nonrecursive (FIR) digital filters, signal flow graph realizations of finite word-length implemented discrete time linear systems, and applications of the Fast Fourier Transform (FFT) to convolution, spectral analysis, and audio processing. 4 credits

ECE552 Digital Signal Processing II
This follow-up course to ECE 551 examines several widely used advanced signal processing. Topics include computational complexity considerations in DSP algorithm development; multirate signal processing; filterbanks and wavelets, and their application in audio and image processing (e.g. MPEG standards). Topic coverage is weighted toward the interests of the students enrolled. 4 credits

ECE553 Control Systems: Classical, Neural, and Fuzzy
Applications of modern control systems range from advanced fighter aircraft to processes control in integrated circuit manufacturing, to fuzzy washing machines. The aim of this class is to integrate different trends in control theory. Background and perspective are provided through the study of basic classical techniques in feedback control (root locus, bode, etc.), as well as state-space approaches (linear quadratic regulators, Kalman estimators, and introduction to optimal control). The course covers recent movements at the forefront of control technology. Neural network control is presented with emphasis on nonlinear dynamics, back-propagation-through-time, model reference control, and reinforcement learning. The course also covers fuzzy logic and fuzzy systems as a simple heuristic-based, yet often effective, alter-native for many control problems. Prerequisite: ECE 551, ECE 554, or equivalent. 4 credits

ECE 554 Adaptive Signal Processing
The field of adaptive filters and systems constitutes an important part of statistical signal processing. An adaptive system alters or adjusts its defining parameters in such a way that it improves perform-

ance through contact with the environment. Adaptive filters are currently applied in such diverse fields as communications, control, radar, seismology, and biomedical electronics. This course will cover the theory and applications of adaptive linear systems. Topics include Wiener filters, least squares, steepest descent, LMS, RLS, Newton's method, FIR and IIR adaptive structures, and Kalman filters. Applications covered include noise canceling, signal enhancement, adaptive control, adaptive beam-forming, system identification, and adaptive equalization. The theory also lays the foundation for study in nonlinear signal processing with neural networks and will be introduced in the later half of the class. This course should be of interest to electrical and computer engineers specializing in signal processing and the information sciences. This course should also be taken as background for additional classes offered in artificial neural networks, connectionist models, and machine learning.
4 credits

ECE555 Engineering Optimization
Issues of Optimization appear in virtually every area of Engineering and Applied Research. Most practitioners tend merely to rely on "canned" routines when optimization needs to be performed. But successful Optimization entails both a lot of science and a lot of art — deep mathematical derivations and formal convergence proofs on the one hand, conventional engineering "folklore and experiential "rules of thumb on the other. Through this course you will be able to choose intelligently among the very wide range of available optimization strategies, customize given algorithms; to your own specific applications, and even write your own routines entirely from scratch when this approach is needed or preferred. After reviewing some necessary mathematical fundamentals from Linear Algebra and Multivariable Calculus, including Lagrange Multipliers and Kuhn-Tucker conditions, the following topics will be covered. Unconstrained and Constrained nonlinear Multivariable Optimization, via direct-search and gradient-based methods, including: Pattern Search, Simplex Search, Conjugate Gradient, Variable Metric, Feasible Directions, Cutting Plane, Gradient Projection and Penalty Function methods. Algorithms for specially structured problems, such as: Linear Programming, Quadratic Programming, Integer Programming, Geometric Programming. Methods which utilize random heuristics, including: Genetic Algorithm, Dynamic Evolution and Simulated Annealing. Time permitting, an introduction to Dynamic Programming and the Optimal Control problem will also be included. 4 credits

ECE556 Principles of Electronic Packaging
This course introduces the principles and tradeoffs involved in the design of electronic packaging for integrated circuits. Topics include packaging architecture, electrical design concepts in electronic packaging design, thermal management, mechanic design, electrical contacts, reliability and testing, material selection and fabrication, plated through-hole technology, etching by wet processes, joining materials, stress issues, diffusion problems, chemical and physical methods of analysis, and trends in electronic packaging. 4 credits

ECE557 Computer-Aided Analysis of Circuits
Course covers the algorithms and techniques for formulation and solution of circuit equations for large-scale VLSI circuits. Topics include Equation formulation, linear AC and DC networks, linear transient networks, and stability analysis. Solution of nonlinear DC and transient problems. Frequency domain (AWE) techniques for VLSI interconnections, Sensitivity analysis, harmonic balance, circuit optimization, and statistical design.The implementation of device models in circuit simulators and convergence issues is covered. Assignments stress computer-aided implementation techniques and use of simulators such as PSPICE. 4 credits

ECE558 High Speed Interconnect Design
Electrical analysis, design, and validation of interconnect for digital buses operating at speeds greater than 1 GHz. Key topics include: transmission line analysis and tools, digital signals and timing analysis, measurement equipment and techniques, lossy and coupled transmission lines, advanced signaling techniques, design tools and methodology. A design project is used to give students practical insight into high speed bus design problems. 4 credits

ECE559 Design with Programmable Logic
Programmable logic, such as FPGA and PLD devices, has become a major component of digital design. This course will discuss design tools and techniques for creating logic designs using programmable logic. A design is first created in Verilog, a high-level Register Transfer Level (RTL) language, and simulated. Synthesis to a programmable logic device is then performed. In addition, common problems of poor routing and placement are discussed while presenting the student with a comprehensive understanding of the operation of synthesis tools. The course has a strong project orientation. Students will take several designs from concept to RTL verification and synthesis, then to programmable device implementation. A commercial set of software tools will be used. PREREQUISITES: ECE573 Intro to Computer Logic Design or consent of instructor. 4 credits.

ECE560 Microelectronic Device Fabrication I
This course is the first in a full year, three term sequence that treats both the science and practice of modern microelectronic fabrication. The principles of crystal growth and wafer preparation, ion implantation, doping and diffusion, and oxidation are all covered. Emphasis is placed on understanding the basic chemistry, physics, and material science of wafer processing. This includes crystal structure and defects, heterogeneous chemical reactions, the thermodynamics and kinetics of diffusion, etc. In addition, the practical implementation of these processes is also discussed. This includes realistic process flows, physical metrology, device structure and electrical behavior, trade-offs, etc. The course is intended to serve a wide community including both working process engineers and matriculating graduate students. 4 credits

ECE561 Microelectronic Device Fabrication II
In the second class of this series emphasis is on metallization and dielectrics. Metallization issues examined include silicides, barrier layers, interconnects (e.g., Cu), multilevel metallization, and low k dielectrics. This followed by discussion of deposition and properties of different dielectric films. Finally, processing issues of epitaxial growth and properties of SOI devices are covered. Class assignments include computer simulation of device fabrication.
4 credits

ECE562 Microelectronic Device Fabrication III
This class starts with electron beam, x-ray, and photolithography, including discussion of resist technology (e.g., chemically amplified resists). This followed by fundamentals and applications of plasmas for etching and deposition (e.g., high density plasmas), including plasma damage. Other topics considered are process integration that includes several devices such as BiCMOS and memories. Finally yield and reliability statistics as related to microelectronic device fabrication is discussed. Class assignments include computer simulation of device fabrication and testing. 4 credits

ECE563 Plasma Processing of Semiconductors I
Fundamental plasma properties. Plasma production, properties, and characterization. DC and RF plasmas. Sputtering as a deposition process for the growth of thin films. Multicomponent films. Plasma etching. 4 credits

ECE564 Plasma Processing of Semiconductors II
This course, a continuation of ECE 563, covers specific applications of plasmas for processing semiconductor materials. Topics include etching and deposition and the dependence of these processes on plasma parameters. Materials based on both silicon and III-V technology are examined. 4 credits

ECE565 Analytical Scanning Electron Microscopy
This course introduces the operation and theory of SEM and covers sources, lenses, accelerating voltage, detectors, image formation, beam-specimen interactions, beam-produced signals, the combined effects of signal-to-noise ratio and spot size in determining resolution, and stereo imaging SEM. The process of specimen preparation, metallo-graphic grinding and focused ion beam-produced transverse cross sections, planar sections, coating techniques for nonconductors, sampling of powders, and isolation of contaminants are some of the topics covered. Students are encouraged to work on materials they provide. The course covers the operation of energy dispersive X-ray detectors, qualitative analysis, quantitative analysis, elemental mapping, spectrum artifacts, and contaminant and compound identification. The lecture portion of this course can be presented on site at companies in a 6 week period. Corresponding lab sessions are done at OGI. A project requiring operation of the SEM at the studentsí convenience during the remainder of the quarter and a written report is the basis for a grade.
4 credits

ECE566 Focused Ion Beam Technology
This course covers operation and theory of a FIB workstation, including ion sources, accelerating voltage, electrostatic lenses, beam-material interactions, resolution, beam intensity distribution, beam produced signals, detectors, metal and oxide deposition, and enhanced etch. FIB-produced site-

specific SEM transverse cross sections, the location and sectioning of micron and sub-micron scale structures on the surface and buried in multilayered stacks or bulk materials, cross sections in metals, semiconductors, ceramics, and composites are covered. The location and sectioning of micron and submicron surface and buried structures to create electron transparent foils with little or no damage in metals, semiconductors, ceramics, and composites, and artifacts of specimen preparation are presented.† Ion beam lithography and microfabrication of structures on the micron and sub-micron scales are also covered.† This course uses a combination of lectures and hands-on practice to cover these topics. The lecture portion of this course can be presented on site at companies in a 6 week period. Corresponding lab sessions are done at OGI. A project requiring operation of the FIB at the students convenience during the remainder of the quarter and a written report is the basis for a grade.

4 credits

ECE567 Transmission Electron Microscopy
Electron microscopy is a continually evolving discipline, which, has developed a wide range of techniques to solve specific problems. This course is designed to help the student develop a broad appreciation and knowledge of the important techniques for the analysis of crystalline and amorphous materials. Modern transmission electron microscopes can give the investigator detailed information of crystal structure, crystal defects and quantitative local chemistries on a nanometer scale. This information is often critical to the understanding of material properties. Principles, methods and application of transmission electron microscopy to crystalline materials. The construction and design of electron microscopes, electron diffraction, reciprocal lattice and Ewald Sphere construction will be covered. Kinematic and dynamic theories of image formation will be introduced. Combining lectures with hands-on laboratory practice, students will be instructed in the use of sample preparation equipment and an analytical transmission electron microscope. Students will be expected to carry out basic experiments on selected materials which illustrate fundamental concepts covered in the lecture. The lecture portion of this course can be presented on site at companies in a 6 week period. Corresponding lab sessions are done at OGI. A project requiring operation of the SEM at the students convenience during the remainder of the quarter and a written report is the basis for a grade.

4 credits

ECE568 Failure and Reliability in Microelectronics
The failure and reliability of microelectronics depends on the stability of thin films and the purity of the bulk semiconductors. Contamination, film thickness, diffusion and phase changes all drive mechanisms of failure. Characterization of a failed device depends on analysis of thin film structure, crystalline structures, contaminant identification and microchemistry. This requires a variety of microanalytical techniques involving the SEM, TEM, and FIB. This course covers the potential defects, failure mechanisms and the methodology used to analyze them. Case studies also are discussed. The lecture portion of this course can be presented on site at companies in a 6 week period. Corresponding lab sessions are done at OGI. A project requiring operation of the SEM at the students convenience during the remainder of the quarter and a written report is the basis for a grade. 4 credits

ECE569 Electronic Materials and Device Characterization
This class is designed for engineers and scientists who wish to understand the basic principals behind the electrical and optical techniques used to characterize semiconductor materials and devices. These techniques are crucial in determining the causes of failure in semiconductor devices. Among the parameters to be covered include contact resistance, carrier mobility and lifetime, defects, oxide and interface trapped charges, as well as series resistance, channel length /width, threshold voltage and hot carriers in MOSFETs. This class will include some lab time. 4 credits

ECE570 Gallium Arsenide MESFET Integrated Circuit Design
Technology overview, device structures, SPICE models, limitations, regions of MESFET operation. Transconductance, output resistance, biasing. Single-stage, high-gain, and feedback amplifiers, current sources, compensation. Buffered FET logic, enhancement/depletion technology,data conversion, comparators, digital-to-analog converters. 4 credits

ECE571 Analog Integrated Circuit Design
Design techniques for analog integrated circuits. Silicon bipolar and JFET analog integrated circuit design. Technology overview, device structures, Ebers-Moll equations, hybrid-pi model. Single-stage amplifiers, current sources, active loads, output stages. Operational amplifiers, frequency response, feedback, stability. Design project. 4 credits

ECE572 Digital Integrated Circuit Design
Design techniques for digital integrated circuits. Silicon bipolar and MOS digital integrated circuit design. Technology overview, device structures, modeling. Standard logic families. NMOS and CMOS logic design. Regenerative circuits and memory. Design project. 4 credits

ECE573 Introduction to Computer Logic Design
This course constitutes a basic introduction to the design and implementation of computer logic. Basic principles of discrete logic will be presented, including boolean algebra, finite-state machine theory, minimization, and optimization. Students will apply logic design theory to actual PLD (Programmable Logic Devices) and FPGA (Field Programmable Gate Array) devices. In addition, students will learn the basics of the hardware design languages, Verilog and VHDL. This course or its equivalent is a prerequisite to all other ECE Electronics Design Automation courses. 4 credits

ECE574 CMOS Digital VLSI Design I
An introduction to CMOS digital IC design. Course covers basic MOS transistor theory; operation of basic CMOS inverter; noise margins; switch level modeling of MOS devices; capacitive characteristics of MOS devices; introduction to device fabrication, design rules and layout issues; power consumption; gate design/transistor sizing; pass transistors and complimentary pass transistor logic; dynamic domino and precharge/discharge circuits; memory element design (RAM/ROM/flip-flops) and subsystem design (adders, multipliers, etc.). An understanding of basic digital design concepts is assumed. Lab exercises use industry standard design tools. Laboratories include circuit validation and characterization. Prerequisite: ECE 573. 4 credits

ECE575 CMOS Digital VLSI Design II
Concentration on advanced digital VLSI circuit design techniques. Architecture and micro-architecture of VLSI components, clocking schemes, input/output circuits, and special functional blocks such as random access memories, read only memories and programmable logic arrays. The course covers design tradeoffs, especially considering cost, power and performance. The course devotes a considerable amount of time to layout, parasitics and performance verification. Introduction to design and verification tools with hands-on experience. Prerequisites: ECE 574, familiarity with MOS transistor operation; computer architecture and organization; logic design. 4 credits

ECE577 Principles for Technology Development and Introduction to Manufacturing
A project-oriented course on management procedures and key underlying concepts for effective manufacturing technology planning and development; an introduction to commercial production in a competitive environment. While emphasis is on semiconductor technology, most principles and methodology are generally applicable to both hardware and software technology management. Issues of technology strategic planning, process definition and characterization, decision making, technology transfer, product definition, yield and reliability improvement, and concurrent engineering are explored to identify effective management approaches to shorten time-to-volume production, reduce risk, and minimize engineering effort.

4 credits

ECE578 Embedded and Real Time Operating Systems
A study of concepts, techniques, and standards in embedded operating systems including real time embedded operating systems. Topics include kernel design, device driver and interface techniques, scheduling, robustness and industry standards such as Windows-CE and Tornado (VxWorks). This is a hands-on lab course where students will experience real-world real time embedded systems using commercial software tools. Prerequisites: CSE 521 Introduction to Computer Architecture or a demonstrable understanding of computer architecture.

4 credits

ECE579 Embedded Computer Systems
A study of concepts, techniques, and standards in embedded systems from design through deployment to retirement. Topics include programmable logic, interfacing, power supply, packaging, robustness, certification, and maintenance. This is a hands-on lab course based on a student project, where students will experience real-world embedded systems using commercial software and hardware tools. Prerequisites: CSE581 Introduction to Computer

Architecture, ECE 578 Embedded and Real Time Operating Systems, or permission from instructor.
4 credits

ECE580-XXX Special Topics
Under this number, we offer courses of particular relevance to the research interests of faculty or in state-of-the-art subjects of interest to the community. Individual course descriptions are listed as follows. Special Topic courses are subject to change and are offered intermittently. For Special Topics offered during the current term, please view www.ogi.edu/schedule.

ECE580-ACD	Selected Topics in Analog IC Design
ECE580-ACS	Advanced Control Systems: Nonlinear, Neural & Fuzzy
ECE580-AFA	Applied Functional Analysis
ECE580-AIC	Analog CMOS Integrated Circuit Design
ECE580-CLI	Computational Approaches to Laser Interaction with Biological Tissues
ECE580-CLT	Computational Approaches to Light Transport in Biological Tissues
ECE580-CMP	Chemical Mechanical Planarization
ECE580-CN	Introduction to Computer Networks
ECE580-COD	Introduction to Computer Organization and Design
ECE580-CP	The New Millenium in Copper Plating: Faster Chips with Slower Plating
ECE580-DDC	Design of digital Communication Circuits
ECE580-FLC	Fabrication Lab Class
ECE580-FSM	Fundamentals of Sensors and MEMS Fabrication
ECE580-GAP	Introduction to Genetic Algorithms and Programming
ECE580- IB	Introduction to Biomaterials (formerlyMSE589)
ECE580-IE	Internet Engineering
ECE580-ISM	Introduction to Sensor Microfabrication
ECE580-IVC	Information Visualization and Computer Graphics
ECE580-LCD	Introduction to Liquid Crystal Displays
ECE580-MBD	Introduction to Modeling of Business Dynamics
ECE580-MC	Multimedia Communications
ECE580-MEM	Microelectromechanical Systems
ECE580-MPE	Modern Photolithographic Engineering
ECE580-MTF	Mechanics and Thin Films
ECE580-ONE	Optical Non-destructive Evaluation
ECE580-PEM	Phase Equilibria in Microelectronics (offered Fall 2001)
ECE580-PGO	Physical and Geometric Optics,
ECE580-QM	Quantitative Microscopy
ECE580-RFD	Reliability and Failure of Electronic Devices, Packages, and Assemblies
ECE580-SJM	Soldering and Joining in Microelectronics
ECE580-SLD	Statistical Learning and Data Mining
ECE580-SMVI	Simulation & Modeling of VLSI Interconnect
ECE580-SSE	Semiconductor Sensors
ECE580-SSL	Structure of Spoken Language
ECE580-SSY	Speech Synthesis
ECE580-TP	Technology of Photoresists
ECE580-WCS	Wireless Communication Systems
ECE580-UOS	Understanding Operation of Semiconductor Devices

ECE591 Independent Study
Student works with professor on selected topic(s). Requires pre-approval of professor, ECE Department, as well as formal agreement between student and professor outlining objectives and expectations of independent study topic. May only be taken once during a student's graduate program at OGI for a maximum of 3 credits.

ECE600 Prequalifying Ph.D. Research
Supervised research participation. Pre-qualifying Ph.D. research prior to passing ECE department qualifying examination.
Variable and repetitive credit.

ECE610 M.S. Nonthesis Project Research
Supervised research for up to eight credits as a component of the nonthesis M.S. degree. Students are required to produce cogent research deliverable(s) including, but not limited to, a final report equivalent to an EE project paper. This research classification requires the approval of the department head and the student's SPC.
Variable and repetititive credit

ECE620 Professional Internship
This course provides the student with an opportunity to earn credit for relevant work experience in industry. Students gain valuable industrial experience that allows them to both apply the knowledge gained in the classroom and prepare for their future careers.U.S. citizens, permanent residents, students on F-1 visas enrolled in Curricular Practical Training take ECE620 and must obtain additional permission from OGI personnel department. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit.

ECE700 M.S. Thesis
Research toward the thesis for the M.S. degree.
Variable and repetitive credit.

ECE800 Ph.D. Dissertation
Research toward the dissertation for the Ph.D. degree. Variable and repetitive credit.

RESEARCH CENTERS

CENTER FOR BIOLOGICALLY INSPIRED INFORMATION ENGINEERING (CBIIE)

Science and engineering have achieved great advances in automating and creating information processing and analysis tools. Microelectronics, programming, signal processing and information theory underpin these achievements. Modern microprocessors and those that will be produced over the next decade will provide huge computational power, enabling new information processing applications. In fact, it will soon be possible to place one billion transistors on a single piece of silicon.

Many information-processing applications involve huge amounts of real world data that have to be processed and analyzed for making decisions. The complexity of the analysis is often beyond current science and engineering's techniques and methodologies. Yet, natural evolution has evolved very sophisticated information processing systems, and the information analysis performed by the human brain, or even by the brain of simple animals, is far superior to what current state-of-the-art human-developed techniques can achieve.

A new research area is now coalescing which is devoted to consolidating and refining existing solutions, and finding better solutions to these transformation problems. The term Intelligent Signal Processing (ISP) is being used to describe algorithms and techniques that involve the creation, efficient representation, and effective utilization of complex models of semantic and syntactic relationships. Even the most primitive biological systems perform complex ISP. In addition, biological computing is robust in the presence of faulty and failing hardware, and is fundamentally asynchronous. Biological computing is energy efficient, consists of networks of sparsely connected and sparsely activated nodes, and requires only moderate levels of computational precision.

We believe that the merging of neuroscience and semiconductor engineering is creating what Andy Grove, ex-CEO of Intel, refers to as a strategic inflection point. Therefore, the mission of the Center for Biologically Inspired Information Engineering is to harvest biology for solutions to real-world information engineering and Intelligent Signal Processing problems, and leverage the incredible functional density of GSI (Giga-Scale Integrated) Silicon. The Center was established in 2001 and currently consists of two professors - Dan Hammerstrom and Marwan Jabri - and their staff and graduate students. The Center currently receives funding from NASA, NSF, SRC, ONR and Intel.

Current projects focus on:

- Computational models of sensorimotor control;
- High-level visual feature extraction using unsupervised learning techniques;
- Top-down/bottom up sensory fusion and sensorimotor control;
- Simulation of large-scale networks on PC clusters;
- Mapping computational neurobiology to FPGAs and eventually custom silicon; and
- Understanding the issues involved in scaling neural models to very large configurations.

CENTER FOR INFORMATION TECHNOLOGY (CIT)

Digital signal processing has made a significant impact on human lives since its introduction several decades ago. The broad field of information technologies has become a vital driving force in the

United States economy, both regionally and nationally. Industries are in the process of shifting emphasis from instrumentation and manufacturing to multimedia and communications services. Wide arrays of technologies, ranging from digital telephones to the ability to accurately predict the behavior of complex systems, rely on elegant mathematical concepts and on the power of digital computers. Even the most advanced techniques, however, fail to carry out many tasks that are effortlessly performed by humans.

The mission of the Center for Information Technology (CIT) is to support the development and deployment of signal-processing systems that would emulate and surpass human information processing capabilities. CIT activities focus on the "human-like," or anthropic, processing side of information systems. The anthropic signal processing is the synthesis of robust signal-processing techniques that exceed the performance of standard classical signal-processing methods by appealing to human-like processing strategies and capabilities. This unique combination of engineering and human information processing strategies is strengthened by recent incorporation of OGI into Oregon Health & Sciences University that allows for close collaboration between engineering and humanistic sciences.

The center's efforts focus on several target-engineering systems, including robust feature extraction for speech recognition systems, speech quality enhancement in cellular communications, automatic target detection and identification, and a forward visibility system for aviation. These projects are supported by basic research on several key-supporting technologies, i ncluding neural networks, prediction, image and speech representation, information fusion and the incorporation of prior knowledge in adaptive systems.

Within the OGI School, CIT provides a natural complement to other centers, including the Center for Spoken Language Understanding and its Center for Human-Computer Communication. CIT compliments CSLU by developing advanced signal processing techniques used in speech processing. In a similar way, CIT is developing solutions to a variety of signal-processing problems in natural communication using images, sound and gestures. CIT is an important component in the ECE department's focus on intelligent signal processing.

CENTER FOR SPOKEN LANGUAGE UNDERSTANDING

The research program of the Center for Spoken Language Understanding (CSLU) encompasses a broad range of technologies critical to advances in the development of interactive conversational systems. Such research is inherently multidisciplinary, and the center brings together a team with expertise in signal processing, speech recognition, speech synthesis, dialogue modeling, natural language processing, multimodal systems, linguistics and human-computer interaction.

Within CSLU there are five collaborating research groups:

- Neural Speech Enhancement Lab
- Anthropic Signal Processing Group
- Speech Recognition Group
- Speech Synthesis Research Group
- Natural Dialog Group

These groups focus on specific problem areas such as: robust methods for enhancing speech in noisy environments; large vocabulary recognition of continuous speech, as in broadcast news; unit selection and voice conversion for more realistic speech synthesis; robust parsing and interpretation of spoken and multimodal input; modeling of disfluencies in spontaneous speech; and effective methods for dialog management. CSLU research projects incorporate and evaluate these research advances. For example, one project involves the development of an animated conversational agent for learning and language training with profoundly deaf children. The center is also highly active in the development and distribution of a wide variety of language resources, including corpora of transcribed telephone and cellular speech data for over 20 languages.

Professor Jan van Santen is the director of OGI's Center for Spoken Language Understanding. The center is co-directed by Professors Peter Heeman, John-Paul Hosom, Yonghong Yan, and Eric Wan. Other center faculty includes Professors Todd Leen, Hynek Hermansky, and Xubo Song. The center receives support from government agencies including NSF, DARPA, and ONR, as well as industrial sources. For additional information, visit the CSLU web site: www.cslu.ogi.edu.

RESEARCH PROGRAMS

Advanced Lithography

Lithography is the key technology pacing the evolution of microelectronics. Research is ongoing in developing a viable patterning technology for use in large scale manufacturing of semiconductor devices. By using either semiconductor technology or new cathode materials, it should be possible to generate arrays with significantly enhanced speed and improved pattern fidelity. *Berglund, Freeouf, McCarthy*

Atmospheric Optics

The use of laser systems to transmit signals through the atmosphere for purposes of communication, radar, recognition, and designation is severely limited by scattering due to turbulence and particulates such as water droplets or dust. Turbulence, which causes shimmer on a hot day and makes stars seem to twinkle, results in the random steering, spreading and breaking-up (scintillation) of a laser beam. Particulate scattering that severely attenuates the received signal also causes depolarization and multiple path effects such as pulse stretching and scrambling of the signal. Experimental studies, which in conjunction with concurrent theoretical work, are contributing significantly to fundamental understanding of the effects of atmospheric turbulence on laser beam, speckle propagation and its application to optical remote sensing. *Holmes*

Biomedical Optics

The program in Biomedical Optics prepares the student to use lasers and light to measure, image, modify and machine materials, with emphasis on biological materials but with broad application to a variety of materials. The program offers a series of courses and labs on tissue optics, laser-tissue interactions, and engineering design, with elective courses in optics, spectroscopy, optical fibers, biomechanics, imaging and image analysis, optical measurement techniques, and computational methods for simulating light transport through and interaction with biological materials. Students have the opportunity to work in the hospital-based research laboratories at the Oregon Medical Laser Center at Providence St. Vincent Medical Center and the Biomedical Optics Laboratory on the OHSU Medical Center campus. *Jacques, Kirkpatrick, Prahl, Song*

Electronic Materials

An active research program in the area of electronic materials growth and characterization is focused on demands of the ever shrinking microelectronic devices. The main materials growth technique investigated is atomic layer deposition which allows growth of highly conformal thin films, one atomic layer at a time. Materials investigated using this approach include thin gate dielectrics, including nanolaminates and metallic films which include copper seed layers and barrier metals. Another area of research involves electrodeposition of copper films for microelectronic device interconnect applications. The focus of this investigation is to determine the correlation between the bath chemistry to the physical properties of the films and their electromigration lifetimes. *Solanki, Freeouf, McCarthy*

Flat Panel Displays

The video screen is becoming an indispensable link between information processing electronics systems and human beings. Although the cathode ray tube (CRT) remains the dominant display technology, its size, weight, and power requirements become unsuitable for many applications. As a replacement for CRTs, several flat panel display technologies are being explored due to their compactness, light weight and low power consumption. A flat panel display research group has been established to develop research capabilities and to work closely with the emerging display companies to assist them in overcoming technological hurdles. At present, research is directed towards electroluminescent, field emission, and liquid crystal displays. *Berglund, Solanki, Rananavare, McCarthy*

Image Processing and Analysis

The main research interests of our group are twofold. One thrust is image processing and image recognition. One of the techniques we are investigating is incorporating contextual information into recognition. Context incorporation is a mechanism

that ensures accurate perception and appropriate interpretation of ambiguities. Ambiguities arise eitherbecause information is missing or because information is partially or completely obscured by noise. Probabilistic or statistical models can be developed for context incorporation, and it has been demonstrated that utilizing contextual information is crucial for improving recognition accuracy. Another research thrust is on machine learning and data mining. We are interested in a fundamental understanding of learning, and in the development of learning systems that achieve state of the art performance. *Song*

Modification of Semiconductor Materials
Research is under way on the processing and characterization of semiconductor materials as affected by localized transient heating, plasma passivation, and thermal annealing. The recrystallization of polysilicon is studied using various laser sources and rapid thermal annealing. *Solanki, Freeouf, McCarthy*

Neural Networks and Adaptive Systems
Neural computation and adaptive systems are studied from both theoretical and practical standpoints. Current research in theory, architecture, and algorithm design includes deterministic and stochastic network dynamics, learning algorithms (supervised, unsupervised, and reinforcement), generalization theory (including model selection and pruning, invariant learning), context-sensitive learning, signal processing, time series analysis, and control. Practical application domains include adaptive signal processing, pattern recognition, speech recognition, image processing, control systems, macroeconomics, and finance. *Leen, Moody, Pavel, Song, Wan*

Optical Remote Sensing
Analytical and experimental studies are being made on the use of the interaction of electromagnetic radiation and turbulence to measure winds and turbulence. Recent efforts include analytical, numerical and experimental work on a CO2, optical heterodyne system for remote measurement of atmospheric cross winds and strength of turbulence. *Holmes*

Organizational Evolution
In recent years an increased understanding of evolutionary processes has emerged from work in molecular biology, computer science and complex systems analysis. This new understanding potentially can be harnessed by managers to create human organizations which evolve rapidly in desired directions. Our objective is to develop a conceptual toolkit for "evolutionary management". In our research, we draw analogies between policies and genes, between mutations and policy innovations, and between recombination and learning. We present a theoretical framework drawing on a computer simulation environment combining system dynamics modeling with genetic algorithms. Currently, we use this framework to explore the evolutionary implications of management hierarchy and team learning. *House*

Speech and Speaker Recognition in Adverse Communication Environments
Biological signals such as speech carry large amounts of information from different information sources. Typical engineering applications such as automatic speech recognition, speaker verification, or low bit-rate coding of speech may require information from only one particular source, and all other information introduces undesirable and harmful variability into the signal. Humans appear to be able to partially separate the various information sources in the speech signal. This ability spurred interest in modeling human-like processing of speech by modern discrete signal processing techniques. The anthropomorphic signal processing techniques could, in principle, yield improved performance of man/machine I/O technologies in real practical environments. Our research project on speech analysis, carried on jointly with the International Computer Science Institute, Berkeley, Calif., focuses on human-like processing of speech in realistic telecommunications environments to ensure reliable recognition of speech in adverse conditions such as the current mobile cellular telephone. *Hermansky*

Speech Synthesis
Speech is the most natural and efficient means by which individuals may access most information, and the need for speech-based interfaces is growing as computing gradually moves off of the desktop and into mobile devices. Since most on-line information is represented as ASCII text, the automatic conversion of text to speech provides a critical component in voice-based systems. Text-to-speech synthesis (TTS) has the further advantage of providing textual information to people who are visually impaired or functionally illiterate. The current trend in TTS research is to develop algorithms that rely on automatic training of models from labeled data, rather than hand-tuned rules as used historically. This strategy leads to systems that can be "trained" rapidly to speak in a new language or speaking style. Our work has been focused on signal processing models of the human voice and their use in data-driven speech synthesis algorithms. This is an interdisciplinary field that draws elements from linguistics, computer science, machine learning, human perception, and digital signal processing. *van Santen, Hosom*

VLSI Architecture for Intelligent Computing
Some of the most fundamental problems in computing involve teaching computers to act in a more intelligent manner. Key to this is the efficient representation of knowledge or contextual information. In this project a variety of highly parallel algorithms are studied, including neuromorphic structures, with the intent of implementing knowledge representation and manipulation in silicon. *Hammerstrom*

MEMS and Micro-sensors
Microelectromechanical systems (MEMS) and micro-sensors are rapidly becoming ubiquitous in technological society. Research applications range from micro-cilia, micro-turbines, and chips that

RESEARCH FACILITIES

The department has a complete complement of electronic measuring, recording, amplifying, signal generating, data processing, and servicing gear with associated power supplies and component stocks. Additional facilities and equipment include:

- **Access to FT-IR, fluorescence, diode array UV/VIS, scanning UV/VI Snear IR spectrophotometers**
- **NT/PC Computer Lab**
- **Solaris Servers with X-terminal access**
- **DTV Lab**
- **Intel Semiconductor Educational Lab**
- **Embedded Computer Lab**
- **High-end PCs & workstations**
- **Far-infrared Fourier spectrometer**
- **Parallel field-vibrating sample magnetometer**
- **Mossbauer spectrometer**
- **Field electron and ion microscopes**
- **Ultra-high vacuum systems**
- **Thin-film evaporation equipment**
- **Electron energy analyzers for Auger and field electron spectroscopy**
- **Micromachining capabilities**
- **Scanning electron microscope and transmission electron microscope**
- **High-resolution electron and ion microprobes**
- **Work function analysis instrumentation**
- **Quadrupole mass spectrometers for surface desorption studies**
- **Arc zone refinement system for single crystal specimen preparation**
- **Wire bonder**
- **Die attach system**
- **X-ray diffraction generator and cameras**
- **Facility for electronic transport and luminescence measurements as a function of temperature**
- **Visible, ultraviolet, and infrared gas, solid state, and dye lasers**
- **MOCVD crystal growth reactors**
- **1.25 meter visible and IR spectrometer**
- **High-performance optical microscope**
- **Depth profiling ellipsometer**
- **Photolithography and semiconductor metallization**
- **Sputter etching**
- **Device interconnect and packaging**
- **C-V, I-V measurement facilities**
- **Pulsed uv-laser processing system**
- **Electrical characterization (Hall)**
- **Sputtering machine**
- **Atomic layer epitaxy**
- **Liquid crystal display lab with pretilt rubbing, and single-cell electro-optic characterization facilities**
- **Scanning Auger Microprobe**
- **Spectroscopic Ellipsometers**

walk to MEMS & micro-sensors that have been commercialized in diverse applications such as airbag accelerometers and 'electronic noses' used to detect gases and chemicals. While VLSI fabrication techniques are exploited to produce MEMS and micro-sensor devices economically, these devices can be fabricated by an even greater range of processes and with a far wider variety of materials. The MEM/micro-sensor microfabrication laboratory in ECE is building glucose sensors, pressure sensors, and even micro-peristaltic pumps with a multidisciplinary exposure to mechanics, electronics, physics and fluid dynamics. Research and courses on MEMS and micro-sensors are focused on developing understanding of a large toolbox of processes and materials to design and fabricate these devices. *Scholl, House, McCarthy*

Microanalysis

The characterization, failure studies and in-situ testing of materials and structures used in microelectronics, opto-electronics, micro electromechanical systems(MEMS), sensors and biotechnology require a range of techniques that allow the measurement of properties on an ever decreasing scale. Probing materials on the sub-micron and nanometer scales was first necessary in the fabrication of sub-micron transistors to provide feedback on the thin film fabrication processes. These same thin film processes are now being employed by the budding biotechnology, MEMS and sensor industries. The probing is accomplished by scanned atomic force microscope tips, light, electron and ion beams. The signals produced by the probes are used to create high resolution images of surfaces and internal structures, measure compositions, thickness, roughness and identify crystal structures. The geometries, crystal structures, elements present and compositions revealed can then be correlated with electrical, mechanical, thermal and optical properties or more generally the performance of a microelctronic device, MEMS or sensor. The development of microanalysis techniques and application to research and development projects at OGI-ECE has a long history and continues to be a major portion of efforts here. Optical, atomic force, scanning electron, scanning Auger electron and transmission electron microscopes are used to characterize materials following tests, changes in processes or failures in service. The recent addition of a heating straining stage to the SEM and a heating stage with electrical feed-through's to the TEM will permit the complete evolution of microstructures during thermal processing or mechanical failures to be recorded digitally giving a more complete and accurate picture of mechanisms of change in materials on the micron and nanometer scales. *McCarthy, House, Freeouf*

Focused Ion Beam Technology

The use of focused ion beam workstations(FIB) in the microelectronics industry as development and production tools is widespread. The first research and development steps in producing practical FIB workstations in collaboration with local microelectronics companies were taken here at OGI. Focused ion beams are used to locate micron and sub-micron structures and produce cross-sections of these structures for examination in scanning and transmission electron microscopes. The deep sub-micron development efforts now in progress require the nano- and atomic scale characterization feedback on fabrication processes provided by these FIB produced cross-sections for the development efforts to be successful. The FIB is also used to modify existing microelectronic devices by adding or removing components by the removal or addition of conductors and insulators. This permits designers to test a change in a device quickly and inexpensively before making a costly change to a fabrication line or a mask. More generally the FIB provides the ability to micro-machine and microform on the micron and sub-micron scale in three dimensions. This has applications in the MEMS, sensor and biotechnology fields as a micron and sub-micron prototype fabrication tool. The FIB is also a lithography tool that does not require resists. A region is made chemically more active by careful control of the area of beam scan, beam energy and dwell to produce a volume of material that reacts when subjected to wet or dry etches. There is active research at OGI-ECE on the development of sub-micron cantilevers as high frequency electromechanical switches using ion lithography. *McCarthy*

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RESEARCH INTERESTS

Neuromorphic computing. Application of FPGAs to image processing, digital video, intelligent and neuromorphic computing. VLSI design. Highly parallel computer architecture and microarchitecture. Technology transfer.

REPRESENTATIVE PUBLICATIONS

D. Hammerstrom, "Computational Neurobiology Meets Semiconductor Engineering," Invited Paper MultiValued Logic 2000, May 2000.

S. Rehfuss & D. Hammerstrom, "Comparing SFMD and SPMD Computation for On-Chip Multiprocessing of Intermediate Level Image Understanding Algorithms," Proceedings of the conference for Computer Architectures for Machine Perception 1997, Boston, MA, October 1997.

D. Hammerstrom & D. Lulich, "Image Processing Using One-Dimensional Processor Arrays," The Proceedings of the IEEE, 84(7), 27-43, July 1996.

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D. Hammerstrom, "A Digital VLSI Architecture for Real World Applications," An Introduction to Neural and Electronic Networks, S.F. Zornetzer, J.L. Davis, C. Lau & T.McKenna (Eds.), Academic Press, 1995.

ANTHONY E. BELL

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RESEARCH INTERESTS

Development of liquid metal field ion sources; field ionization, surface physics, and chemistry; field emission microscopy and energy distribution measurements. Selected area processing for microcircuit fabrication using focused electron beams. Direct-write electron-beam lithography for both mask making and IC fabrication using multiple photo-emitted electron beams. Plasma processing for thin film deposition and etching.

REPRESENTATIVE PUBLICATIONS

A.E. Bell & D.F. Barofsky, "Field Emission and Field Ionization," in Encyclopedia of Applied Physics, 6, 379, 1993.

A.E. Bell, K. Jousten & L.W. Swanson, "High Field Ion Sources," Rev. Sci. Intr., 61(1) Part II, 363, 1990.

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L.W. Swanson & A.E. Bell, "Liquid Metal Ion Sources," I.G. Brown (Ed.), The Physics and Technology of Ion Sources, John Wiley & Co., 313, 1989.

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Ph.D., Electrical Engineering
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RESEARCH INTERESTS

Management of technology, and advanced lithography for semiconductor fabrication.

REPRESENTATIVE PUBLICATIONS

J. Ye, M. Takac, C.N. Berglund, G. Owen & R.F.W. Pease, "An Exact Algorithm for the Self-Calibration of Precision X-Y Stages," Conference on Electron, Ion & Photon Beam Technology and Nanofabrication, May 1996.

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W. Wang, J. Ye, A.B. Owen, C.N. Berglund & R.F.W. Pease, "Adaptive Metrology: An Economical Strategy for Judging the Acceptability of a Mask Pattern," J. Vac. Sci. Technol., B13(6), November/December 1995.

J. Ye, C.N. Berglund & R.F.W. Pease, "Field Distortion Characterization Using Linewidth or Pitch Measurement," J. Vac. Sci. Technol. B13(6), November/December 1995.

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RESEARCH INTERESTS

The large and growing semiconductor industry has clearly established that to control something you must be able to measure it. A major thrust of my research efforts is to determine how to measure the specific parameters required to best understand and improve our semiconductor materials and devices. Typically, these measurements will involve incident photons; the output may be either photons or some electrical response.

REPRESENTATIVE PUBLICATIONS

Seung-Gu Lim, Thomas N. Jackson, W.C. Mitchel, R. Bertke and J.L. Freeouf, Optical Characterization of 4H-SiC by Far Ultraviolet Spectroscopic Ellipsometry, Applied Physics Letters, vol. 79, No. 2, 2001.

Todd Holden, P. Ram, Fred H. Pollak, J. L. Freeouf, B. X. Yang and M. C. Tomargo, Spectral Ellipsometry Investigation of Zn Cd Se Lattice Matched to InP, Physical Review B56, 4037, 1997.

M. Leibovitch, P. Ram, L. Malikova, Fred H. Pollak, J. L. Freeouf, L. Kronik, B. Mishon, Yoram Shapira, A. R. Clawson, and C. M. Hanson, Reflection Anisotropy Spectroscopy, Surface Photovoltage Spectroscopy, and Contactless Electroreflectance Investigation of the InP/In0.53Ga0.47As (001) Heterojunction System, J. Vac. Sci. Technol. B14, 3089, 1996.

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M.D. School of Medicine
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RESEARCH INTERESTS

Application of laser energy for the treatment of altherosclerotic vascular disease, laser thrombolysis in acute myocardial infarction and stroke, vascular smooth muscle response to light, Elastin biomaterials for tissue replacement and repair, and dye-targeted laser-tissue fusion.

REPRESENTATIVE PUBLICATIONS

M.J. Girsky, K.W. Gregory, A. Shearin & S.A. Prahl, "Photoacoustic Drug Delivery to Arterial Thrombus: A New Method for Local Drug Delivery," American Heart Association, 69th Annual Scientific Session, New Orleans, LA, November 1996.

K.W. Gregory, "Laser Thrombolysis in Acute Myocardial Infarction," Current Review of Interventional Cardiology (D. Holmes Jr. & P. Serruys), 3rd Edition, August 1996.

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H. Shangguan, L.W. Casperson, A. Shearin, K.W. Gregory & S.A. Prahl, "Photoacoustic Drug Delivery: The Effect of Laser Parameters on Spatial Distribution of Delivered Drug," SPIE, Laser Tissue Interaction VI (S.L. Jacques, Ed.), San Jose, CA, 1995.

K.W. Gregory & J.M. Grunkemeier, "Arterial Reconstruction using an Elastin-based Biopolymer with Dye Targeted Diode Laser Fusion," American Society for Laser Medicine and Surgery, 15th Annual Meeting, San Diego, CA, April 1995.

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RESEARCH INTERESTS

Communication between human and machine; human perception and its computer simulation; speech production and perception; automatic recognition of speech, speech coding, synthesis and enhancement; identification and extraction of linguistic information in realistic communication environments.

REPRESENTATIVE PUBLICATIONS

H. Hermansky, "Should Recognizers Have Ears?" Speech Communication, Publishers, Holland, June 1998.

H. Hermansky, "Modulation Spectrum in Speech Processing, in Signal Analysis and Prediction," Prochazka, Uhlir, Rayner, Kingsbury, Eds., 1998.

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C. Avendano & H. Hermansky, "On the Properties of Temporal Processing for Speech in Adverse Environments," Proceedings of 1997 Workshop on Application of Signal Processing to Audio and Acoustics, Mohonk Mountain House, New Paltz, New York, October 1997.

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H. Hermansky, C. Avendano, S. van Vuuren, & S. Tibrewala, "Recent Advances in Addressing Sources of Non-Linguistic Information," Proceedings of ESCA-NATO Tutorial and Research Workshop on Robust Speech Recognition for Unknown Communication Channels, 103-106, Pont-a-Mousson, France, April 1997.

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RESEARCH INTERESTS

Speckle propagation through turbulence, optical remote sensing of wind and turbulence, electro-optic systems, instrumentation signal processing, and biomedical optics.

REPRESENTATIVE PUBLICATIONS

J. Fred Holmes, Steven L. Jacques, and John M. Hunt, "Adapting atmospheric lidar techniques to imaging biological tissue", SPIE, Bios 2000 Conference, San Jose, California, January 22 - 28, 2000.

M. Becker, J.F. Holmes, & L. Meekisho, "Interdisciplinary Curriculum Development in Electronics Packaging Using Course Segmentation," ASEE 1998 Frontiers in Education Conference, Tempe, Arizona, November 4-7, 1998.

J.F. Homes & B. J. Rask, "Range Resolved, 3-D Optical Remote Sensing of Atmospheric Winds Using a CW Lidar," Advances in Atmospheric Remote Sensing with Lidar, A. Amsmann, R. Neuber, P. Rairoux, and U. Wandinger (eds.), Springer-Verlag, Berlin, 1997.

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J.F. Holmes & B.J. Rask, "Optimum, Optical Local Oscillator Levels for Coherent Detection Using Photodiodes," Appl. Opt., 34, February 1995.

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RESEARCH INTERESTS

Electronic and photonic device design for microsensor applications with a current concentration on materials. Applications in genetic algorithms and programs as applied to electronic materials and devices as well as human organizations. System dynamics modeling of human organizations for public policy development. The role early engineering education processes have in retention and attraction of female engineering students.

REPRESENTATIVE PUBLICATIONS

Hines, J. and House, The Source of Poor Policy: Controlling Learning Drift and Premature Consensus in Human Organization. System Dynamics Review, 17(1); p. 3-32, 2001.

Hines, J.H. and J.L. House. Management fads & poor policies: A year of organization evolution research. In 2001 NSF Design and Manufacuring Research Conference. Tampa, FL, 2001

House, J.A. Kain and J. Hines. Evolutionary Algorithm: Metaphor for Learning. In Genetic and Evolutionary Computation Conference. Las Vegas, NV: Morgan Kaufmann, 2000.

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RESEARCH INTERESTS

Robert S. Jaffe is a full-time instructor in ECE. He teaches in the areas of signals and systems, applied mathematics and mathematical systems theory. His area of specialization is linear systems and robust control. He received a Ph.D. in Electrical and Computer Engineering from Portland State University in 1988. During an earlier career phase he was a Professor of Philosophy and a researcher in the philosophy of education.

MARWAN JABRI

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Ph.D., Electrical Engineering
University of Sydney 1988
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RESEARCH INTERESTS

Artificial intelligence, computer architecture. The understanding of the principles by which humans and/or other organisms perceive the environment, process sensory signals, reason, make decisions and learn. The design and engineering of humanoids that exhibit faculties similar to humans.

REPRESENTATIVE PUBLICATIONS

O. Coenen, M. Arnold, T. Sejnowski and M. Jabri, Bayesian analysis of parallel fiber coding in the Cerebellum, ICONIPí2000, pp 1301-1306, Korea, 2000.

M.A. Jabri and R. Coggins, "Micro Power Adaptive Circuits for Implantable Devices," Low Power – Low Voltage Circuits and System, E. Sanchez-Sinencio & Andreas Andreou Editors, IEEE Press, USA, pp. 500-518, 1999.

Raymond J. W. Wang and Marwan Jabri, "A Computational Model of the Auditory Pathway to the Superior Colliculus," in Brain-like computation and Intelligent Information Systems, Shun-ichi Amari and Nikola Kasabov (Eds.), Springer Verlag, pp. 81-104, 1998.

R. Coggins, R. Wang and M.A. Jabri, "A micropower adaptive linear transform vector quantiser," to appear in Analog integrated circuits and signal processing, Kluwer, February 1999.

R. Coggins, M.A. Jabri, A Low Complexity Intracardiac Electrogram Compression Algorithm, IEEE Transactions on Biomedical Engineering, Vol. 46, No. 1, pp. 82-91, January 1999.

X.Q. Li and M.A. Jabri, "Machine learning based VLSI Cells Shape Function Estimation," IEEE Transactions on CAD for Integrated Circuits and Systems, Vol 17, No. 7, pp. 613-623, 1998.

M. Schenkel and M.A. Jabri,† "Low resolution degraded document recognition using neural networks and hidden Markov models," Pattern Recognition Letters, V19 N3-4 pp. 365-371, 1998.

M. Partridge and M.A. Jabri, "Template Decision Trees," Journal of Applied Intelligence, 1997.

M.A. Jabri and E. Tinker, "Classifier architectures for Single Chamber Arrhythmia Recognition," Journal of Applied Intelligence, Kluwer Academic Press, 6:3, pp. 215-224, July 1996.

M.A. Jabri, R. Coggins and B. Flower, "Adaptive Analog Neural Systems," Chapman and Hall, UK, 1996.

M.A. Jabri, "Neural Networks for ECG Signal Interpretation," Handbook of Neural Computation, Institute of Physics Publishing and Oxford University Press, G2.5, 1996.

STEVEN L. JACQUES

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Ph.D., Biophysics
and Medical Physics
University of California,
Berkeley, 1984
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RESEARCH INTERESTS

Biomedical optics and laser-tissue interactions. Development of diagnostic and therapeutic devices for medicine and biology using optical technologies.

REPRESENTATIVE PUBLICATIONS

S. L. Jacques, J. R. Roman, K. Lee, "Imaging superficial tissues with polarized light," Lasers Surg. Med. 26:119-129, 2000.

L. V. Wang, S. L. Jacques, "Source of error in calculation of optical diffuse reflectance from turbid media using diffusion theory," Comput Methods Programs Biomed. 61(3):163-170, 2000.

S. L. Jacques, "Modeling photon transport in transabdominal fetal oximetry," J Biomed. Optics, in press, 2000.

S. L. Jacques, "Light distributions from point, line, and plane sources for photochemical reactions and fluorescence in turbid biological tissues," Photochem. Photobiol. 67:23-32, 1998.

S. L. Jacques, S. J. Kirkpatrick, "Acoustically modulated speckle imaging of biological tissues," Optics Letters, 23:879-881, 1998.

S. L. Jacques, "Path integral description of light transport in tissue," Ann N Y Acad Sci. 9;838:1-13, 1998.

JOHN-PAUL HOSOM

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2000, Oregon Graduate
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RESEARCH INTERESTS

Automatic speech recognition (ASR). Time alignment of phonemes. Acoustic-phonetic analysis of speech. Assistive technology.

REPRESENTATIVE PUBLICATIONS

Hosom, J.P., "Automatic Speech Recognition," in H. Bidgoli, S. B. Eom, A. Prestage (Eds.), Encyclopedia of Information Systems. San Francisco: Academic Press, 2001.

Hosom, J.P. and Cole, R.A., "Burst Detection Based on Measurements of Intensity Discrimination," Proceedings of ICSLP 2000, Beijing, vol. IV, pp. 564-567, October 2000.

Cosi, P. and Hosom, J. P., "High Performance General Purpose Phonetic Recognition for Italian," Proceedings of ICSLP 2000, Beijing, vol. II, pp. 527-530, October 2000.

Hosom, J.P., Cole, R.A, and Cosi, P., "Improvements in Neural-Network Training and Search Techniques for Continuous Digit Recognition," Australian Journal of Intelligent Information Processing Systems (AJI-IPS), vol. 5, no. 4, pp. 277-284, Summer 1999, (invited paper).

Cole, R.A., Serridge, B., Hosom, J.P., Cronk, A., and Kaiser, E., "A Platform for Multilingual Research in Spoken Dialogue Systems," Proceedings of the Workshop on Multi-Lingual Interoperability in Speech Technology (MIST), Leusden, The Netherlands, September 1999.

Hosom, J. P. and Yamaguchi, M., "Proposal and Evaluation of a Method for Accurate Analysis of Glottal Source Parameters," The Institute of Electronics, Information and Communication Engineers (IEICE) Transactions on Information and Systems, vol. E77-D, no. 10, pp. 1130-1141, October 1994.

SEAN J. KIRKPATRICK

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RESEARCH INTERESTS

Development and application of coherent light techniques to address issues in biomaterials science and tissue mechanics. Laser speckle techniques are of particular interest. Recent investigations have focused on the evaluation of the micromechanical behavior of vascular, dermatological, and skeletal tissues using novel laser speckle strain measurement methods. We envision that these investigations will lead not only to an expansion of our basic science understanding of tissue mechanics and laser-tissue interaction, but will also result in optical instrumentation to assist in the diagnosis and treatment of disease. Other interests include experimental investigations into the micromechanics of synthetic biomaterials used to replace or augment damaged or pathological tissue.

REPRESENTATIVE PUBLICATIONS

Kirkpatrick, S.J. and Duncan, D.D., Processing techniques for laser speckle data derived from biological tissues, J. Biomed. Optics (in press), 2001.

Kirkpatrick, S.J. and Duncan, D.D. Acousto-optic elastography, Proceedings SPIE 4257, 2001.

Patrickeyev, I., Kirkpatrick, S.J., and Duncan, D.D., Tracking speckle motion with directional wavelets, Proceedings SPIE 4257, 2001.

Kirkpatrick, S.J. and Cipolla, M.J., High resolution images laser speckle strain gauge for vascular applications, J. Biomed Optics, 5(1): 62-71, 2000.

Kirkpatrick, S.J. and Jacques, S.L., Acoustically modulated speckle imaging of soft tissue, ASME BED vol. 43, 1999 Advances in Bioengineering, Wayne, J.S. (Ed.), American Society of Mechanical Engineers, N.Y., 1999.

Kirkpatrick, S. J. Transform method for laser speckle strain rate measurements in biological tissues and biomaterials. In "Light Scattering Technologies in Biomedicine and Materials Science", SPIE Press, Bellingham, WA, 1998.

Kirkpatrick, S.J. and Cipolla, M.J. High resolution imaged laser speckle strain gauge for vascular applications. J. Biomed. Optics (accepted), 1998.

Jacques, S.L. and Kirkpatrick, S.J. Acoustically modulated speckle imaging of biological tissue. Opt. Letters 23:879-881, 1998.

Kirkpatrick, S.J. and Brooks, B.W. Micromechanical behavior of cortical bone as inferred from laser speckle data. J. Biomed. Mater. Res. 3:373-379, 1998.

JACK McCARTHY

Assistant Professor
Ph.D., Materials Science
and Engineering
Oregon Graduate Institute of
Science and Technology, 1996
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RESEARCH INTERESTS

Mechanisms of change in metallization and insulator thin films used in microelectronic applications, in-situ testing of these films in transmission and scanning electron microscopes to develop better processing techniques and more reliable thin films. The development of focused ion beam processes for the fabrication of structures on the micron and sub-micron scales to produce sensors and electro-mechanical devices for testing the physical properties of sub-micron thin films. Thin film transmissive photocatodes for use in multi-beam electron lithography and surface reactions at the emission site. Materials characterization techniques using analytical electron microscopy and focused ion beam technology.

REPRESENTATIVE PUBLICATIONS

F. Radulescu, J.M.McCarthy, "The Effect of Stress in the PdGe Mediated Solid Phase Epitaxial Growth of Ge on GaAs," MRS Symposium Proceedings, Substrate Engineering for Epitaxy, 587, 1999.

F. Radulescu, J.M.McCarthy, E.Stach "In-Situ Annealing Transmission Electron Microscopy of Pd/Ge/Pd/GaAs Interfacial Reactions," MRS Symposium Proceedings, Advances in Materials Problem Solving with the Electron Microscope, 589, 1999.

J.McCarthy, Z. Pei, M.Becker, D.Atteridge "FIB Micromachined Submicron Thickness Cantilevers for the Study of Thin Film Properties," Thin Solid Films 358 (2000) p146-151. Accepted 8/31/99.

S. Gosavi, J.M.McCarthy, C.N. Berglund, W.A.Mackie, L.A.Southall "Practical Gold Thin Film Photocathodes for Advanced Electron Beam Lithography," BACUS Symposium on Photomask Technology, SPIE Vol.3873, September 1999.

Z. ei, J.McCarthy, C.N.Berglund, T.H.P.Chang, M.Mankos, K.Y.LEE and M.L.Yu, "Thin Film Gated Photocathode for e-Beam Lithography," J.VAC.Sci.Technol.B 17(6), p2814, 1999.

J.M. McCarthy, SEM and TEM Characterization of Materials Using a Focused Ion Beam Milling Workstation, IMS Conference Proceedings in Materials Characterization.Accepted 1997.

MISHA PAVEL

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Ph.D., Experimental Psychology
New York University, 1980
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RESEARCH INTERESTS

Analysis and modeling of complex behaviors of biological systems, including visual and auditory processing, pattern recognition, information fusion and decision making. Development of engineering systems mimicking these abilities to support multimodal communication between humans and machines (speech and video), machine vision, visually guided vehicular control, and virtual reality. Applications of these techniques to the development of future biomedical and healthcare systems.

REPRESENTATIVE PUBLICATIONS

J. Palmer, P. Verghese, and M. Pavel, The psychophysics of visual search, Vision Research, 40, 1227-1268, 2000.

Arai, T., Pavel, M., Hermansky, H., and Avendano, C. Syllable intelligibility for temporally filtered LPC cepstral trajectories, The Journal of the Acoustical Society of America, 105, 2783-2791, 1999.

Sharma, R.K., Leen, T.K., and Pavel, M. Probabilistic image sensor fusion. In M.S. Kearns, S.A. Solla, and D.A. Cohn (Eds.), Advances in Neural Information Processing Systems 11. Cambridge, MA: MIT Press, 1999.

M. Pavel and H. Hermansky: "Information Fusion by Human and Machine," in Proccedings of the First European Conference on Signal Analysis and Prediction, pp. 350-353, Prague, Czech Republic, June 1997.

M. Pavel & H.A. Cunningham, "Eye Movements and the Complexity of Visual Processing," in M.S. Landy, L.T. Maloney and M. Pavel (Eds.), Exploratory Vision: The Active Eye, 101-120 New York, NY, Springer-Verlag, 1996.

H. Hermansky & M. Pavel, "Psychophysics of Speech Engineering Systems," invited paper, Proceedings of the 13th International Congress on Phonetic Science, Stockholm, Sweden, August 1995.

P. Suppes, M. Pavel & J. Falmagne, "C. Representations and Models in Psychology," Annu. Rev. Psycho., 45, 517, 1994.

M. Pavel, "Predictive Control of Eye Movement," in E. Kowler (Eds.), Eye Movement and Their Role in Visual and Cognitive Processes, 71-114, Amsterdam, Elsvier, 1990.

SCOTT A. PRAHL

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Ph.D., Biomedical Engineering
University of Texas at Austin, 1988
prahl@ece.ogi.edu

RESEARCH INTERESTS

Diagnostic and therapeutic applications of light in medicine: laser thrombolysis, non-invasive optical diagnostics, hemostasis and tissue repair.

REPRESENTATIVE PUBLICATIONS

Wadia Y, Xie H, Kajitani M, and Prahl SA, Liver repair and hemorrhage control using laser soldering of liquid albumin in a porcine model, in SPIE Proceedings of Lasers in Surgery, vol. 3907, 74-81, 2000.

Viator JA, Jacques SL, and Prahl SA, Depth profiling of absorbing soft materials using photoacoustic methods, IEEE Journal of Selected Topics in Quantum Electronics 5:989-996, 1999.

Viator JA and Prahl SA, Laser thrombolysis using long pulse frequency-doubled Nd:YAG lasers, Lasers in Surgery and Medicine 25:379-388, 1999.

Prahl SA, Denison T, and La Joie EN, Laser repair of liver, in Malek RS, ed., SPIE Proceedings of Lasers in Surgery: Advanced Characterization, Therapeutics and Systems XI, vol. 4244, 2001.

Paltaulf G, Viator JA, Prahl SA, and Jacques SL, Iterative reconstruction method for three-dimensional optoacoustic imaging, Journal of Acoustic Society of America (submitted).

Janis AD, Nyara AN, Prahl SA, Gregory KW, and Buckley LA, A reconstituted in vitro clot model for evaluating laser thrombolysis, Lasers in Surgery and Medicine, (submitted).

Moffitt TP and Prahl SA, Dual-sized fiber reflectometry for measuring local optical properties, IEEE Journal of Selected Topics in Quantum Electronics, (submitted).

SHANKAR RANANAVARE

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Ph.D., Physical Chemistry
University of Missouri,
St. Louis, 1983
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RESEARCH INTERESTS

Nanotechnology: Nanoparticles and Photoresists, Dynamics of complex systems, Ferroelectric, Antiferroelectric and Amphitropic Liquid Crystals, Flat Panel Displays, Phase Transitions and Critical Phenomena.

REPRESENTATIVE PUBLICATIONS

Ciro Di Meglio, S. B. Rananavare, S. Sorenson, D. H. Thompson, " Bolaamphiphilic Phosphocholines: Structure and Phase Behavior in Aqueous Media," Langmuir, 16, 128, 2000.

V.G.K.M. Pisipati & S.B. Rananavare, "X-Ray Diffraction Studies of 10O.14 and 10O.8," Mol. Cryst. Liq. Cryst.,238,, 207-214, 1994.

J.H. Freed, A. Naveem & S.B. Rananavare, "ESR and Liquid Crystals: Statistical Mechanics and Generalized Smoluchowski Equations," Chapter 4, 71-84, "ESR and Molecular Motions in Liquid Crystals," "Thermodynamics of Liquid Crystals and the Relation to Molecular Dynamics: ESR Studies," "ESR Studies of Molecular Dynamics at Phase Transitions in Liquid Crystals," "ESR and Slow Motions in Liquid Crystals," Chapters 12-15, 271-402, The Molecular Dynamics of Liquid Crystals, (G. R. Luckhurst and C. A. Veracini eds.), NATO ASI Series, Kluwer Academic Publishers, Netherlands, 1994.

S.B. Rananavare, V.G.K.M. Pisipati & E.W. Wong, "The ACC Multicritical Point in Ferroelectric Liquid Crystals," Phys. Rev. Lett, 72, 3558, 1994.

S.B. Rananavare, V.G.K.M. Pisipati & E.W. Wong, "A Lifshitz Point in Ferroelectric Liquid Crystals," Liquid Crystal Materials, Devices and Applications III, (R. Shashidhar, ed.), 2175, 108-119, SPIE-94, San Jose, CA, Feb. 8-10, 1994.

V. G. K. M. Pisipati and S. B. Rananavare, "Interdigitated Smectic A and B Mesophases in Higher Homologues of 50.m Series," Liquid Crystals, 13,757-764, 1993.

MILTON R. SCHOLL

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Ph.D., Materials Science and Engineering
OGI School of Science and Engineering, 1987
milts@mse.ogi.edu

RESEARCH INTERESTS

Micro-mechanical systems and their design and use, particularly the mechanics, the materials, and interaction of contacting surfaces, i.e. tribology of microsystems. Tribological systems ranging from chemical mechanical polishing, to fiber-plate interactions in chip refining and woodcutting, to wheel-rail interactions. Tribological performance of materials including abrasive and erosive wear, sliding behavior, rolling / sliding conditions and the interactions of the phenomena with the working environment, focusing on surface response to external stimuli and mitigation techniques to reduce or eliminate surface damage.

REPRESENTATIVE PUBLICATIONS

M. Scholl, "Abrasive wear of titanium nitride coatings," Wear, Vol. 203-204, 57- 64, 1997.

M. Scholl, "Unique Thermal Spray Coatings by High Energy Plasma Spraying," Proceedings of the International Conference on Advances in Welding Technology: Joining of High Performance Materials, Columbus, Ohio, Nov. 6-8, 1996.

D. Christensen, Y. Jia, M. Scholl, P. Clayton, & S. Abubakr, "Surface Deterioration of Refiner Plates for Thermo-Mechanical Pulping," Proceedings of the 1994 Pulping Conference, Nov. 6-10, 1994, San Diego, California, pub. by TAPPI Press, Atlanta, 1994, pp. 193-203.

M. Scholl, "Plasma Spraying with Wire Feedstock," Proceedings of the 1994 National Thermal Spray Conference, Boston, MA, June 1994.

M. Scholl, C. Steinkamp & W.E. Wood, "Acoustic Emission Monitoring of Plasma Sprayed Tubes," EWI Research Report, 1994.

M. Scholl & P. Clayton, "Surface Texture and Abrasive Wear Resistance of Some High Velocity Air Plasma Sprayed Coatings," Proceedings of the 1991 National Thermal Spray Conference, Pittsburgh, PA, May 1991.

RAJ SOLANKI

Professor
Ph.D., Physics
Colorado State University, 1982
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RESEARCH INTERESTS

Atomic Layer Deposition, copper electrodeposition and electromigration, multilevel metallization, high k gate dielectrics, inorganic and organic electroluminescent devices, polysilicon thin film transistors.

REPRESENTATIVE PUBLICATIONS

H. Zhang and R. Solanki, Atomic Layer Deposition of High Dielectric Constant Nanolaminates, J. Electrochem. Soc. 63, 148, 2001.

(Invited paper) B. Pathangey and R. Solanki, Atomic layer deposition for nanoscale thin film coatings, Vacuum Tech. and Coatings, 1 , 32, 2000.

R. Solanki and B. Pathangey, Atomic Layer Deposition of Copper Seed Layers, Electrochem and Solid-State Letters, 3 , 479, 2000.

H. Zhang, R. Solanki, B. Roberds, G. Bai, and I. Banerjee, High Permittivity Thin Film Nanolaminates, J. Appl. Phys. 87, 1921, 2000.

A.T. Voutsas, M.A. Marmorstein, and R. Solanki, The Effect of Laser Annealing Ambient on the Performance of Excimer Laser Annealed Thin Film Transistors,î J. Electrochemical Soc. 146 , 3500, 1999.

R. Engelmann, J. Ferguson, and R.Solanki, "Quantum Well Activated Phosphors-A New Concept for Electroluminescent Displays," Appl. Phys. Lett. 70, 411, 1997.

J. Fogarty, W. Kong, and R. Solanki,"Monte Carlo Simulation of High Field Electron Transport in ZnS," Solid-State Electronics, 38, 653, 1995.

W. Kong and R. Solanki, "The Effect of Ultraviolet Radiation on a ZnS:Tb Thin Film Electroluminescent Device," J. of Appl. Phys.75, 3311, 1994.

T. Dosluoglu and R. Solanki, "Self-Consistent Calculations of Carrier Distribution and Energy Bands in InGaAs/InP PIN Diodes," Solid State Comm., 85, 243, 1993.

XUBO SONG

Assistant Professor
Ph.D., Electrical Engineering
California Institute
of Technology, 1998
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RESEARCH INTERESTS:

Digital Image/Video Processing; Sensor Fusion; Computer Vision; Pattern Recognition; Machine Learning; Information Theory and Coding; Biomedical Engineering.

REPRESENTATIVE PUBLICATIONS

Xubo Song, Yaser Abu-Mostafa, Joseph Sill, Harvey Kasdan, "Image Recognition in Context: Application to Microscopic Urinalysis," in Advances in Neural Information Processing Systems, S.A. Solla, T.K. Leen and K.-R.Muller, Editors, MIT Press, pp. 963-969, 2000.

Xubo Song, Yaser Abu-Mostafa, Joseph Sill, Harvey Kasdan, "Incorporating Contextual Information into White Blood Cell Image Recognition," in Advances in Neural Information Processing Systems, M.I. Jordan, M.J. Kearns and S.A. Solla, Editors, MIT Press, pp. 950-956, 1998.

Yaser Abu-Mostafa, Xubo Song, "Bin Model for Neural Networks," in Proceedings of the International Conference on Neural Information Processing, S. Amari, L. Xu, L. Chan, I. King and K. Leung, Editors, Springer, pp. 169-173, 1996.

Xubo Song, "Contextual Pattern Recognition with Applications to Biomedical Image Identification," PhD Thesis, California Institute of Technology, 1999.

Yaser Abu-Mostafa, Xubo Song, Alexander Nicholson, Malik Magdon-Ismail, "The Bin Model," under revision for IEEE Transactions on Information Theory, 2001.

Xubo Song, "Pattern Recognition in Context," to be submitted to IEEE Transactions on Pattern Analysis and Machine Intelligence, 2001.

Xubo Song, "Contextual Biomedical Image Recognition," to be submitted to IEEE Transactions on Biomedical Engineering, 2001.

Malik Magdon-Ismail, Xubo Song, "Effective Choice of Weight Decay Parameters," to be submitted to Neural Computation, 2001.

JAN P.H. VAN SANTEN

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Ph.D., Mathematical Psychology
University of Michigan, 1979
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RESEARCH INTERESTS

Speech timing, intonation, signal processing, statistical analysis of text and speech corpora, and text-to-speech (TTS) system evaluation.

REPRESENTATIVE PUBLICATIONS

Gu W., Shih C., and van Santen J. "An Efficient Speaker Adaptation Method for TTS Duration Model". Proceedings of EUROSPEECH 99, Budapest, Hungary, 1999.

van Santen J., and Sproat R., "High-accuracy automatic segmentation". Proceedings of EUROSPEECH 99, Budapest, Hungary, 1999.

Sproat R., van Santen J., "Automatic Ambiguity Detection." Proceedings of ICSLP 98. Sydney, Australia, 1998.

van Santen J. "Evaluation." In Multilingual Text-to-Speech Synthesis: The Bell Labs Approach Kluwer, Dordrecht, 1998.

van Santen J., Sproat R.W., Olive J., and Hirschberg J. (Eds.). Progress in speech synthesis. Springer Verlag, New York, 1996.

ERIC A. WAN

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Ph.D., Electrical Engineering
Stanford University, 1994
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RESEARCH INTERESTS

Learning algorithms and architectures for neural networks and adaptive signal processing; applications to time-series prediction, speech enhancement, adaptive control, and telecommunications.

REPRESENTATIVE PUBLICATIONS

E. A. Wan and R. van der Merwe, The Unscented Kalman Filter. In Kalman Filtering and Neural Networks, chap. Chapter 7, Wiley Publishing, Eds. S. Haykin, 2001.

E. Wan & A. Nelson, "Networks for Speech Enhancement," in Handbook of Neural Networks for Speech Processing, Edited by Shigeru Katagiri, Artech House, Boston, USA, 1999.

E. Wan & F. Beaufays, "Diagrammatic Methods for Deriving and Relating Temporal Neural Networks Algorithms, In Adaptive Processing of Sequences and Data Structures," Lecture Notes in Artificial Intelligence, M. Gori & C.L. Giles (eds.), Springer Verlag, 1998.

E. Wan and A. Nelson, "Neural Dual Extended Kalman Filtering: Applications in Speech Enhancement and Monaural Blind Signal Separation," IEEE Workshop on Neural Networks and Signal Processing, 1997.

E. Wan, "Adjoint LMS: An Alternative to Filtered-X LMS and Multiple Error LMS," ICASSP96, 3, 1842-1845, 1996.

E. Wan, "Time Series Prediction Using a Neural Network with Embedded Tapped Delay-Lines," in Predicting the Future and Understanding the Past, A. Weigend and N. Gershenfeld (eds.), SFI Studies in the Science of Complexity, Proc., 17, Addison-Wesley, 1993.

E. Wan, "Discrete Time Neural Networks," Journal of Applied Intelligence, 3(1), 91-105, 1993.

E. Wan, "Neural Network Classification: A Bayesian Interpretation," IEEE Transactions on Neural Networks, 1(4), 303-305, December 1990.

YONGHONG YAN

Associate Professor Ph.D.,
Computer Science
& Engineering, 1995
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RESEARCH INTERESTS

Human computer interface design, spoken language system, large vocabulary speech recognition, computer vision, real time embedded system, speech signal processing.

REPRESENTATIVE PUBLICATIONS

X. Wu & Y. Yan. Linear regression under maximum a posteriori criterion with markov random field prior. In proceedings IEEE ICASSP2000, June 2000.

C. Liu and Y. Yan. Speaker change detection using minimum message length criterion. In proceedings 6th International Conference on Spoken Language Processing, vol 3. pp 514-515, October 2000.

C. Zheng, Y. Yan. Efficiently Using Speaker Adaptation Data. In proceedings ICSLP, 2000.

Y. Yan. Speech Recognition using correlation generated neural network target. IEEE Trans. on Speech and Audio Processing, May 1999.

E. Barnard,Y. Yan. Toward new language adaptation for language identification. Speech Communication, 21(4):245-254, May 1997.

Y. Yan, E. Barnard, R.A. Cole. Development of an Approach to Automatic Language Identification based on Phone Recognition. In Computer, Speech Language, Volume 10(1), pp. 37-54, January 1996.

JOINT FACULTY APPOINTMENTS

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THE DEPARTMENT OF ENVIRONMENTAL SCIENCE AND ENGINEERING is one of the oldest stand-alone environmental and engineering programs in the country. Founded more than 25 years ago, we are known for our research and graduate education programs that balance practical applications with fundamental investigations of the physical, chemical, and biological processes underlying environmental phenomena. The curriculum is highly interdisciplinary and is built on a solid foundation of fundamental science and engineering.

The department offers graduate study leading to the degrees of Doctor of Philosophy (Ph.D.) and Master of Science (M.S.). M.S. programs are offered with both thesis and non-thesis options. All programs may be pursued on a full-time or part-time basis. Ph.D. students and M.S. thesis students participate in a program that includes both formal course work and research. The research experience is intensive and consists of laboratory, computational, theoretical and/or field studies. Thesis students are involved in all aspects of departmental research and have ready access to modern analytical instrumentation and computers.

The Ph.D. program can be completed in 4 to 5 years, and the M.S. thesis option takes approximately 2 years to complete. Thesis students can concentrate their studies in the following areas:

- Environmental Science and Engineering (ESE) (traditional program)
- Environmental Information Technology (EIT)

The non-thesis M.S. program can be completed in 12 months. Students in the non-thesis M.S. program can concentrate their studies in the following areas:

- Environmental Science and Engineering (ESE) (traditional program)
- Ecosystem Management and Restoration (EMR)
- Environmental Information Technology (EIT) (beginning Fall 2002)

ADMISSION REQUIREMENTS

Applications for admission to full-time and part-time degree programs are invited from persons with bachelor's degrees in the physical or biological sciences, mathematics, or engineering. Previous course work in chemistry, biology, and mathematics (through at least one year of calculus) is expected.

Requirements for admission to the Department of Environmental Science and Engineering are the same as the OGI School of Science and Engineering's admission requirements, except for the minimum TOEFL score. The department requires TOEFL scores of all applicants whose native language is not English. The minimum acceptable TOEFL score is 600 for the written test or 250 for the computer-based test. Students who earned undergraduate degrees in the United States are not required to submit TOEFL scores. GRE general aptitude scores are required for admission to all of the department's M.S. and Ph.D. programs. A GRE subject examination score is not required.

Completed Ph.D. applications should be received by February 15 for matriculation in the fall of the same year. M.S. applications are accepted year-round, although most new M.S. students apply by July for matriculation in the fall. Prospective applicants for the Ph.D. program should examine the faculty research programs at http://www.ese.ogi.edu/people.html to determine whether their professional goals can be fulfilled in the department. Communication with individual faculty members prior to applying is encouraged.

DEGREE REQUIREMENTS

DISTRIBUTION REQUIREMENTS

To achieve the necessary breadth in training, students in all programs take courses that cover a range of scientific disciplines and environmental media. Five courses must be taken that satisfy the following distribution requirements. No course can satisfy more than one requirement.

At least one course must be taken from three of the following four discipline groups:

Applied Mathematics	**ESE500; ESE504; ESE506; ESE508**
Chemistry	**ESE510; ESE511; ESE514; ESE516**
Fluid Dynamics	**ESE520; ESE530; ESE537; ESE539**
Biology	**ESE550; ESE554**

And, at least one course must be taken from each of the following environmental media groups:

Surface Waters	**ESE520; ESE530; ESE537; ESE539**
Ground Water	**ESE540; ESE541; ESE542; ESE543**

Global positioning system (GPS) technology is an important component of field-investigation acitivities in the department's curriculum.

All full-time students are required to take Environmental Science Seminar (ESE599) during the Fall, Winter, and Spring quarters. However, this course does not count toward degree credit requirements.

For all ESE educational programs, up to 8 credits may be granted for courses taken in other OHSU departments. Up to 12 quarter credits may be transferable from other accredited institutions for graduate courses comparable in content and level to courses offered in the department. The Student Program Committee (SPC) decides on the appropriateness of internship and transfer credits.

Transfer credits do not reduce the annual tuition, but may allow for greater flexibility in scheduling.

PH.D. IN ENVIRONMENTAL SCIENCE AND ENGINEERING

Students may complete the Ph.D. program in Environmental Science and Engineering (ESE) or Environmental Information Technology (EIT). The EIT program is a track within the ESE Department. Students who complete the EIT program receive their degree in Environmental Science and Engineering with a concentration in EIT.

Ph.D. students must complete 5 distribution courses as outlined above. Students must also complete additional courses for a total of at least 52 credit hours of course work, selected with the approval of their SPC.

Ph.D. candidates must also pass a two-part comprehensive exam. The first part is a written examination covering four subject areas selected by the department. The second part is the preparation and oral defense of a proposal that defines the student's Ph.D. dissertation research. A written Ph.D. dissertation with an oral defense is also required.

M.S. IN ENVIRONMENTAL SCIENCE AND ENGINEERING

M.S. THESIS OPTIONS

Students may pursue M.S. thesis options in Environmental Science and Engineering (ESE) or, beginning Fall 2002, Environmental Information Technology (EIT). The EIT program is a track within the ESE Department. Students who complete the EIT program receive their degree in Environmental Science and Engineering with a concentration in EIT.

Students pursuing the M.S. thesis option must complete at least 45 credits. These credits include the distribution requirements outlined above, additional courses selected with the approval of the SPC, and research credits. Master's thesis research (ESE 700) is usually no more than 9 credits. Comprehensive examinations are not required of M.S. thesis students. However, a written M.S. dissertation with an oral defense is required.

M.S. NON-THESIS OPTIONS

Students may pursue the M.S. non-thesis options in Environmental Science and Engineering (ESE), Ecosystem Management and Restoration (EMR) or, beginning Fall 2002, Environmental Information Technology (EIT). The EMR and EIT programs are tracks within the ESE Department. Students who complete the EMR or EIT programs receive their degree in Environmental Science and Engineering with a concentration in EMR or EIT.

For the non-thesis M.S. degree, 5 distribution courses must be taken as outlined above. Students must complete additional courses for a total of at least 45 credit hours. Up to 8 credits may be granted for approved participation in non-thesis research or approved work as an intern with a local company or government agency. No comprehensive examinations are required for the non-thesis M.S. options.

DEGREE PROGRAMS

ENVIRONMENTAL SCIENCE AND ENGINEERING (ESE) (TRADITIONAL PROGRAM)

The department offers Ph.D., M.S. thesis, and M.S. non-thesis options in Environmental Science and Engineering (ESE). The ESE program is known for its research and education programs that balance practical applications with fundamental investigations of the physical, chemical, and biological processes underlying environmental phenomena. The curriculum is highly interdisciplinary and is built on a solid foundation of fundamental science and engineering. For more information, please see http://www.ese.ogi.edu/curriculum.html.

ECOSYSTEM MANAGEMENT AND RESTORATION (EMR)

The Ecosystem Management and Restoration (EMR) program is a 12-month, non-thesis M.S. track offered within the Department of Environmental Science and Engineering. The objective of the EMR program is to integrate rigorous environmental principles, field and laboratory applications, modeling, project management, and policy/regulation into a cohesive curriculum. The program emphasis is on timely issues, including nonpoint source pollution, water quality, and ecological and human risk assessments. For more information, please see http://www.ese.ogi.edu/EMR/. Requirements for the EMR program are the same as for the non-thesis M.S. option described above, except that students must include ESE570 and ESE589 in their elective course work.

ENVIRONMENTAL INFORMATION TECHNOLOGY (EIT)

The Environmental Information Technology (EIT) program is the newest program offered within the Department of Environmental Science and Engineering. The Ph.D. option in EIT began Fall 2001, and the M.S. thesis and non-thesis options in EIT will begin Fall 2002. The EIT program combines the expertise and coursework found in ESE and in the Computer Science and Engineering (CSE) and Electrical and Computer Engineering (ECE) Departments at the OGI School of Science and Engineering. The goal of the EIT program is to combine a deep understanding of environmental processes with mastery of sensing, modeling, and information technology. Requirements for the EIT program are the same as the thesis and non-thesis options described above, except that students in the EIT program complete approximately 20% of their coursework in the CSE and ECE Departments. The EIT curriculum includes fundamental courses, science courses, technology courses, elective courses, and capstone integrative courses. Elective courses may include classes offered through OHSU's Medical Informatics program. For more information on the EIT program and its curriculum, please see http://www.ese.ogi.edu/EIT/.

A NOTE ABOUT TUITION

Tuition for the full-time non-thesis M.S. program is $19,620 for the 2001-2002

academic year, which is typically spread equally over the first four quarters. Upon admission to the department, a $100 deposit is required with the return of a student's acceptance to reserve a place in the department. This deposit will be applied toward tuition and is non-refundable.

COURSE OFFERINGS

ESE500 Introduction to Discrete Methods
This course is an introduction to discrete methods for environmental fluid dynamics. Lectures cover the theory and application of the numerical solution of boundary-value and mixed initial-boundary value problems. Emphasis is on finite differences, finite elements and finite volumes. Prerequisites: Calculus.
new for 2002/2003 4 credits

ESE504 Uncertainty Analysis
A survey of basic probability concepts followed by introductions to several statistical advanced techniques that play an important role in environmental data analysis. Topics may include distribution functions, propagation of error, hypothesis testing, analysis of variance, experimental design, sampling theory, regression analysis, time-series analysis, and spatial statistics techniques. The course provides a balance of theory and application using environmental data sets.
not offered 2001/2002 4 credits

ESE506 Environmental Systems Analysis
Introduction to techniques of systems analysis applied to environmental quality management. Emphasis is placed on development and application of mathematical models with computer simulation and optimization. Analysis is efficient computational algorithms and search techniques. Linear and separable programming applied to evaluate management alternatives. Applications to air, water, solid, and hazardous waste management. Prerequisites: Computer programming and calculus.
not offered 2001/2002 4 credits

ESE508 Computational Fluid Dynamics
This course describes advanced topics in computational fluid dynamics, including specialized discrete methods (e.g., for advection-dominated problems), formal analysis of stability and accuracy, and selected simulations of complex environmental and biological systems. Prerequisites: Advanced calculus and ESE 500.
new for 2003/2004 4 credits

ESE510 Aquatic Chemistry
General acid/base concepts (mono- and polyprotic systems); activity corrections; numerical calculations; titration concepts as applied to natural systems; buffer intensity; dissolved CO2 chemistry; pH, acidity, and alkalinity in open CO2 systems; minerals and their role in controlling natural water chemistry; solubility characteristics of oxide and hydroxides; redox chemistry in natural systems; pe-pH diagram. 4 credits

ESE514 Distribution and Fate of Organic Pollutants
Discussion of the physico-chemical processes that control the behavior and fate of organic chemicals in the environment. Introduction considers all environmental compartments, water, soil, and air, and partitioning between those phases. Recommended prerequisite: ESE 510. 4 credits

ESE516 Chemical Degradation and Remediation
A thorough introduction to the transformation reactions that contribute to the fate of organic substances in the environment. The course covers pathways, mechanisms and kinetics of hydrolysis, oxidation, reduction, elimination, conjugation, etc. Treatment is balanced to reflect the importance of these processes in all types of environmental waters ranging from engineered systems to groundwater, surface water, rain, and fog. Recommended preparation: ESE 510 and ESE 514. 4 credits

ESE519 Air Pollution: Origins, Chemistry, and Control
This course will focus on tropospheric air pollution with particular emphasis on the urban and regional scales. It will discuss the following items: basic structure of the atmosphere and relevant meteorological considerations; sources of tropospheric air pollutants; atmospheric photochemistry; the ozone, oxide of nitrogen, and hydrocarbon chemical cycles; chemistry of toxic organic compounds in the atmosphere; gas and aqueous phase chemistry of sulfur dioxide; size distributions, lifetimes, origins and formation mechanisms of aerosols; and control of atmospheric emissions. 3 credits

ESE520 Introduction to Environmental Observation and Forecasting Systems
This course introduces environmental observation and forecasting systems and their application towards the enhanced understanding and management of natural resources. Emphasis is on estuaries and coasts. Students are exposed to a novel, cross-disciplinary culture for understanding and interacting with environmental systems. This culture relies heavily on "real-time" generation of modeling and observational data, which are integrated and distributed through information networks designed to bring the right environmental information at the right time to the right user. Prerequisite: Instructor permission. 4 credits

ESE522 Introduction to Spatial Sciences
Students will learn theoretical and practical applications of geospatial sciences within the context of Environmental Sciences and Engineering. Theory of satellite-based Geographic Positioning Systems (GPS) will be studied while performing practical, hands-on laboratory experiments using the latest in GPS equipment. Classroom discussions will then focus on relating location on the Earth's surface to a common mapping grid. Non-projected and projected maps, ellipsoids and spheroids, and geoids will be discussed. Spatial relationships, or analysis, of continuous and categorical data will be addressed through the application of standard statistics and probability. ARCVIEW, a popular Geographic Information System (GIS) software tool will be stressed. 4 credits

ESE523 Introduction to Remote Sensing of the Environment
This course will explore the acquisition, analysis and visualization of remotely sensed data. The physics behind the collection of remotely sensed data will be introduced as will both airborne-platform and satellite-platform sensors. Data from the Light Detection and Ranging (LIDAR) sensor as it pertains to Airborne Topographic Mapping will be used. Single band, multi-spectral and hyper-spectral data sets will be used to discuss such concepts as image statistics, radiometric and geometric corrections, spatial filtering and special transformations like the Normalized Difference Vegetation Index. Supervised and Unsupervised classification schemes will be discussed as will change detection. The course pedagogy is designed to address the needs of the advanced level Environmental Science and Engineering graduate student. While there is no prerequisite for this course, many topics from ESE522, Introduction to Spatial Science are incorporated into this course. It is therefore recommended that students unfamiliar with classification methods and the fundamental concepts of Geographic Information Systems complete ESE522 or equivalent. 4 credits

ESE530 Transport Processes
An introductory course in the physics of transport processes in the natural environment. The course examines heat, mass, and momentum transport via conservation principles and the Reynolds Transport Theorem, but strongly emphasizes the environmental applications of these processes. Example studies include atmospheric and oceanic circulation, flow and dispersion in rivers, and heat budgets for lakes and reservoirs. 4 credits

ESE532 Modeling Coastal Circulation and Transport I
This course introduces the students to the process of modeling coastal circulation and transport. Topics include governing equations, review of state-of-the-art models, in-depth description of selected models, and solution of benchmark problems. Prerequisites: ESE500 or ESE508, and ESE530.
new for 2001/2002 4 credits

ESE533 Modeling Coastal Circulation and Transport II
This course provides an advanced treatment of coastal circulation and transport modeling. Students are introduced to the detailed modeling of complex estuarine, plume, and continental shelf processes, through a combination of lectures and labs focused on specific sites and processes. Prerequisites: ESE532.
new for 2002/2003 4 credits

ESE534 Modeling Coastal Flow and Transport
Description of state-of-the-art modeling principles and techniques for simulation of flow and of conservative and nonconservative transport in coasts and estuaries. Students have the opportunity to model an actual coastal system through a hands-on term project that includes a realistic sequence of modeling steps: data analysis, grid generation, flow modeling, modeling of conservative transport, and modeling of nonconservative transport. Prerequisites: ESE 500, ESE 532.
not offered 2001/2002 4 credits

ESE537 Methods in Oceanography
This course covers the fundamentals of processing estuarine and coastal oceanographic data, including time series (e.g., surface elevation, currents, and winds) and data obtained from vessels (e.g., profile and bathymetric data).
not offered 2001/2002 2 credits

ESE539 Methods in Estuarine Oceanography: Field Observation
This course covers the fundamentals of estuarine and coastal oceanographic data collection using vessels and remotely moored equipment. Topics include vessel logistics and sampling, navigation systems, interfacing of instruments with personal computers, types of moorings and their deployment and recovery, and telemetry.
not offered 2001/2002 2 credits

ESE540 Subsurface Hydrology
Hydrologic cycle infiltration theory; principles of unsaturated and saturated flow in the subsurface; well hydraulics; analytical models of drawdown, capture zones and velocity plots; porous media characterization methods and tools. 4 credits

ESE541 Groundwater Modeling
Applied groundwater modeling using finite difference and finite element methods. Introduction to numerical methods for solving the partial differential equations for saturated and unsaturated subsurface flow. Model execution and calibration. Prerequisite: ESE 540.
not offered 2001/2002 4 credits

ESE542 Contaminant Hydrology
Processes controlling subsurface contaminant movement in porous and fractured media, including groundwater flow, dispersion, diffusion, sorption, and degradation. Parameter estimation, mathematical and laboratory modeling of aquifers is also covered. 4 credits

ESE543 Modeling in Contaminant Hydrogeology
This course is designed to be taken concurrently with ESE 542. It emphasizes the hands-on use of common mathematical models for groundwater flow and transport (e.g., MODFLOW, RANDOMWALK, SUMATRA) to examine real groundwater contamination problems. Prerequisite: ESE 542.
not offered 2001/2002 4 credits

ESE550 Environmental Microbiology
Introduction to environmental microbiology, with emphasis on the role of microbes in the environment and in remediation processes. Microbes and their interaction and activities in soil and aquatic environments will be discussed, as well as elemental cycling as influenced by microbes. Microbially-mediated transformation of organic pollutants, transformation kinetics, and remediation technologies will be considered. 4 credits
offered in combination with ESE554 in 2001/2002

ESE554 Biodegradation and Bioremediation
A process-oriented survey of microbially mediated transformations of organic pollutants. Transformations occurring in the natural environment as well as in remediation technologies are considered. Emphasis is on the pollutant properties, micro-biological factors, and medium properties that determine the pathways and kinetics of biodegradation. Recommended preparation: ESE 550. 4 credits
offered in combination with ESE 550 in 2001/2002

ESE560 Environmental Soil Science
Soil physics, chemistry, and microbiology; soil development, soil description and mapping, soils and land use, agricultural and urban forestry; soil-plant relationships for environmental restoration; soil process modeling. Prerequisites: ESE 510 and ESE 550.
not offered 2001/2002 4 credits

ESE562 Ecosystem Ecology
Principles of ecology and of ecosystem process, description, and measurement, with emphasis on ecosystem health assessment. Simulation modeling of ecosystem processes; transport and transformation.
not offered 2001/2002 4 credits

ESE570 Principles of Toxicology and Risk Assessment
This course applies toxicological principles to both human and ecological risk assessments. The principles and methodologies for risk assessments are presented within a regulatory context. Topics include hazard identification, exposure assessment, LD_{50}, dose-response relationships, deterministic and probabilistic risk assessments, responses of various receptors to different contaminants, and environmental management decisions. 3 credits

ESE58X Special Topics
Typically involves a scholarly and critical review of an advanced scientific topic by one or more students together with one or more faculty members. Requirements of the student typically include a written review paper and/or a seminar to be given as part of ESE 599. Selection of this course for credit and the topic to be investigated must be approved by the Student's Program Committee.
Variable and repetitive credit

ESE580 Ecosystem Management and Restoration
This course will provide an overview of ecosystem management and restoration at the local and regional scale. It will follow the hydrologic cycle from upland watersheds through streams, rivers and estuaries to the ocean and will track important system parameters such as water flow and temperature. 4 credits

ESE586 Environmental Law and Regulation
A survey of environmental law and regulation concepts essential to practicing scientists and engineers. Topics covered include the theory and practice of environmental regulation, environmental litigation, and legislation including Superfund (CERCLA), the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), the Clean Air Act, and the Toxic Substances Control Act (TSCA). 3 credits

ESE587 Clean Air Act Laws and Regulations
A thorough introduction to the Clean Air Act in its federal and state permutations, as well as the detailed regulations guiding the Act's implementation. The course focuses on the practical aspects of statutory and regulatory interpretation, application to specific facilities, and negotiation of Clean Air Act issues with EPA and the states
not offered 2001/2002 2 credits

ESE589 Special Topics: Advanced Topics in Field Sampling and Analysis
An intensive capstone course that integrates field processes with theory from previous lecture material. Approximately 1 week is spent at site locations where students critically examine current techniques for collecting surface water, groundwater, and soil samples to characterize chemical, biological, and physical properties. Laboratory methods for analyzing organic and inorganic chemicals are included. Students work in teams on projects to collect and evaluate data, write reports, and make recommendations for future management of the sites. Anticipate overnight travel. Variable credit

ESE598 Organization of Environmental Science and Engineering Seminar
This course is for the Ph.D. student responsible for managing the weekly Environmental Science and Engineering Seminar series (ESE599). Students enroll for this course with their advisor's approval.
1 credit

ESE599 Environmental Science Seminar
Weekly seminars by invited guests on all aspects of environmental science, and by ESE faculty and students on their research. Visitors are welcome. Schedules are available on the World Wide Web at http://www.ese.ogi.edu/seminars/, or by request at info@ese.ogi.edu. 1 credit

ESE600 Research
Research toward the dissertation for the Ph.D. degree before completing the comprehensive examinations. Variable and repetitive credit

ESE610 Non-Thesis Research
Supervised research as a component of the non-thesis M.S. degree. The plan of research and final deliverables must be approved by the research advisor and the Student Program Committee. Deliverables include a written report and/or seminar given as part of ESE 599. A maximum of 8 credits from ESE 610 and ESE 620 can be applied to a degree. Variable and repetitive credit

ESE620 Professional Internship
This course provides the student with an opportunity to earn credit for relevant work experience in industry. Students gain valuable experience that allows them to both apply the knowledge gained in the classroom and prepare for their future careers.

Enrollment requires a faculty advisor and is limited by the number of internship opportunities available. International students need to submit appropriate paperwork for the Immigration and Naturalization Service. A maximum of 8 credits from ESE 610 and ESE 620 can be applied to a degree.
Variable and repetitive credit

ESE700 M.S. Thesis Research
Research toward the M.S. thesis degree.
Variable and repetitive credit

ESE800 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree after completing the comprehensive examinations. Variable and repetitive credit

RESEARCH PROGRAMS

Contaminant Diffusion in Clay
Clay liners are often used in waste disposal facilities to prevent the advective transport of contaminants into the surrounding groundwater. Even when advective transport is small, however, contaminant transport through liners may be significant as the result of molecular diffusion. This phenomenon has been studied in the laboratory and at actual waste disposal facilities to evaluate its roles in mass transport and groundwater contamination. *Johnson*

Processes Controlling the Subsurface Transport of Dense Chlorinated Solvents
The uncontrolled release of chlorinated solvents is a common cause of serious groundwater contamination in many parts of the world. It is in this context that it is important to understand the physical and chemical principles that govern the movement of these dense nonaqueous phase liquids (DNAPLs). Experiments under way at OGI and in conjunction with the University of Waterloo are examining the behavior and remediation of chlorinated solvents in the saturated and unsaturated zones. *Johnson*

Simulation of Subsurface Processes Using Very Large Scale Experimental Aquifers
Many important chemical, physical, and biological processes are difficult to study in the laboratory because of problems of scaling. Many of these processes are also difficult to characterize in the field, because of the complex and uncontrolled nature of environmental systems. For these reasons, OGI has established the Large Experimental Aquifer Program (OGI/LEAP). At present, the facility consists of five large aquifers used to examine the movements of organic solvents and petroleum compounds in the unsaturated and saturated porous media. Future LEAP aquifers will examine inorganic geochemistry and the interactions between chemical, biological, and physical processes in contaminated aquifers. *Johnson and other faculty*

Gas-Phase Transport in Unsaturated Porous Media
Gas-phase transport is important in controlling many subsurface processes including respiration, pesticide behavior, and contaminant volatilization and movement. Laboratory experiments have been conducted to determine diffusion rates of a variety of organic compounds in porous media and the kinetics of adsorption and desorption for a variety of soil types and a range of water contents. *Johnson*

Multi-Phase Monitoring of Gasoline Movement Using a Very Large Physical Model (OGI/LEAP)
Leaks from underground storage tanks (UST) represent a major ongoing source of groundwater contamination. The rapid detection of leaks is, therefore, a major goal of UST legislation. The OGI/LEAP facility is used to study the movement of gasoline components in the vapor, aqueous, and pure-product phases. This work will help establish which of a variety of leak-detection technologies is best suited to detect leaks under a range of environmental conditions. *Johnson*

Remediation of Halocarbon-Contaminated Groundwater
There is enormous demand for improved ways to clean up aquifers that have been contaminated with halogenated hydrocarbon solvents like carbon tetrachloride and TCE. Recent field-scale tests have shown that technologies based on dechlorination with granular iron may have substantial value. The goal of our research in this area is to provide a sound scientific basis for designing and operating such technologies by determining the mechanisms of dechlorination by iron and the geochemical and microbiological processes that affect the performance of this technique in the field. For more information on this work, see http://cgr.ese.ogi.edu/iron. *Tratnyek*

Reduction Reactions of Organic Pollutants in Anaerobic Environments
Some organic pollutants undergo rapid reduction in anaerobic sediments, soils, and groundwaters. Despite the potential importance of this process, little is known about the natural reducing agents that are responsible for these reactions. In this project, assays are being developed that will identify and quantify environmental reducing agents in situ. These assays will be used in kinetic studies of important pollutant reduction reactions. *Tratnyek*

Oxidation Reactions of Organic Pollutants
Some organic pollutants undergo rapid oxidation in natural waters, when catalyzed by sunlight, and in technological systems, when chemical oxidants are added to effect remediation. These reactions are usually mediated by "activated oxygen species" such as hydroxyl radical. We are studying the kinetics, mechanisms, and products of these reactions with a wide variety of contaminants. The aim of this work is help assess the suitability of various advanced oxidation technologies (AOTs) for remediation of groundwater, as well as to better understand the fate of contaminants in natural waters that are exposed to sunlight. *Tratnyek*

Correlation Analysis of Contaminant Reactivity
Quantitative Structure-Activity Relationships (QSARs) are of enormous importance in environmental chemistry and toxicology because of their predictive power, but they also reveal a great deal about reaction mechanisms and the nature of substituent effects. We are involved in the development of QSARs for a wide range of redox reactions involving organic contaminants. This work involves the use of computational chemistry methods as well as advanced statistical techniques in exploratory data analysis. *Tratnyek*

Fate and Effects of Fuel Oxygenates
The recent realization that oxygenated fuel additives such as MTBE are becoming widely distributed groundwater contaminants has created a sudden and pressing demand for data on the processes that control their environmental fate. On-going work in this area includes modeling of MTBE infiltration to the groundwater, laboratory studies of MTBE biodegradation, and field studies of several contaminated sites for MTBE and its possible breakdown products. For more information on this work, see http://cgr.ese.ogi.edu/mtbe/. *Pankow, Tratnyek, Johnson*

Hydrocarbon Biodegradation in Soil
Petroleum hydrocarbon contamination is prevalent in soils and groundwater. Efforts to clean up this extensive petroleum contamination have prompted research into in-situ bioremediation. Depending on site characteristics, in-situ hydrocarbon biodegradation is a cost effective and environmentally sound remediation alternative or partner to pump-and-treat and vacuum extraction technologies. We have studied the processes by which the biodegradation rates of organic compounds can be optimized. *Toccalino*

Human-Health Assessment of Water Quality
A national effort is underway with the U.S. Geological Survey's National Water-Quality Assessment (NAWQA) program, in collaboration with the U.S. Environmental Protection Agency (USEPA) and State agencies to conduct a pilot effort to develop, test, and refine concepts to more effectively communicate water-quality information in a human-health context. The study includes determining how to effectively communicate the data from this study in a human-health context to Congress, the media, the public, etc. *Toccalino*

Distribution of Organic Compounds Between the Gas and Urban Aerosol Particulate Phases
The behavior of organic compounds in the atmosphere depends in large part on the extent to which they partition from the gas phase to aerosol particulate matter. Processes that are affected by this partitioning process include precipitation scavenging of gases and particles as well as dry deposition of gases and particles. Fundamental gas/solid sorption theory is being used to investigate important aspects of atmospheric gas/particle partitioning. The study involves the investigation of basic partitioning behavior of a wide range of representative atmospheric compounds (including alkanes and polycyclic aromatic hydrocarbons) on a variety of representative model particulate substrates, including elemental carbon, organic carbon, silica, and clay. *Pankow*

Thermodynamics of Inorganic Solid Solutions
The manner in which inorganic solid solutions behave is one of the last major research frontiers in ambient temperature aqueous geochemistry. Coprecipitation of metal ions is well known in nature, e.g., Sr^{2+} can form a solid solution in calcium carbonate ($CaCO_3(s)$). Unfortunately, little is known about the thermodynamics of such solid solutions. That is, little is known about how the activity coefficients of metal ions vary as a function of composition in solid solutions of various types. The values of the activity coefficients are of interest because they control the extent to which the constituents in the solid solutions will be soluble in water, e.g., the extent to which a toxic metal ion like Cd^{2+} that is present in calcium carbonate will

be soluble in water. In this work, activity coefficient values for a variety of environmentally important divalent metal ions are being sought as a function of composition in calcium carbonate. *Pankow*

Global Distributions and Mass Balances of Halocarbons, Nitrous Oxide, and Other Trace Gases

Gases such as CCl_3F (F-11), CCl_2F_2 (F-12) $CHClF_2$ (F-22), CF_4 (F-14), $C_2Cl_3F_2$ (F-113), CH_3CCl_3, CH_3Cl and N_2O are being added to the atmosphere by various industrial processes and the use of high-technology products by the public. Such chlorine-containing compounds are believed to threaten the earth's natural ozone layer high in the atmosphere (stratosphere). This research will systematically obtain a long-time series of concentration measurements by a flask sampling system. The results are then interpreted with global mass balance models and sophisticated statistical techniques to quantify the sources and lifetimes of these gases in the environment. Such data are now obtained from sites all over the world extending from the Arctic Circle to the South Pole. *Rasmussen*

Studies of Past Atmospheres

Atmospheric gases such as N_2O, CO_2, CO, CH_3Cl, carbonyl sulfide (OCS), and CH_4 are primarily produced by natural processes, but over the past century human activities have been adding growing amounts to their natural abundance. This process can upset the cycles of these gases and lead to possibly adverse environmental effects such as the warming of the earth's surface (N_2O, CO_2, CH_4). When both natural and anthropogenic processes contribute to the current atmospheric abundance of a trace gas, it is of interest to determine the amount which existed before human activities had any effect. Perhaps the only realistic method to determine the composition of the ancient atmosphere is to analyze the air in bubbles buried deep in polar ice. The depth of the ice indicates the age of the air in the bubbles. By going far enough back in time, the relationship between past atmospheric composition and climate might be found. The novel and simple method of studying the old atmosphere of the earth is beset by many problems that complicate the relationship between the gases in the bubbles and the composition of the old atmosphere. Theoretical and experimental research for resolving these problems as well as the measurement of trace gases are the major goals of this project. *Rasmussen*

Ocean-Air Exchange of Gases

Some atmospheric gases are greatly influenced by the earth's oceans. For instance, a large amount of the atmospheric methyl chloride (CH_3Cl) and methyl iodide (CH_3I) are produced in the oceans, possibly by biogenic processes. It has also been shown recently that carbonyl sulfide (OCS) is produced in the oceans and subsequently emitted to the atmosphere. On the other hand, man-made gases such as CCl_3F (F-11) can dissolve in the oceans and thus be removed from the atmosphere. This research project is devoted to determining the solubility of such gases in water and to modeling the flux of gases into or out of the oceans. The results obtained are essential ingredients in determining the sources and fates of atmospheric trace gases and in estimating the effects of human activities on the future warming of the earth or depletion of the ozone layer. *Rasmussen*

Studies of Atmospheric Methane

Considerable evidence has been accumulated showing that methane (CH_4) is increasing in the atmosphere, most likely as an indirect result of growing human population. In the future, such an increase of CH_4 can lead to a global warming by enhancing the earth's natural greenhouse effect and create more ozone and carbon monoxide in the atmosphere. However, it might also prevent some of the destruction of the stratospheric ozone layer by the man-made fluorocarbons 11 and 12. In this project, experimental and theoretical research is focused on statistical trend analyses for the global increase of CH_4, its seasonal variation, sources and sinks, models of its effect on the CO, O_3, and OH cycles and its role in the future of the environment. *Rasmussen*

Development of Experimental Methods for Tracel Gas Measurements

At present, some 50 atmospheric gases can be measured at the Trace Gas Laboratory. Still, new methods are needed to improve the accuracy and precision of measurements and to satisfy the stringent demands of ultra-clean background air sampling. New methods are also being developed for automated real-time analysis of many trace gases. Research programs include development of gas chromatographic and mass spectrometric methods for the analysis of trace gases. At present, GC/MS systems in the laboratory are being used to routinely measure C2-C12 nonmethane hydrocarbons at tens of parts per trillion levels. Techniques for collecting and storing air and water samples also are being developed. *Rasmussen*

Biogenic Sources of Atmospheric Gases

Living organisms produce and consume a variety of gases and may therefore form an integral part of the global cycle of a trace gas. Selected plants and animals, living in the sea or on land, are being studied to determine their role in the cycles of CH_4, N_2O, CH_3Cl, CH_3I, isoprene and other hydrocarbons. *Rasmussen*

The Global Cycle of Carbon Monoxide (CO)

Based on 15 years of global sampling and the application of modern trend analysis techniques, our data have shown that CO increased in the atmosphere until around 1987 and has since declined. These changes in CO have major implications for atmospheric chemistry and the role of biomass burning in causing global increases of trace gases. Present research includes modeling of the global budgets, seasonal cycles, and potential environmental effects. *Rasmussen*

Methane Emissions from Rice Fields

Methane concentrations have nearly tripled compared to the natural atmosphere of 300 years ago (based on ice core analyses). The increase of rice agriculture to sustain an increasing population may be a major contributor to the increase of methane during the last century. This research program is designed to determine the role of rice agriculture in the global methane cycle. Field experiments are being conducted in China, Indonesia and the U.S. Laboratory experiments and theoretical research are being done at the Global Change Research Center (Portland State University) in a comprehensive research program. This work includes modeling the production, oxidation and transport of methane in the rice paddy ecosystem and measuring the controlling parameters. *Rasmussen*

Land-Margin Ecosystem Research in the Columbia River Estuary

The Columbia River Estuary Land-Margin Ecosystem Research (LMER) Program funded by the National Science Foundation focuses on the estuarine turbidity maximum, which is the heart of the estuarine ecosystem. Long-term funding allows analysis of seasonal and interannual variability in estuarine processes and evaluation of the impacts of flow regulation on the system. The extensive data sets collected by this program provide a basis for studies of estuarine circulation, hydraulic control processes at the estuary mouth, nonstationary tidal processes, suspended sediment transport, turbulence and mixing, and biological processes. *Jay, Baptista, and external collaborators*

Internal Circulation in Tidal Channels and Straits

This project, funded by the Office of Naval Research, seeks to use wavelet data analysis techniques and novel modeling strategies to improve our conceptual understanding of estuarine circulation and scalar transport. Continuous wavelet transforms allow resolution of time variation in tidal processes in each frequency band. Dr. Jay's group is using this technique to understand estuarine internal circulation and shelf internal tides in buoyant plumes. Modeling efforts use symbolic mathematics software to provide a balance between the intuitive understanding and compact nature of analytical solutions and the superior flexibility and accuracy of full-numerical solutions. *Jay*

CORMIX Graphic User Interface and GIS Database Integration

This project develops computer information systems for the CORMIX mixing zone water quality model. A fully interactive Windows-based application is proposed, designed to give CORMIX additional functionality, flexibility, and power using object-oriented rule-base technology for forms-based interactive data entry, flow classification, simulation logic description, and GIS database integration. *Doneker*

D-CORMIX Decision Support System

This project involves development, validation, and scientific review of the D-CORMIX decision support system. D-CORMIX is a physically-based simulation model linked to a knowledge-based classification system for predicting of water quality and sediment deposition impacts resulting from dredging operations. The purpose of the project is to assist water quality managers in performing waste load allocations for continuous dredge discharges. The methodologies developed in this project are also necessary for long term pollutant fate and trans-

port studies by providing information on initial boundary conditions. This project also develops validation studies and documentation for USEPA Science Advisory Board (SAB) review of D-CORMIX. *Doneker*

CORMIX Documentation Development, Workshop Instruction, and Technical Support

OGI has a 3-year cooperative agreement to maintain, update and distribute the CORMIX user manual, conduct technical training workshops on mixing zone models, and to provide technical assistance to CORMIX model users. The CORMIX water quality model has approximately 1000 users worldwide, feedback from them through technical support and training workshops directly supports current model development activities. *Doneker*

CORIE: A PILOT ESTUARINE NOWCAST-FORECAST SYSTEM (http://www.ccalmr.ogi.edu/CORIE)

Since 1996, we have been developing CORIE, an observation and forecasting system for the Columbia River estuary. The motivation is two fold. First, the Columbia River and its near-shore plume are a dominant oceanographic feature of the northeastern Pacific Ocean and the focus of controversial ecosystem management issues. CORIE represents a novel, promising, and much needed infrastructure for physical and ecological research in this system. Second, we envision that multipurpose nowcast-forecast systems will become central to the management of coasts and estuaries worldwide. The Columbia River estuary is a challenging natural laboratory to test concepts and tools, and CORIE is a pilot system developed to anchor our observation and forecasting research.

CORIE has three main components. The first component is a real-time data acquisition system, including an array of 12 permanent stations, a variable number of temporary stations, and one mobile station. We currently monitor, in various combinations at each station: temperature, conductivity, water pressure, water velocities, acoustic backscatter, wind speed and direction, air temperature, and atmospheric pressure. "Real-time" is defined by latencies of typically a few seconds, and is achieved through a telemetry network based on spread-spectrum radio technology. The second component of CORIE is a suite of circulation and transport models currently extending from the Bonneville dam to the coastal vicinity of the CR estuary, and including parts of the Willamette and Cowlitz rivers. Hindcast model runs are being used to benchmark systematically all models, individually and in their contrasting features. The third component of CORIE is a data management and distribution system, with real-time and archival access through the web to script-generated graphical displays and actual data. *Baptista*

COUPLED PHYSICAL AND BIOGEOCHEMICAL PROCESSES AT SEDIMENT-WATER INTERFACES

The overall goal of this project is to advance our quantitative understanding of the fate and bioavailability of chemical elements in estuaries by coupling meso-scale experimentation with diagnostic numerical modeling and field observations. In a preparatory phase, we designed, constructed and instrumented a meso-scale biogechemical rotating annular flume (RALF). We are beginning the process-based research phase on the project, in which we will focus on elements important for both water quality and ecosystem dynamics, namely the cycling of Fe, Mn, and other divalent metals at sediment-water interfaces (SWI). We are especially interested in quantifying the effect of episodic sediment disruptions on the speciation and phase (dissolved, particulate, and colloidal) of these metals. We are also interested in the effect of shear upon particle desegregation, differential settling, sorption, precipitation, and dissolution. We will place the chemical reactions in a controlled, yet realistic, shear-driven physical environment by conducting primary experiments in the controlled environment of RALF. For more information on this work, see http:www.ccalmr.ogi.edu/ralf/. *Baptista, Tratnyek, external collaborators*

OCEAN SURVIVAL OF SALMONIDS

We are initiating an integrated observational/ modeling study of the physical variability of the Columbia River plume and estuary, to provide oceanographic context for research on the role of the coastal ocean on the life cycle of salmon. *Baptista, Jay, external collaborators*

CASCADIA SUBDUCTION ZONE TSUNAMIS

Large tsunamis are believed to be locally generated in the Cascadia Subduction Zone (CSZ) every 200 to 600 years, based on geological records. The last large tsunami dates back about 300 years, raising concerns about the protection of coastal communities in Oregon, Washington, California, and British Columbia. The coastal impact of potential CSZ tsunamis is being investigated through numerical modeling. The need to use geological evidence on paleotsunamis as the sole, loose reference for model validation makes this an unusually interesting and challenging problem. The Oregon Department of Geology and Mineral Industry (DOGAMI) has incorporated our joint research results into the development of tsunami inundation maps for the Oregon and Washington coasts. *Baptista, external collaborators*

RESEARCH CENTERS

CENTER FOR GROUNDWATER RESEARCH

The principal mission of the Center for Groundwater Research (CGR) is to conduct state-of-the-art research in areas relating to the transport and fate of contaminants in the subsurface. This is accomplished through a combination of research grants and contracts, support from Center corporate sponsors, and through collaboration with other universities, industries, and government agencies.

The Center coordinates a range of projects relating to the transport and fate of contaminants in soils and groundwater. The scope of the Center includes, among other things, the development of: 1) new sampling and site characterization techniques; 2) new analytical techniques; and 3) improved groundwater remediation methods.

The Center operates the Large Experimental Aquifer Program (LEAP) which contains the experimental cells outlined below. The LEAP facility provides staff with the capability to conduct both bench-scale experiments and pilot-scale demonstrations. Current projects include transport through fractured clay, air sparging of source petroleum zones containing MTBE, and a pilot scale demonstration of zeolite as an in-situ permeable barrier material.

Students involved in LEAP research graduate with a rare combination of experience in full-scale remediation engineering and a process-level understanding of contaminant hydrology and chemistry.

Additional information about CGR may be obtained from:

DR. RICHARD JOHNSON
phone: (503) 748-1193 **e-mail**: rjohnson@ese.ogi.edu
CGR Web site: cgr.ese.ogi.edu.

CGR FACULTY

Richard Johnson, Associate Professor
Paul Tratnyek, Associate Professor
James F. Pankow, Professor
Patricia L. Toccalino, Assistant Professor

LEAP EQUIPMENT

- **Five tanks: one 10 m x 10 m x 3 m, two 10 m x 10 m x 5 m, one 10 m x 2.5 m x 0.5 m, and one 8 m x 2.5 m x 0.5 m**
- **In situ instrumentation, including: automated temperature, pressure, and water level monitoring; multilevel samplers; down hole video camera; and automated vapor and product sensing equipment**
- **Remediation equipment, including soil vapor extraction and air sparging capabilities**
- **Automated on-site analytical equipment, including capillary GC-MS instrumentation**

CENTER FOR COASTAL AND LAND MARGIN RESEARCH (CCALMR)

The Center for Coastal and Land-Margin Research (CCALMR) is an interdisciplinary research center affiliated with the Department of Environmental Science and Engineering. CCALMR conducts research, graduate education and advanced technology development that directly address the need for better scientific understanding of coasts, land margins and estuaries. Improved knowledge of these complex systems is necessary to preserve and enhance their environmental integrity, maintain the economic viability of communities dependent on them and protect human populations from natural and man-made hazards.

Real-world natural resource management issues motivate CCALMR research and education activities. Insights drawn from the experience of science and engineering professionals in the public and private sectors influence the identification of emerging research challenges, the design of research projects, the development of supporting tools and applications and the transfer of knowledge and technology.

Additional information about CCALMR may be obtained from:

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CCALMR Web site: www.ccalmr.ogi.edu/

CCALMR FEATURED PROJECTS

- **Cascadia Subduction Zone tsunamis**
- **CORIE: a pilot estuarine nowcast-forecast system**
- **CORMIX: mixing zone decision support system**
- **Coupled physical and biogeochemical processes at sediment-water interfaces**
- **Internal circulation in tidal channels and straits**
- **Land-margin ecosystem research in the Columbia River estuary**
- **Ocean survival of salmonids**
- **Reduction reactions of organic pollutants in anaerobic environments**
- **Trace element distributions**
- **Watershed analysis**

CCALMR FACILITY

The Center is well equipped to conduct state-of-the-art scientific research. The following is a list of facilities and instruments available in addition to those available through the Department of Environmental Science and Engineering.

OCEANOGRAPHIC EQUIPMENT

- **300, 600 and 1200 kHz Acoustic doppler current profilers (RD)**
- **500 and 1500 kHz Acoustic doppler profilers (Sontek)**
- **Conductivity and temperature pairs (Seabird)**
- **Conductivity, temperature and pressure sensors (Coastal Leasing and Ocean Sensors)**
- **Echosounder and digitizer (Ross)**
- **Optical backscatter sensors (Downing Associates)**
- **Wind gauges (Coastal Leasing)**
- **High-density thermistor chains (CCALMR)**
- **Differential GPS (Trimble)**
- **Spread spectrum radio data modems (FreeWave)**

REAL-TIME DATA ACQUISITION NETWORK (CORIE)

The pilot nowcast-forecast system CORIE includes a real-time data acquisition network with twelve multi-sensor oceanographic stations in the Columbia River estuary. Field operations are conducted from the Marine Environmental Research and Training Station (MERTS). MERTS is a facility developed in partnership with and operated by the Clatsop Community College (CCC). CCC operates two training and research vessels: the 50-foot M/V Forerunner and the 21-foot R/V Tansy Point.

BIOGEOCHEMICAL ROTATING ANNULAR FLUME (RALF)

RALF, a 2-meter biogeochemical rotating annular flume, supports research on coupled physical and biogeochemical processes at sediment-water interfaces. Instrumentation providing real-time or pseudo real-time data include:

- **3-dimensional Acoustic Doppler Velocimeter (Sontek)**
- **DO (Orion) and pH/ISE (Orion)**
- **DLK-100 Potentiostat (AIS)**
- **Solid State Au/Hg amalgam microelectrodes**
- **Bipotentiostat equipped with rotating disk electrode (Pine)**

RESEARCH FACILITIES

The department is well equipped to carry on a vigorous research program Instruments and equipment available, in addition to those listed for the centers, include:

GENERAL AND ANALYTICAL EQUIPMENT

- **Carbon/nitrogen/sulfur analyzer**
- **Several high-performance liquid chromatographs with UV-absorbance, fluorescence, refraction index, and conductivity detectors.**
- **Ion chromatograph**
- **Graphite furnace atomic absorption spectrophotometer**
- **Access to FT-IR, fluorescence, diode array UV/VIS, scanning UV/VI Snear IR spectrophotometers**
- **Access to scanning electron microscopes**
- **Access to a complete Raman spectroscopy facility**
- **Purge and trap concentrator and thermal desorption apparatus**
- **Rain and air sampling equipment**
- **Groundwater and soil sampling equipment**
- **Groundwater monitoring equipment, including water table, ambient, and ground temperature measurement, and pressure transducers all integrated into a data logging system**
- **Equipment for supercritical fluid extraction and supercritical fluid chromatography**
- **Several rapid flow injection analysis systems**
- **Sediment samplers**
- **Two-dimensional polyacrylamidel gel densitometer**
- **Aerosol samplers**
- **Trace reduction-gas analyzer**
- **Liquid nitrogen freezer**

COMPUTER EQUIPMENT

- **Computer lab with numerous Pentium and Pentium Pro PCs running Windows NT**
- **SPARC workstations**
- **Network access via X-terminals and personal computers**
- **Numerous IBM compatible and Apple Macintosh computers with HP LaserJet printers, digitizing tablets, plotters and a film image recorder**

SUPPORT FACILITIES

- **Fully equipped machine shop**
- **Toxic chemicals handling laboratory**
- **Electronics support personnel**
- **Greenhouse facility and growth chambers**

ANTÓNIO M. BAPTISTA

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RESEARCH INTERESTS

Integrated understanding and prediction of hydrodynamic and environmental processes in estuaries and coasts. Development of associated concepts and technologies: environmental observation and forecasting systems, numerical methods and models, physically-based ecological indicators.

REPRESENTATIVE PUBLICATIONS

Baptista, A.M, "Environmental Observation and Forecasting Systems," Encyclopedia of Physical Science and Technology, 3rd Edition, Volume 5, Academic Press, in press.

Myers, E.P. and A.M. Baptista, "Inversion for Tides in the Eastern North Pacific Ocean", Advances in Water Resources, Vol. 24(5), lpp. 505-519, 2001.

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Oliveira A., A.B. Fortunato, and A.M. Baptista "Mass Balance in Eulerian-Lagrangian Transport Simulations in Estuaries," ASCE Journal of Hydraulic Engineering, 126(8):605-614, 2000.

Yang Z., A.M. Baptista, and J. Darland, "Numerical Modeling of Flow Characteristics in a Rotating Annular Flume," Dynamics of Atmospheres and Oceans, 31:271-294, 2000.

Baptista, A.M., M. Wilkin, P. Pearson, P. Turner, C. McCandlish, and P. Barrett, "Coastal And Estuarine Forecast Systems: A Multi-Purpose Infrastructure for the Columbia River," Earth System Monitor, 9(3), National Oceanic and Atmospheric Administration, Washington, D.C, 1999.

Oliveira A. and A.M. Baptista, "On the Role of Tracking on Eulerian-Lagrangian Solutions of the Transport Equation," Advances in Water Resources, 21(7), 539-554, 1998.

ROBERT L. DONEKER, P.E.

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Ph.D., Environmental Engineering
Cornell University, 1989
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RESEARCH INTERESTS

Development of decision support systems for environmental simulation modeling, engineering design optimization, and natural resource management. Current research areas focus on development of technology transfer systems with emphasis on water quality modeling and control of point and nonpoint source pollutant transport.

REPRESENTATIVE PUBLICATIONS

Doneker, R. L. And G. H. Jirka, 1999. Discussion of "Mixing In Inclined Dense Jets" by P.W. Roberts, A. Ferrier, and G. Daviero, Journal of Hydraulic Engineering, ASCE, vol. 125 No.3 pp.317-318.

Ford D.A., A.P. Kruzic, and R.L. Doneker, "Using GLEAMS to Evaluate the Agricultural Waste Application Rule-Based Decision Support System (AWARDS) Computer Program", Water Science and Technology, Vol. 28, No-35, pp.625-634, 1993.

Doneker, R.L., and G.H. Jirka "Expert Systems for Mixing Zone Analysis and Design Aqueous Pollutant Discharges," Journal of Water Resources Planning and Management, ASCE, Vol. 117, No. 6, November/December 1991.

Jirka, G.H. and R.L. Doneker "Hydrodynamic Classification of Submerged Single Port Discharges", Journal of Hydraulics Division, ASCE, Vol. 117, No. 9, September 1991.

Jirka G.H., R.L. Doneker, and T.O. Barnwell, "CORMIX: A Comprehensive Expert System for Mixing Zone Analysis of Aqueous Pollutant Discharges," Water Science and Technology, 24, No. 6, 267-274, 1991.

Doneker R.L., and G.H. Jirka, "Schematization in Regulatory Mixing Zone Analysis", *Journal of Water Resources Planning and Management,* ASCE, Vol 128, No. 1, Jan./Feb. 2002.

Doneker, R.L., and G.H. Jirka, "CORMIX-GI Systms for Mixing Zone Analysis of Brine Wastewater Disposal," *Desalination,* 139, 2001.

DAVID A. JAY

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Ph.D., Physical Oceanography
University of Washington, 1987
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RESEARCH INTERESTS

River basin, estuarine, and continental shelf processes, turbulent mixing, tides and tidal analysis. A unifying theme is the influence of hydrodynamic processes on ecosystems.

REPRESENTATIVE PUBLICATIONS

Cudaback, Cynthia N. and D. A. Jay, 2001, "Tidal asymmetry in an estuarine pycnocline, 2", Transport J. Geophys. Res. 106: 2639-2652.

Cudaback, C. N., and D. A. Jay, 2000, "Tidal asymmetry in an estuarine pycnocline: Depth and thickness", J. Geophys. Res. 105: 26,237-26,252.

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Flinchem, E. P. and D. A. Jay, 2000, "An introduction to wavelet transform tidal analysis methods", Coast. Estuar. Shelf Sci. 51: 177-200.

Jay, D. A. and Flinchem, E. P., 1997, "Interaction of fluctuating river flow with a barotropic tide: A test of wavelet tidal analysis methods", J. Geophys. Res. 102: 5705-5720.

B.M. Hickey, L.J. Pietrafesa, D.A. Jay &W.C. Boicourt, 1996, "The Columbia River Plume Study:subtidal variability in the velocity and salinity field," J. Geophysical Research, 103(10), 229-368.

D.A. Jay & J.D. Musiak, 1996, "Internal Tidal Asymmetry in Channel Flows: Origins and Consequences", C. Pattiaratchi (Ed.), "Mixing Processes in Estuaries and Coastal Seas, an American Geophysical Union," Coastal and Estuarine Sciences, 53, 219-258.

D.A. Jay & J.D. Musiak, 1994, "Particle trapping in estuarine turbidity maxima," J. of Geophysical Research, 99(20), 446-461.

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Ph.D., Environmental Science
Oregon Graduate Center, 1985
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RESEARCH INTERESTS

Physical and chemical behavior of organic contaminants in the air, soil, and water; analytical organic chemistry; groundwater transport, fate, and modeling of contaminants in porous and fractured porous media.

REPRESENTATIVE PUBLICATIONS

Thomson, N.R. and R.L. Johnson. "Air Distribution During In Situ Air Sparging: An Overview of Mathematical Modeling", J. Hazardous Materials 72(2-3), 265-282 (2000).

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Slater, L., A.M. Binley, W. Daily and R.L. Johnson. "Cross-hole electrical imaging of a controlled saline tracer injection." J. Applied Geophysics, 44, 85-102 (2000).

Johnson, P. C.; M. W. Kemblowski, R. L. Johnson. "Assessing the significance of subsurface contaminant vapor migration to enclosed spaces: site-specific alternatives to generic estimates." J. Soil Contam. 8(3), 389-421 (1999).

Daily, W., A. Ramirez and R.L. Johnson. "Electrical Impedance Tomography of a Perchloroethylene Release", J. Explor. Eng. Geology, 2, 189-201 (1998).

Johnson, P.C., R.L. Johnson, C. Neaville, E.E. Hansen, S.M. Stearns, and I.J. Dortch. "An Assessment of Conventional In situ Air Sparging Tests." Ground Water, 35(5), 765-774, (1997).

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California Institute of Technology, 1978
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RESEARCH INTERESTS

Physical and analytical chemistry of organic compounds and metals in natural waters and in the atmosphere; the formation and chemistry of atmospheric aerosols; the chemistry of nicotine in tobacco smoke.

REPRESENTATIVE PUBLICATIONS

Pankow, J.F., J.H. Seinfeld, W.E. Asher, G.B. Erdakos, "Modeling the Formation of Secondary Organic Aerosols. 1. Theory and Measurements for the (-Pinene-, (-Pinene-, Sabinene-, (3-Carene, and Cyclohexene-Ozone Systems," Env. Sci. Technol., 35, 1164-1172 (2001). See also Errata, Env. Sci. Technol., 35, 3272 (2001).

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J.F. Pankow, B.T. Mader, L.M. Isabelle, W. Luo, A. Pavlick, C. Liang, "Conversion of Nicotine in Tobacco Smoke to its Volatile and Available Free-Base Form through the Action of Gaseous Ammonia," Environmental Science and Technology, 31, 2428-2433 (1997).

C. Liang & J.F. Pankow, "Gas/Particle Partitioning of Organic Compounds to Environmental Tobacco Smoke: Partition Coefficient Measurements by Desorption," Environ. Sci. Technol. 30(9), 2800-2805 (1996).

J.F. Pankow, "An Absorption Model of Gas/Particle Partitioning in the Atmosphere," Atmos. Environ., 28, 189 (1994).

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Ph.D., Botany Plant Physiology
Washington University,
St. Louis, 1964
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RESEARCH INTERESTS

Atmospheric chemistry of trace gases; biogenic and anthropogenic emissions of trace gases and their roles in stratospheric ozone destruction and tropospheric ozone formation; measurements of trace gases at parts per trillion to parts per quadrillion levels; sources and sinks of isoprene and other hydrocarbons.

REPRESENTATIVE PUBLICATIONS

C. Geron, R.A. Rasmussen, R.R. Arnts, A. Guenther, "A review and synthesis of monoterpene speciation from forests in the United States," Atmos. Environ, 34(11), 1761-1781 (2000).

J. Zhang, K.R. Smith, R. Uma, Y. Ma, V.V.N. Kishore, K. Lata, M.A.K. Khalil, R.A. Rasmussen, S.T. Thorneloe, "Carbon monoxide from cookstoves in developing countries: 2. Exposure potentials," Chemosphere: Global Change Sci., 1(1-3), 367-375 (1999).

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E. Grosjean, R.A. Rasmussen, D. Grosjean, "Toxic air contaminants in Porto Alegre, Brazil," Environ. Sci. Technol., 33(12) 1970-1978 (1999)

R.A. Rasmussen, M.A.K. Khalil & F. Moraes, "Permafrost Methane Content: 1. Experimental Data from Sites in Northern Alaska," Chemosphere, 26:591 (1993).

M.A.K. Khalil, R.A. Rasmussen, J.R. French & J. Holt, "The Influence of Termites on Atmospheric Trace Gases: CH4, CO2, CHCl3, N2O, CO, H2 and Light Hydrocarbons," J. Geophys. Res., 95:3619 (1990).

D.A. Hegg, L.F. Radke, P.V. Hobbs, R.A. Rasmussen & P.J. Riggan, "Emissions of some trace gases from biomass fires," J. Geophys. Res., 95:5669 (1990).

PATRICIA L. TOCCALINO

Assistant Professor and Director of Education
Ph.D., Environmental Science and Engineering
Oregon Graduate Institute of Science and Technology, 1992
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RESEARCH INTERESTS

Human and ecological risk assessments, water-quality assessments, optimization of hydrocarbon biodegradation in soil and subsurface systems, contaminant fate and transport in various environmental media.

REPRESENTATIVE PUBLICATIONS AND TECHNICAL REPORTS

Toccalino, P. L., L. Nowell, and R. Phillips. 2001. "Recommendations for the development of health-based screening levels." Report to U.S. Geological Survey, U.S. Environmental Protection Agency, and N.J. Department of Environmental Protection.

Toccalino, P. L. and R. Binder. 2000. "Methodologies for presenting contaminant concentration data from the Glassboro, New Jersey study area in a human-health risk context." Report to U.S. Geological Survey, U.S. Environmental Protection Agency, and N.J. Department of Environmental Protection.

Toccalino, P. L., K. M. Auer, D. A. Mervyn, and B. Stirling. 1997. Phase II Remedial Investigation/Risk Assessment Report for Westside Light Rail Transit (LRT) Construction Spoils at the Port of Portland's Portland International Center, Portland, OR.

Toccalino, P. L. 1997. Evaluation of the Contained Burn of Two M88 NIKE Rocket Motors for Environmental Safety & Health Implications, Nevada Test Site X-Tunnel Facility (U25X), Las Vegas, NV.

Toccalino, P. L., R. L. Johnson, and D. R. Boone. 1993. "Nitrogen limitation and nitrogen fixation during alkane biodegradation in a sandy soil." Appl. Environ. Microbiol. 59:2977-2983.

Toccalino, P. L., K. M. Harmon, and J. Harmon. 1988. "Hydrogen bonding. Part 26. Thermodynamics of dissociation and infrared spectra-crystal structure correlations for betaine monohydrate and trimethylamine oxide dihydrate." J. Mol. Struct. 189:373-382.

PAUL G. TRATNYEK

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Ph.D., Chemistry
Colorado School of Mines, 1987
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RESEARCH INTERESTS

Mechanistic and kinetic aspects of the fate of organic pollutants in the environment; degradation reactions involving pesticides, phenols, munitions, dyestuffs and chlorinated hydrocarbon solvents; chemical and microbiological processes in sediments, soils and groundwaters as well as photochemical processes in surface waters; natural and engineered remediation systems.

REPRESENTATIVE PUBLICATIONS

Tratnyek, P. G.; Scherer, M. M.; Deng, B.; Hu, S. (2001) "Effects of natural organic matter, anthropogenic surfactants, and model quinones on the reduction of contaminants by zero-valent iron." Wat. Res., in press.

Scherer, M. M.; Johnson, K.; Westall, J. C.; Tratnyek, P. G. (2001) "Mass transport effects on the kinetics of nitrobenzene reduction by iron metal." Environ. Sci. Technol., 35(13), 2804-2811.

Tratnyek, P. G.; Reilkoff, T. E.; Lemon, A.; Scherer, M. M.; Balko, B. A.; Feik, L. M.; Henegar, B. (2001) "Visualizing redox chemistry: Probing environmental oxidation-reduction reactions with indicator dyes." The Chemical Educator, 6(3), 172-179.

Nam, S.; Tratnyek, P. G. (2000) "Reduction of azo dyes with zero-valent iron." Wat. Res., 34(6), 1837-1845.

Tratnyek, P. G.; Macalady, D. L. (2000) "Oxidation-reduction reactions in the aquatic environment." In: Handbook of Property Estimation Methods for Chemicals: Environmental and Health Sciences; Mackay, D.; Boethling, R. S., Eds.; Lewis: Boca Raton, FL; pp. 383-415.

Church, C. D.; Pankow, J. F.; Tratnyek, P. G. (1999) "Hydrolysis of tert-butyl formate: Kinetics, products, and implications for the environmental impact of MTBE." Environ. Toxicol. Chem., 18(12), 2789-2796.

JOINT APPOINTMENTS

DR. J. FRED HOLMES
Electrical and Computer Engineering
OGI School of Science and Engineering

DR. JAMES HUNTZICKER
Center for Professional Development
OGI School of Science and Engineering

ADJUNCT FACULTY

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DR. DAVID BOONE
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Portland State University

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Department of Management in Science and Technology

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THE DEPARTMENT OF MANAGEMENT IN SCIENCE AND TECHNOLOGY provides the rigorous educational preparation necessary for highly effective managerial- and professional-level work in industries, organizations and departments that have a strong technical, engineering, manufacturing or scientific orientation.

Our courses, certificate and master's degree programs focus on managing people and processes and building effective and competitive organizations in the specific contexts of technology and science. Managing change and competing in the global marketplace are prominent themes in the MST program.

LEARN ON-LINE, ANYTIME, ANYWHERE

MST delivers challenging and engaging versions of its courses over the Internet. This is an excellent option for students facing time pressures or working in locations where travel to the OGI campus is not feasible. The course delivery system is based on interactive multimedia lectures and lessons, faculty-managed chat, and on-line discussions, all in a seamless browser-centric environment. Students can take individual courses, enroll in the Certificate in Management in Science and Technology program, or apply for the full Master of Science degree (currently only the Managing the Technology Company degree option is offered on-line). Courses offered on-line will have a "D" designation following the course number. For further information dial toll free in the U.S. 1-877-GO TO OGI (1-877-468-6644) or visit the MST on-line learning Web site: http://elearning.cenquest.com/

INDIVIDUAL COURSES IN MST

Each MST course has been designed as a valuable professional development experience for working professionals. Project Management, Quality Management, Building Effective Organizations in Science and Technology, for example, may be taken as stand-alone courses. We encourage non-matriculated students to join our courses for their own career development in specific areas.

CERTIFICATE OPTIONS

The MST department offers certificates in Management Studies and Technology, Building the General Manager, and Industrial Design.

MANAGEMENT STUDIES

MST offers a six-course certificate in Management Studies. The following five courses, plus an additional MST elective course chosen in consultation with a faculty advisor, are required:

MST501/501D	**Managerial and Financial Accounting for Science and Technology**	**4 credits**
MST503/503D	**Marketing in Science and Technology**	**4 credits**
MST510/510D	**Principles and Trends in Technology Management**	**3 credits**
MST512/512D	**Project Management**	**3 credits**
MST520/520D	**Managing in Science and Technology**	**4 credits**
	Elective to be chosen after consultation with faculty advisor	**3-4 credits**

BUILDING THE GENERAL MANAGER (BGM)

A CERTIFICATE PROGRAM FOR SENIOR MANAGERS IN TECHNOLOGY-INTENSIVE COMPANIES

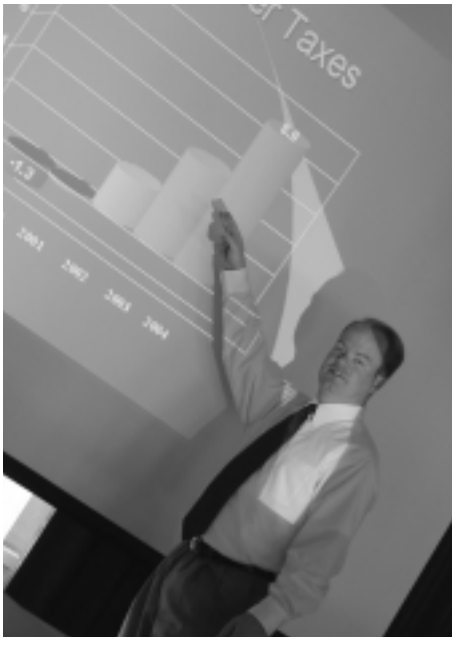
The program focuses on building general management skills needed to successfully manage the established but still-growing high-tech business, and can be completed in a series of long weekends over the course of one year.

The ideal BGM participant does not need an additional degree for career advancement, can spare the time only for a concentrated program, and wishes to leverage the learning experience to build a network of peers in other technology companies.

The three key areas of the BGM Certificate are: Business Management Foundations, which selectively draws on MST courses; and Executive Assessment and Coaching, which is incorporated into the program with pre- and post-assessment and jointly undertaken with incumbent companies; and Building Executive Leadership Skills, which serves as the core of the program.

BUILDING EXECUTIVE LEADERSHIP SKILLS CORE (6 CREDITS)

MST541/541D	**Seminar in Leadership Development**	**3 credits**
MST522/522D	**Building Effective Organizations**	**3 credits**



MST student Dave Kennedy presents a business plan for his Capstone Project.

In addition, four workshops, chosen in consultation with the firms employing each BGM participant, help build executive skills. Workshops conclude with a team project-a high-impact business project for the company. Nationally recognized instructors join the OGI faculty to teach these executive workshops. Titles include: Leading the Strategy Process; Mindset and Skills for Managing Globally; Managing Development Projects for Profits, Growth and Renewal; and Managing for Innovation and Leading Change.

INDUSTRIAL DESIGN

This certificate program introduces participants to the full range of activities involved in the design of products for industry and the marketplace. The role of the ID process within the organization is addressed, as are the key elements of an effective design project from conceptualization to product manufacturing, product launch and marketing program.

Topics taught include new product development and design management strategy, application of CAD in product development (including CAD/CAE/CAM integration), and an overview of future development in technology for ID and manufacturing. During the previous year, certificate requirements included 40 contact-hours in Industrial Design, 40 contact-hours in Modeling Computer Aided Development, 20 contact-hours in management seminars, plus a number of site visits.

ADMISSION REQUIREMENTS

Admission requirements are the same as the general requirements for the institution. In addition, the MST department requires:

- A bachelor, master or doctoral degree from an accredited institution
- A recommended cumulative undergraduate grade point average of 3.0
- A minimum of two years of full-time work experience-preferably at the professional, supervisory or managerial level-in a technical, scientific, business, or related area
- Three letters of recommendation, one of which should come from an employer or supervisor
- Recommended TOEFFL score of 625 if English is not the applicant's first language. Scores are not required for students who earned an undergraduate degree in the United States, or who have worked for a business for at least two years and where the primary business language is English
- GMAT or GRE scores are not required, except under certain circumstances

Part-time students may apply for admission to the M.S. program during any quarter. Full-time students must begin in the fall quarter.

DEGREE REQUIREMENTS

MST offers a non-thesis M.S. in Management in Science and Technology. Students elect one of three areas of concentration within the degree program: Managing the Technology Company, Computational Finance or Managing in the Software Industries. Students must complete a minimum of 53 credits with an average of 'B' or better; up to four courses or twelve credits taken in the department prior to matriculation may be used toward the degree requirements.

MST CORE SEQUENCE

All M.S. students must take the MST core sequence, consisting of the following courses or their equivalent (38 credits). The courses listed below are offered both on-campus and on-line. Either is acceptable for the M.S. in Management in Science and Technology degree. If you intend to take ONLY on-line courses, please see the Distance Degree Requirements after this section.

MST501/501D	Managerial and Financial Accounting for Science & Technology	4 credits
MST502/502D	Financial Management	4 credits
MST503/503D	Marketing: Planning for Market	4 credits
MST510/510D	Principles and Trends in Technology Management	3 credits
MST512/512D	Project Management	4 credits
MST513/513D	Manufacturing Practices and Management	3 credits
MST520/520D	Managing in Science and Technology	4 credits
MST530/530D	Strategic Management and Planning	4 credits
MST550/550D	Capstone Project: Business Plan	4 credits
MST590/590D	Effective Business Writing for Management	OR 1 credit
MST591/590D	Professional Writing for Non-native Speakers	1 credit

AREA OF EMPHASIS

All emphasis areas require the completion of the 34-credit M.S. core sequence. Specific courses required for each emphasis area are as follows:

MANAGING THE TECHNOLOGY COMPANY SEQUENCE

Core Sequence plus three of the following
MST Core Sequence plus three of the following five courses are required (9 credits):

MST511/511D	Quality Management	3 credits
MST514/514D	Issues in R&D Management	3 credits
MST522/522D	Building Effective Organizations in Science and Technology	3 credits
MST540/540D	International Management in Science and Technology	3 credits
MST541/541D	Seminar in Leadership Development	3 credits

ELECTIVES: Any course in the above list not already taken and/or any of the following (6-7 credits):

ECE555	Engineering Optimization	4 credits
ECE577	Principles for Technology Development and Introduction to Manufacturing	3 credits
ESE504	Uncertainty Analysis	4 credits
ESE586	Environmental Law and Regulation	3 credits
CSE503	Software Process Processes	3 credits
CSE549	Applied Business Forecasting	3 credits
CSE568	Empirical Research Methods	3 credits
FIN541	Principles of Modern Finance	3 credits
FIN544	Investment and Portfolio Management	3 credits
FIN547	Global Markets &Foreign Exchange	3 credits
FIN551	Options and Futures I	3 credits
FIN552	Options and Futures II	3 credits
FIN558	Advanced Numerical Computing in Finance	3 credits
FIN561	Risk Management	3 credits
FIN573	Financial Time-Series Analysis	3 credits
FIN576	Financial Markets and Trading	3 credits
MST504	Marketing: Going to Market	3 credits
MST515	Supply Chain Management	3 credits
MST517	Global Logistics and Financial Management	3 credits
MST521/ 521D	Human Resource Management in Science and Technology	3 credits
MST523	New Products Development	4 credits
MST524	Digital Economy: Strategy for Success	4 credits
MST531	Software Commercialization	3 credits
MST542	Seminar in Social Issues in Management	3 credits
MST543	Commercialization Practicum	3 credits
MST544/ MST544D	Strategic Alliances	3 credits
MST58X	Special Topics (special electives offered on a one-time only basis)	

Students may petition the MST department for elective credit for other OGI School academic courses relevant to the theory or practice of management.

COMPUTATIONAL FINANCE SEQUENCE

MST Core Sequence plus the following three courses are required (9 credits):

FIN541	Principles of Modern Finance	3 credits
FIN551	Options and Futures 1	3 credits
FIN561	Risk Management	3 credits

Electives: three of the following courses are required (9 credits)

FIN544	Investment and Portfolio Management	3 credits
FIN547	Global Markets and Foreign Exchange	3 credits
FIN552	Options and Futures II	3 credits

FIN558	**Advanced Numerical Computing in Finance**	**3 credits**
FIN573	**Financial Time-Series Analysis**	**3 credits**
FIN574	**Financial Markets and Trading**	**3 credits**

Students should note that tuition for the CSE Computational Finance courses listed above (FINxxx) is higher than for other OGI courses.

MANAGING IN THE SOFTWARE INDUSTRIES SEQUENCE

MST Core Sequence plus the following two courses are required (6 credits):

MST531	**Software Commercialization**	**3 credits**
CSE500	**Introduction to Software Engineering**	**3 credits**

Electives: Four of the following courses are required (12-13 credits):

CSE503	**Software Process Practicum**	**4 credits**
CSE504	**Object-Oriented Analysis and Design**	**3 credits**
CSE514	**Introduction to Database Systems**	**3 credits**
CSE518	**Software Design and Development**	**3 credits**
CSE560	**Artificial Intelligence**	**3 credits**
CSE564+	**Human-Computer Interaction**	**3 credits**
CSE567+	**Developing User-Oriented Systems**	**3 credits**
MST504	**Marketing: Going to Market**	**3 credits**
MST511/511D	**Quality Management**	**3 credits**
MST522/ 522D	**Building Effective Organizations in Science and Technology**	**3 credits**
MST540/ 540D	**International Management in Science and Technology**	**3 credits**
MST541	**Seminar in Leadership Development**	**3 credits**

+Credit will be given for no more than one of the indicated courses.

Students may petition the MST department head for elective credits for other OGI academic courses relevant to the theory or practice of management.

YOU CAN COMPLETE YOUR ENTIRE DEGREE ON LINE!

MST DISTANCE DEGREE REQUIREMENTS

The department of Management in Science and Technology *recommends* that students take at least two on-campus courses. A proctored comprehensive exam may be required at or near the completion of the MST Distance degree requirements. Students must complete a minimum of 52 credits with an average of B or better.

MST DISTANCE CORE SEQUENCE

All M.S. student must take the MST core sequence, consisting of the following courses or their equivalent (34 credits):

MST501D	**Managerial and Financial Accounting for Science and Technology**	**4 credits**
MST502D	**Financial Management**	**4 credits**
MST503D	**Marketing in Science and Technology**	**4 credits**
MST510D	**Principles and Trends in Technology Management**	**3 credits**
MST512D	**Project Management**	**4 credits**
MST513D	**Manufacturing Practices and Management**	**3 credits**
MST520D	**Managing in Science and Technology**	**4 credits**
MST530D	**Strategic Management and Planning**	**4 credits**
MST550D	**Capstone Project: Business Plan**	**4 credits**
MST590D	**Effective Business Writing (4 workshops at .25 credits each)**	**OR 1 credit**
MST 591D	**Professional Writing for Non-native Speakers (with dept. approval; 4 workshops at .25 credits each)**	**1 credit**

AREA OF EMPHASIS — DISTANCE DEGREE

MST currently offers only the Managing the Technology Company emphasis to students who take only online classes.

MANAGING THE TECHNOLOGY COMPANY DISTANCE SEQUENCE

MST Distance Core Sequence plus three of the following four courses are required (9 credits)

MST511D	**Quality Management**	**3 credits**
MST514D	**Issues in R&D Management**	**3 credits**
MST522D	**Building Effective Organizations in Science and Technology**	**3 credits**
MST540D	**International Management in Science and Technology**	**3 credits**

Electives: any course in the above list not already taken and/or any of the following (9 credits)

MST521D	**Human Resource Management in Science and Technology**	**3 credits**
MST544D	**Strategic Alliances**	**3 credits**
MST58XD	**Special Topics**	**Variable credits**

Students may petition the MST department head for elective credits for other OGI School academic courses relevant to the theory or practice of management.

COURSE DESCRIPTIONS

MST 501, MST 501D Managerial and Financial Accounting for Science and Technology

The course focuses on understanding and evaluating financial reports and information for use in making decisions, particularly as they pertain to managing in science, technology, engineering, and manufacturing. 4 credits

MST 502, MST 502D Financial Management for Science and Technology

The course combines a survey of the relevant aspects of micro- and macroeconomics with in-depth study of key concepts in financial management of a firm, financial structure and financial analysis of the firm, working capital management and short- and long-term financing. Particular attention is paid to valuation of investment alternatives through study of risk and rates of return, bond and stock valuation, and capital budgeting. The course is designed to achieve balance between understanding theoretical foundations and techniques of practical application. Prerequisite: MST 501. 4 credits

MST 503, MST 503D Marketing in Science and Technology

The course introduces the graduate student to the full range of issues and activities involved in the marketing of technology-based products. The role of marketing within the organization is addressed, as are the key elements of an effective marketing program. The course is organized to cover the full product introduction process, from market identification to product conception and definition, to market research, to competitive analysis, and ultimately, to product launch. Topics include pricing, sales and distribution alternatives, and marketing communications. To the extent possible, assignments utilize or draw from students' work experiences in technology, engineering, manufacturing, and science. 4 credits

MST 504, Marketing: Going to Market

The overall goal of this course is to teach students to write a marketing plan that develops a product or service's business model and persuasively makes the business case. This goal is achieved by using two strategies: by helping students understand and apply the critical concepts and principles driving the implementation of a high technology-oriented marketing plan; and by helping students acquire and develop the language, methodologies, models, processes, standards, tools, and skills for analyzing and dealing with the high technology opportunities and challenges facing marketing at the dawn of this new century. 3 credits

MST 510, MST 510D Principles and Trends in Technology Management

This course is about how companies choose, acquire, and develop the technologies that they use to develop, manufacture, deliver and support their products. We look at these practices both from the vendor and buyer points of view, and also consider internal technology development for internal use. Other topics addressed include profitably managing technology cycles; standards; technology forecasting; and the technology startup company. Related topics such as competitive analysis, managing researchers, and maintaining an innovative organizational atmosphere are dealt with in MST 503 and MST 514. The format includes lectures, discussions, guest speakers, and team and homework projects. 3 credits

MST 511, MST 511D Quality Management

The course covers total quality management (TQM) from the managerial vantage point-that is, both the behavioral and operations management aspects, excluding sophisticated statistical analysis, of TQM are addressed. Classroom discussion, based on the participants' experiences and the assigned readings from the text and cases, is the primary source of learning for many students. Lectures are used but generally as a basis for a facilitated discussion led by the instructor. The limitations of TQM also are discussed, given the inherent risks of excessive optimism associated with any social trend or perceived panacea. 3 credits

MST 512, MST 512D Project Management
The course focuses on the managerial aspects of project selection and management. Topics addressed include planning, design, scheduling, implementation, control, evaluation, and termination. 4 credits

MST 513, MST 513D Manufacturing Practices and Management
Topics covered include practices and trends in the overall design, analysis, organization, and control of manufacturing operations, as well as relationships with vendors, suppliers, and customers. 3 credits

MST 514, MST 514D Issues in R & D Management
Participants examine issues in managing R&D and technological innovation in an environment of increasing time- and competence-based competition, a competition that is simultaneously global and local in both markets and technology, where competitors draw on an existing technology base that supports incremental innovation through radical innovation, and where quality is a given. Particular attention is given to R&D management issues in integrating technology into business strategy and operations, managing internal development and external sourcing of technology, seeking competitive advantage through collaborative advantage, and building new technical competence as a part of every project. Key trends, new conceptual frameworks, management tools and techniques, and best practices in R&D management are examined through presentation, interactive class discussions, selected readings, case studies, and a number of invited speakers from both small and large companies. 3 credits

MST 515 Supply Chain Management
This is a course in Supply Chain Management, a term which denotes a total system approach to the management of all of those activities involved in physically moving raw materials, inventory, and finished goods inventory from point of origin to point of consumption. Supply Chain Management (SCM) is a system approach to managing the entire flow of information, materials, products, and financial funds to and from suppliers and end-customers. 3 credits

MST 516 SCM – Advanced Modeling
This course will introduce the use of mathematical programming in supply chain modeling. The emphasis will be mainly on large-scale optimization of real-world supply chain distribution networks. The major skills taught are problem definition, model formulation, and solution analysis. We will teach the use of commercial software, which include the MAPLE algebraic modeling system for planning problems, What's BEST for decision-making, and GSCM for large mixed-integer programming network design. 3 credits

MST 517 Global Logistics and Financial Management
The global environment that characterizes the business world of today has pointed out the importance of developing strategies that go beyond the geographical boundaries of one country. Nowadays, it is not uncommon to see a company that develops a new product in the US manufactures it in Asia and sells it in Europe. Wage-rate differentials, expanding foreign markets, and improved transportation are breaking down barriers of time and space between countries forcing the logistics function to take a global dimension. Global logistics is the response to the increasing integration of international markets as firms try to remain competitive.

The emphasis of the course is the operations and logistics function in firms that source, produce, distribute and market in multiple nations. The management of logistics in such firms differs from its domestic counterpart along several key dimensions. First, there is the need to be able to identify and analyze factors that differ across nations, which influence the effectiveness of this function. These include worker productivity, process adaptability, governmental concerns, transportation availability, culture and soon. In addition, because of the distances involved, transportation and distribution are of greater significance. Finally, these geographically dispersed set of facilities and markets must be integrated and manage to enhance the strategy of the business unit. Therefore, some of the sessions of the course will focus on cross-national decisions and others will focus on managing across nations. 3 credits

MST 520, MST 520D Managing in Science and Technology
This course focuses on developing participants' ability to understand and influence human behavior. Four theory-based frames are elaborated and used for understanding human behavior. Using the structural frame, we examine work design and redesign for individuals and groups, and consider the impact of restructuring. Using the human resource frame, we examine interpersonal and group dynamics, communication and creativity. Using the political frame, we consider power, conflict, and differences in the workplace. Using the symbolic frame, we examine the impact of individual leadership and corporate culture on organizational outcomes.

The course also examines the influence processes and network of relationships required for managing research scientists, engineers, and other professionals, as individuals and in teams, in a fast-changing environment. Self-assessment, networking, and developmental relationships are explored as means of developing influence and having impact within a technologically driven organization. 4 credits

MST 521, MST 521D Human Resource Management in Science and Technology
This course focuses on the development, implementation, and evaluation of human resource management (HRM) systems, and the relationship between an organization's HRM practices and the organization's effectiveness and competitive success. Specifically, the course addresses the choices an organization must make in three HRM policy areas: organization of work and employee influence; personnel flows and development; and measurement and rewards. We consider the perspectives of both the line manager and the HRM specialist in examining these three policy areas. The course also includes a limited overview of employment law, with a particular focus on recent cases and changes in employment legislation. 3 credits

MST 522, MST 522D Building Effective Organizations in Science and Technology
This course focuses on designing effective organizations and managing change in organizations in which engineering, manufacturing, and/or scientific technologies are critical. Tools for assessing the need for reorganization and implementing structural changes are emphasized. The course pays special attention to organizing for lateral coordination and integration, as this is a required capability in technology-intensive organizations. Students are invited to consider the relationship between organizational theory and practice. A range of theoretical perspectives is reviewed, and students are encouraged to compile their own approach by combining those presented. Extensive use is made of cases and actual examples drawn from the readings and from course participants' experiences. Taking MST 520 first is recommended. 3 credits

MST 523 New Product Development
Successful product development has been key to survival in today's competitive markets. This course was designed to address professionals who are in product development organizations or support such organizations. It has been seen that technology integration and creating innovative environments have been critical to developing profitable products in today's technology oriented companies. The course will review cases and published articles addressing key issues in new product development. Topics such as Disruptive Technologies, Technology Integration, Concurrent Engineering, and Managing Technological Innovation will be covered. 4 credits

MST 524 Digital Economy: Strategy for Success
The purpose of this course is to equip the student with a practical and conceptual understanding of what it takes to develop and maintain a competitive advantage in the new economy. We will look at it from several perspectives. We will start by investigating the fundamental changes that the Internet and other technologies introduce in the economy and how this completely changes the rules of the competitive game. We will then look at how entire industries and activities are being transformed and why.

In the second part of the course we will look at strategy from several angles. The first one will address the question of what a company should consider to develop its competitive advantage and its competitive strategy. The second angle will address the Internet marketing side or how to go to market and rise to the top. The third angle is addressing the question of how successful companies organize and what they do to operate at the "speed of change." Students will use the learning they acquire to develop a business concept to be presented at the last session. The course will be supported by a Web site, where course materials and resources will be made available. We will also carry discussions off-line. Several executives from local companies have been invited to share their experience in the dot-com world. 4 credits

MST 530, MST 530D Strategic Management and Planning
This course focuses on the analysis of the competitive environment and on the decision-making process leading to the formulation and implementation of strategy. Other topics include using time, knowledge, and technologies as competitive advantages, managing strategic change, and developing strategic plans. Prerequisites: MST 502, MST 503, MST 520. 4 credits

MST 531 Software Commercialization
This course examines the structure of the software industry, and problems of marketing privately developed software and commercializing software from the government and nonprofit sector. Because the business models for hardware and software companies are quite different, the course focuses on the special problems of marketing, entrepreneurship, globalization, and alliances experienced by software firms. Relationships between marketing strategy and development strategy also are examined. 3 credits

MST 540, MST 540D International Management in Science and Technology
Topics in this course include trends in the conduct of international business, the international business environment, the operation of multinational enterprises, international technology transfer, and the special considerations associated with managing on the international level. 3 credits

MST 541 Leadership and Negotiation
This course focuses on the negotiation and interpersonal communication skills required to exercise effective leadership. Topics include creating clarity about one's own values and mission, exercising influence through both formal and informal authority channels, and being a catalyst for change. 3 credits

MST 542 Seminar in Social Issues in Management
This course focuses on ethical dilemmas, social issues and responsibilities, and government regulations and influences. First, the course examines different frameworks for individual decision making in an organizational setting. Next, the impact of organizational policies and practices, and the words and actions of managers, on the behavior of individuals within those organizations is examined. Finally, the course focuses on the relationship between organizations and the societies in which they operate. We consider the perspectives of key stakeholders, including government regulators, community representatives, customers, employees, managers, and stockholders, and examine different views on corporate social responsibility. 3 credits

MST 543 Commercialization Practicum
Students will have the opportunity to work in teams with real technologies. Student teams will produce assessments and plans for bringing new technologies to market using Vijay Jolly's Mind to Market Technology Commercialization and other frameworks such as a Total Life Cycle Planning approach. Wherever possible, industry advisors will mentor students in their area of expertise within the design, management and product manufacturing process. Each team adopts a real technology held by Batelle-Pacific Northwest Laboratories, OHSU, OGI, Oregon Medical Laser Center, or others. Students will make one or more field trips to these institutions. The technologies may be in the areas of environmental, health, genetics, multimedia, computers or other fields.

Each team's final paper - which may include market research, a design for a manufacturable product, profiles of desired management teams, licensing plans, tech-marketing feasibility, and/or preliminary startup business plan, will be submitted to the institution that originated the technology. MST students may choose to use their 581 project as a preliminary exercise for the capstone project. 3 credits

MST 544, MST 544D Strategic Alliances
This course explores a model of implementing strategic alliances, business partnering and joint ventures originally outlined by Robert Lynch, senior partner of The Warren Company, in his book Business Alliances Guide (John Wiley and Sons, 1993). The book is a compilation of best practices in strategic alliance formation and implementation distilled from approximately 40 different high performance international and domestic strategic alliances. It offers a well-articulated framework, which is applicable across a broad range of alliance types. The objective of this course is to provide each student with an opportunity to learn practical, effective methods for forming, implementing and executing high-performance strategic alliances. 3 credits

MST 550 Capstone Project: Business Plan
In the program's capstone course, students complete major integrative projects as members of teams. Prerequisites: MST 530 and approval of instructor. 4 credits

MST 58X, MST 58XD – Special Topics
Under this number, courses of particular relevance and interest to students and faculty are offered. Variable credits.

MST590, MST 590D Effective Business Writing for Management
This course will review several aspects of conventional punctuation and grammar that address the needs of the participants. In addition, attention is given to stylistics for clear, concise communication necessary in business writing. Class size is limited to ten students. 1 credit

MST 591, MST 591D Professional Writing for Non-native Speakers
An intensive review of English grammar and sentence structure with a focus on formal English for professional purposes. Some attention to the academic essay as well as business writing. Class size is limited to ten students. No prerequisite. 1 credit

Note: descriptions for Computational Finance courses, designated FINxxx, are found in the catalog under the Department of Computer Science and Engineering Course Description section.

FRED YOUNG PHILLIPS

Professor and Department Head
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The University of Texas at Austin, 1978
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RESEARCH INTERESTS

Market research, marketing innovation and high-technology products, managing the new product development process, incubation and commercialization of new technologies, strategic and innovative use of computers

REPRESENTATIVE PUBLICATIONS

F. Phillips, "Market-Oriented Technology Management: Innovating for Profit in Entrepreneurial Times." Springer-Verlag, Heidelberg, 2001.

F. Phillips and M. Burningham, "WTO vs. WTA? Exploring the World Trade Organization's Impact on Technopolis." Presented at 4th International Conference On Technology Policy & Innovation, Curitiba, Brazil, August, 2000.

F. Phillips and S. Tuladhar, "Measures of Organizational Flexibility." Technological Forecasting & Social Change 64/1, May, 2000.

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RESEARCH INTERESTS

Management of technology, and advanced lithography for semiconductor fabrication.

REPRESENTATIVE PUBLICATIONS

J. Ye, M. Takac, C.N. Berglund, G. Owen & R.F.W. Pease, "An Exact Algorithm for the Self- Calibration of Precision X-Y Stages," Conference on Electron, Ion & Photon Beam Technology & Nanofabrication (May 1996).

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MARIANNE KOCH

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RESEARCH INTERESTS

The human side of technology transfer; work/family policies and practices; coaching faculty in the development and teaching of e-learnings courses.

REPRESENTATIVE PUBLICATIONS:

M. Koch & D Moshavi, "The Adoption of Family-Friendly Policies in Family-Owned Firms: Paragon or Paradox, Proceedings of the 2001 Southern Management Association Annual Meeting, New Orleans, LA, 2001.

M. Koch, L. Long, & A. Meyer, "Adoption of Innovations in Hospitals: Exploring the Validity of a Multi-Stage Model," forthcoming, International Journal of Technology Management; alsoin Academy of Management Best Papers Proceedings, August, 1996.

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M. Koch. "Hiring Practices and Labor Productivity", 1995. Garland Publishing, Inc., New York, N.Y., 1995.

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Jack Raiton has been VP and CFO at Planar Systems for the last four years, and also served as VP and CFO at Smith's Home Furnishings. His prior experience includes working at Tektronix for about 22 years, the last 12 as the Corporate Controller and serving as Plant Controller for Fairchild Camera and Instruments. Jack earned his BS in Mathematics from Oregon State University in 1966 and his MBA in Finance and Statistics from the University of Washington in 1967. He attended Harvard University's three-month Advanced Management Program, and passed the CPA exam in 1979.

AREAS OF EXPERTISE

Performance Measurement, Capital Structure, Stock Options and Incentive Plans, Forensic Accounting

ADRIAN ROBERTS

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Ph.D., Metallurgy
University of Manchester, England

Adrian Roberts is a consultant on technology management, specializing in R&D management and technology commercialization. Acting as advisor to Battelle Memorial Institute and other clients on technology projects and new business creation, Adrian was recently appointed Interim Director of Battelle-Pacific Northwest National Laboratories. This past year, he has contributed to the Center for Entrepreneurial Growth and has taught the MST course on Technology Management, as well as working with Brookhaven, Oak Ridge and Pacific Northwest National Laboratories on programs for the US Department of Energy.

AREAS OF EXPERTISE

Technology management, commercialization of technologies, R&D management, strategic planning.

NICOLE STECKLER

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RESEARCH INTERESTS

Tools for diagnosing and improving leadership effectiveness, roles in implementing (and resisting) organizational change, interpersonal communication and influence in organizations, and lateral coordination in organizations.

REPRESENTATIVE PUBLICATIONS

N.A. Steckler & N. Fondas, "Building Team Leader Effectiveness: A Diagnostic Tool," Organizational Dynamics, Vol. 23, 20-35, Winter/Spring 1995.

J. White, S. Jacobson, R. Jacques, N. Fondas & N.A. Steckler, "You Just Don't Understand: Gendered Interaction and the Process of 'Doing' Organizational Scholarship," Journal of Management Inquiry, 4(4), p. 370-379, December 1995.

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N.A. Steckler & R. Rosenthal, "Sex Differences in Nonverbal and Verbal Communication with Bosses, Peers, and Subordinates," Journal of Applied Psychology, Vol. 70, 157-163, 1985.

N.C. Ware, N.A. Steckler & J. Leserman, "Undergraduate women: Who chooses a science major?" Journal of Higher Education, Vol. 56, 73-84, 1985.

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RESEARCH INTERESTS

Alvin Tong teaches Project Management and the CapstoneProject (Business Plan) course, and has been with MST since 1996. Alvin served as a mentor for the 1999 student team, ArtCentral that won first place in the New Venture Championship 2000, a national/international business plan competition held in Beaverton, Oregon. Alvin has thirty years of working experience in the computer and related industry, which includes serving as chief operating officer of Acer, Inc., a Taiwan-based manufacturer of personal computers. While with Acer, he also served as President of their venture capital arm. Prior to Acer, he worked for fourteen years at IBM. In addition, he also had a significant role as the first deputy director-general of the Hsin-chu Science-Based Industrial Park (SBIP) in Taiwan. Alvin has conducted numerous management-training seminars and is frequently invited to speak and lecture on the subject of Globalization and Hi-Tech Science-Based Industrial Parks.

REPRESENTATIVE PUBLICATIONS

P. Schumann, D. Prestwood, A. Tong, & J. Vanston, "Innovate!", McGraw-Hill, Inc., 1994.

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JCB Associates

TUGRUL DAIM
Intel Corporation

DEAN DERRAH
Infocus Systems

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University of California at Davis

DAVID DRAKE
Catalyst Communications, Inc.

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Oregon Health & Science
Unversity

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Science University

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RITA LAXTON-BENZAN
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OHSU includes four schools, two hospitals, numerous primary care and specialty clinics, multiple research institutes, and several public service and outreach units.