# Welcome to the OGI School of Science & Engineering

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Photography by Jerome Hart, Anne Rybak, Viewfinders Stock Photography, and bbg Marketing.
This has been a remarkable year for the OGI School of Science & Engineering. July 1, 2002, marked the first anniversary of the merger that made us the fourth school of Oregon Health & Science University, in addition to Dentistry, Medicine and Nursing. The merger has been widely heralded in the local press, and we are excited at the possibilities it has opened for interdisciplinary collaboration in such fields as biomedical engineering, information technology, environmental science, and management of biotechnology and health care enterprises. As a health and research university, OHSU is unique in having a school of engineering to further innovation in these important areas. Our newest department, Biomedical Engineering, is one fruit of this merger. There will be many more to come.

At the same time, we are committed to the same high-quality graduate education and research in our traditional disciplines: biochemistry and molecular biology, computer science and engineering, electrical and computer engineering, environmental science and engineering, and management in science and technology. The OGI School has been the region’s premier provider of high-technology graduate education since its inception in 1963. The school is home to world-class scientists and researchers, and our alumni go on to careers in academia, government and industry.

We are also an important partner with the local high-tech industry. Many of our part-time students, for instance, are full-time employees of companies both large and small, and are looking to acquire expertise that will enhance their careers. Our full-time students establish valuable contacts within industry. And classroom interactions benefit from real-world experience.

OGI’s size has long been one of its attractions. We focus exclusively on graduate education, with about 170 full-time students and 380 part-time. Our faculty members devote close attention to each student. For Ph.D. students, our faculty/student ratio is an impressive 1.6 to 1.

Our research competes favorably with much larger schools, with about $18 million in research annually, funded mostly by the federal government. That translates roughly to $290,000 per year in research expenditures for each faculty member — a figure some top-tier schools would envy. Students can thus be assured that the education they receive is grounded in leading-edge research in their discipline.

Classroom instruction and research interactions benefit from the diverse backgrounds of our faculty and students. We are a truly international community at OGI.

For all of these reasons, our alumni are well equipped for careers in a world where flexible thinking and innovation are in demand, where technology grows more important and more useful every day, where diversity is the norm, and where the ability to assess and solve problems is life’s most vital skill. Wherever they go, our graduates excel. We measure our success by theirs.
The OGI School is part of OHSU’s West Campus, which also includes the Vaccine and Gene Therapy Institute, the Neurological Sciences Institute and the Oregon Regional Primate Research Center. The West Campus is about 12 miles from the main Marquam Hill campus in Portland.

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 OGI 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

Oregon Health & Science University is firmly committed to a policy of affirmative action and equal opportunity. This encompasses all employment, education and patient service activities connected with OHSU. No patient, employee, student, trainee, beneficiary or potential beneficiary of the hospitals and clinics or the university shall be unlawfully discriminated against on the basis of race, color, sex, sexual orientation, religion, creed, national origin, age, marital status, disability, veteran status or another applicable basis in law.

ABOUT THIS CATALOG

This catalog is as accurate as possible as of July 1, 2002. 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.

*Management in Science and Technology Compressed and Distance Learning courses have unique late registration deadlines. Please refer to OGI’s quarterly course schedule for the specific MST registration information.
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),
- Management in Science and Technology (MST).

Any student, whether a matriculated student in a degree program or a nondegree-seeking student, may take part in research projects outside their main department. This encourages the exchange of ideas across related research areas and provides fullest use of the wide range of instrumentation available at the school.

DEGREE PROGRAMS

The OGI School offers M.S. and Ph.D. degrees in Science and Engineering, Computer Science, Electrical Engineering, Environmental Science and Engineering. We offer Master of Science degrees in Management in Science and Technology and in Computational Science and Engineering. We offer Master of Science and Engineering. 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. For more information visit www.omse.org.

CERTIFICATE PROGRAMS

Various certificate programs are available through the Computational Finance, Management in Science and Technology and in Software Engineering academic programs.

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 before matriculation (enrollment in a degree program) may be accepted toward degree requirements. Departmental regulations may be more restrictive.

COLLABORATIVE/JOINT PROGRAMS

Full-time matriculated students in a OGI School's Computer Science and Engineering (CSE), Electrical and Computer Engineering (ECE) and Management in Science and Technology (MST) departments may take certain courses at Portland State University at no additional cost. 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. For more information visit www.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/or the U.S. Department of Education. The address is: Commission on Colleges, NWASC, 11130 N.E. 33rd Place, Suite 120, Bellevue, WA 98004.

ADMISSIONS

ADMISSIONS REQUIREMENTS

Individual academic departments have specific requirements in addition to those shown below. These are found in the department sections of the catalog.

- To enroll in any degree program at the OGI School, an applicant must have completed the requirements for a bachelor's degree or its equivalent, although a student may be provisionally admitted prior to that time.
- 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, and Oregon Master of Software Engineering.
- The GRE general test is required for Ph.D. applicants in Biochemistry and Molecular Biology (subject test is also required); Computer Science and Engineering, Electrical and Computer Engineering and Environmental Science and Engineering.
- Official transcripts from each college or university attended are required.
- Three original letters of recommendation are required. The recommendation should attest to the student's ability to succeed in a graduate program and must be signed.

ADDITIONAL REQUIREMENTS FOR INTERNATIONAL STUDENTS

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

- Evidence of adequate financial resources to pay for their OGI education and their cost of living.
- Written TOEFL scores are required of all MS 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. The OGI School will accept both the paper-based test and the computer-based test. Minimum required TOEFL scores vary by department: BMB 550 paper/213 computer; CSE 600 paper/250 computer; ECE 575 paper/233 computer; ESE 600 paper/250 computer; MST 625 paper/263 computer. The minimum desired TOEFL score for admission is 575 paper/233 computer, but a lower score may be offset by excellent GRE scores. For more information on the TOEFL, please visit www.toefl.org.

APPLICATION PROCEDURES

For degree programs, the following items must be submitted:

- Completed OGI School of Science & Engineering application form or Oregon Master of Software Engineering (OMSE) degree program application form, if applicable.
- $65 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.
- Official transcripts from each college or university attended. The transcripts must arrive by the student.
- Official GRE scores if applicable, see above.

For certificate programs, the following items must be submitted:

- Completed OGI certificate program application form.
- $25 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.

Printed application forms are available by contacting the Department of Graduate Education. You may also apply for admission online at www.ogi.edu/forms/application.
Completed applications, transcripts and other application materials should be sent to:

Department of Graduate Education
OGI School of Science and Engineering
20000 N.W. Walker Road
Beaverton, Oregon 97006-8921

Phone: 503 748-1027
Toll-free: 800 685-2423
Fax: 503 748-1285
E-mail to: admissions@admin.ogi.edu
www.ogi.edu/grad_ed /

Applications may be submitted as early as one year before the proposed date of enrollment. Applications received by March 1 (February 15 for the Environmental Science and Engineering department) will receive priority review for admission and financial support.

STUDENT VISAS

Information on student visas and other immigration services can be found on the Web site for OGI’s Office of International Students and Scholars, www.ogi.edu/immigration.

TUITION AND FINANCES

TUITION AND FEES

For the 2002-2003 academic year, tuition for full-time matriculated students (defined as nine or more credit hours per quarter) is $5,049 per quarter, with the exception of Computational Finance as described below. Part-time tuition for regular OGI School of Science & Engineering courses is $561 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. Tuition includes OHSU’s activity fee, building fee, technology fee and incidental fee.

- Students matriculated in the Computational Finance degree program pay on a per-credit basis of $561 for the first 48 credits during the 12-month program. Students may take additional courses above the 48 credits within the 12-month program time frame at no additional cost, up to a total of 54 credits.
- ESE students pay tuition on an annual basis, which may be paid in full at the beginning of the year or in quarterly installments.
- Courses in the Oregon Masters of Software Engineering (OMSE) program are $495 per credit hour. Full-time matriculated students may register for OMSE courses when paying full-time OGI tuition.

- Deposits. Upon admission as a master’s student, Environmental Science and Engineering requires a deposit of $100 and Computational Finance requires a deposit of $500 to reserve a place in their respective programs. Deposits will be applied toward tuition and are nonrefundable.

HEALTH INSURANCE

Full-time students enrolled in an OGI degree program are eligible for group student medical insurance through the school. OGI pays the entire premium for full-time Ph.D. students and two-thirds of the premium for full-time master’s students. The current monthly premium is $149, effective through June 30, 2003. Insurance for family members may be purchased for an additional charge.

FINANCIAL AID

Entering full-time Ph.D. students may be eligible for financial support through a combination of tuition scholarships, OGI fellowships, named fellowships and graduate research assistantships. Offers of support are initiated by the individual academic departments. Part-time Ph.D. students may be eligible for some of the above. Partial-tuition scholarships may be awarded by individual academic departments to entering full-time M.S. students.

Subsidized and Unsubsidized Federal Stafford Loans are available to students who have been formally admitted to an M.S. or Ph.D. program at the School of Science & Engineering. To be eligible for a loan, students must take at least five credits each quarter, and must be U.S. citizens or eligible noncitizens (e.g., permanent residents) For application materials and additional information, contact the Financial Aid Office at OHSU at 503 494-7800 or 800 775-5460 or finaid@ohsu.edu. Information about financial aid may also be found on OHSU’s Web site, http://www.ohsu.edu/finaid/ or OGI’s Web site, http://www.ogi.edu/ students/fin.html. The “Free Application for Student Aid” (FAFSA) forms may be found at http://www.fafsa.ed.gov/. Hard copy forms are available from the OGI Department of Graduate Education. Use Federal School Code 004883 when completing the FAFSA form.

ACADEMIC POLICIES

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

AUDITING A COURSE

OGI courses are offered for graded graduate credit hours or ungraded audit units. Students may register to audit a course on a space-available basis. Students taking a course for credit have priority over students auditing a course. Audits are recorded on the student’s transcript at the discretion of the instructor, based upon a reasonable expectation of attendance and minimal participation determined by the instructor. 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 their academic expectations.

CONFIDENTIALITY OF STUDENT RECORDS

With the passage of the Federal Family Educational Rights and Privacy Act (FERPA) of 1974, the OGI School 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 before their records are released to any person, agency or organization other than OGI officials and certain authorized federal and state authorities.

Directory Information. The OGI School can release certain public domain information, known as directory information, unless a student files a written request in the Graduate Education Department. The school limits directory information to the student's name, permanent and local home addresses, e-mail address, date(s) 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.
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 may be terminated. If the student wishes to return to his/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 inactivity status by filing a Temporary Inactive Status form with the Department of Graduate Education.

CREDIT LOAD PER QUARTER

Twelve credits per quarter is considered a normal course load for full-time students, although nine or more is considered full-time. Up to 18 credits plus four audit units may be taken with the approval of the student’s academic department. Registering for more than 18 credits plus four audit units requires Educational Policy Committee (EPC) permission and will incur an additional tuition cost. Students in the Electrical and Computer Engineering Department are limited to 12 credits per quarter, but may take up to 16 with their advisor's and home department’s written approval.

GRADING/SATISFACTORY ACADEMIC PROGRESS

Most OGI School courses are graded with a letter grade. Research work may be graded with either a Pass/No Pass or letter grade at the discretion of the faculty.

Transfer credits and Pass/No Pass grades are not counted in students’ Grade Point Averages (GPAs). The GPA is a weighted average of all eligible credits.

The following scale is employed at the OGI School:

- A = 4.00
- A- = 3.67
- B+ = 3.33
- B = 3.00
- B- = 2.67
- C+ = 2.33
- C = 2.00
- C- = 1.67
- F = 0.00

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. Failure to do so will result in academic probation, and if the GPA is not improved, may lead to dismissal.

Incomplete. 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 accomplished warrants it. If a student wants an extension of this one-quarter deadline, the student may petition the Educational Policy Committee (EPC) showing the instructor’s support of the extension (a separate letter, e-mail or signature on the petition will suffice). Usually 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.

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/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 (EPC) for approval. International students should consult with OGI’s Manager of International Students and Scholars before considering a leave of absence.

MATRICULATED VS. NON-MATRICULATED

A matriculated student is admitted and enrolled in a degree program. A non-matriculated student has not applied and been admitted to a degree program. Full-time matriculated students carry a minimum of nine credits per quarter. Audit units do not count toward the nine-credit minimum. 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 per-credit rate. Non-matriculated students typically carry fewer than nine credits per quarter and pay tuition at the per-credit rate.

MEASLES IMMUNIZATION POLICY

Every full-time student who was born on or after Jan. 1, 1957, must provide the OGI School with evidence of having received a sufficient measles vaccination. Students are expected to submit a completed Immunization Form when they first register for classes at OGI. Students who do not provide the needed evidence on this form will not be allowed to register for classes for the second or succeeding quarters following their initial registration. The complete Measles Immunization Policy and Immunization Form are available at the Graduate Education office.

ON-SITE (RESIDENCY) PH.D. REQUIREMENTS

The OGI School has a two-year on-site Ph.D. program requirement. Full-time Ph.D. students usually meet this requirement by an on-site dissertation project under the advisement of an OGI faculty member. Part-time Ph.D. students can satisfy the first year of the on-site requirement by attendance in classes on the OGI campus. Because part-time Ph.D. students, by
definition, are not on campus full time, the student’s academic department will determine residency requirements for the second year.

In exceptional circumstances (e.g., dissertation topics requiring access to special facilities only available elsewhere), other arrangements may be proposed to the student’s academic department for written approval.

There is no on-site program requirement for M.S. or certificate programs at OGI.

**PRE-MATRICULATION CREDITS APPLIED TOWARD A DEGREE**

A maximum of 21 credits earned before matriculation at OGI may be applied toward degree requirements. This maximum may include a combination of up to 12 (up to 18 from Portland State University, the University of Oregon and Oregon State University) transfer credits and credits taken at OGI. Individual departmental regulations may be more restrictive. If necessary, a student may petition the Educational Policy Committee (EPC) for an exception to this policy.

**REGISTRATION**

Any qualified student may take courses at the School of Science & Engineering, 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.

Each quarter a student must register for courses by submitting a registration form (may be found at http://www.ogi.edu/schedule/registrationform.pdf) to the Department of Graduate Education or registering online at http://www.ogi.edu/forms/regform.html. Each quarter a class schedule is published with the specific courses being offered with the dates, times and locations. To access a current class schedule online, visit http://www.ogi.edu/schedule/. All students attending a course must be registered for that course. A student will not earn a grade or credits for the course if s/he is not registered for that course.

**Department Approvals.** Full- and part-time matriculated students in Biochemistry and Molecular Biology, Computational Finance, Electrical and Computer Engineering and Environmental Science and Engineering, as well as full-time matriculated students in Computer Science and Engineering, must have department approval for all registrations, adds, drops and changes.

**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.

**TRANSCRIPTS**

Your official transcript is a formal, written record of your OGI School of Science & Engineering educational experience. All courses you take at the OGI School and other OHSU schools are recorded on it, as are all grades and degrees you earn while at OGI/OHSU. If you have transferred credits from another institution, they will be recorded on your transcript, as well. Requests for transcripts must be in writing with a signature, submitted either by fax, mail or in person to the OHSU Registrar’s office. Alternatively, you may submit the transcript request form to the Department of Graduate Education on the OGI campus. Official transcripts are on special paper and have the official OHSU seal. Official transcripts cost $8 per copy when ordered 24 hours in advance. For same day service or a faxed official transcript the fee is $10. A request form for an official transcript can be found at http://www.ohsu.edu/academic/txreq.pdf.

**TRANSFER CREDIT**

The OGI School of Science & Engineering accepts transfer credits from accredited institutions that have not previously been applied toward another degree. Up to 12 credits may be transferred to OGI (up to 18 from Portland State University, University of Oregon and Oregon State University). Credits transferred to OGI must typically come from courses completed before matriculation at OGI. The specific credits, if any, which will be accepted as transfer credits into OGI and applied toward degree requirements are determined solely by the academic department. Transfer credit grades are not calculated in the OGI grade point average. Credits graded on a Pass/No Pass basis may not be transferred.

**THE CAMPUS**

**GEOGRAPHIC SETTING**

The greater-Portland metropolitan area has a population of about 1 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 12 miles west of downtown Portland, an area known as the Silicon Forest. OGI’s neighbors include Intel’s largest research and development facility, Tektronix, IBM, Hewlett-Packard, Mentor Graphics, Nike, Adidas and hundreds of other technology-based companies.

We are the newest school within Oregon Health & Science University (OHSU), joining the Schools of Medicine, Dentistry and Nursing, located on the Marquam Hill Campus in downtown Portland. The OGI School is now part of OHSU’s West Campus, which also includes the Neurological Sciences Institute, Oregon Regional Primate Research Center and the Vaccine and Gene Therapy Institute. The OGI School campus consists of modern buildings, providing spacious laboratories, faculty and administrative offices and a research library.

**LIBRARY**

The Samuel L. Diack Library’s collection includes more than 19,000 monographic titles and 350 current print and electronic journal subscriptions. These support the teaching and research efforts at the OGI School by providing texts, conference proceedings, reference materials, journals and research monographs in the subject areas of computer science, electrical engineering, environmental science, 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 print subscriptions. These print collections are available for use when
visiting the libraries. Materials unavailable at the OGI School are obtained on interlibrary loan for faculty, staff and students. An online catalog, acquisitions and circulation system is in place. The library is a member of two consortia that provide access to other college and university collections. The Orbis consortium allows for direct-request borrowing from 18 institutions in Oregon and Washington, including the University of Oregon and Oregon State University. The PORTALS consortium includes libraries in the Portland metropolitan area, including Portland State University and Reed College.

The OGI School Library’s public workstations not only provide for searching the catalog and the library’s databases but also provide entry to Web resources for faculty, staff and students. The librarians will perform searches on the systems and databases that are not available directly 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.

Many of the electronic resources of OHSU Marquam Hill Library and the OGI Library are already available to all OHSU students, and integration is expected to be complete by 2003.

STUDENT COUNCIL

The OGI Student Council serves as the liaison between the student body and the faculty and administration, and strives to improve the quality of life for students at the OGI School. Student representatives make themselves available to students in their department to forward comments, ideas and concerns to the Student Council and to promote involvement in student-body activities. Representatives also disseminate pertinent information to other students in their departments. As liaisons, members of the Student Council represent the student body and student interests on a wide variety of OGI School task forces and committees, including the Faculty Senate, the Educational Policy Committee and the Safety Committee. Two Student Council members are also representatives on OHSU’s All-Hill Council to represent OGI’s student body to the larger institution.

Additionally, the Student Council sponsors and coordinates at least one major social event each quarter, open to everyone at the OGI School. These events have included a coffeehouse with live music performed by people from the school community, an annual International Food and Cultural Fair, the fall orientation lunch and barbecue, and numerous educational forums. Periodic skiing and rafting trips are also arranged. Many student events throughout OHSU are open to all students at the four OHSU schools. Members of Student Council also assist students when they first arrive in Portland by picking them up at the airport, helping them find accommodations or furniture and giving campus tours. More information on Student Council is available on their Web site, csu.cse.ogi.edu/council/ or by e-mail at scouncil@admin.ogi.edu.

PETS ON CAMPUS

The school enjoys the presence of well-behaved pets on our campus and has a detailed pet policy that can be found at www.ogi.edu/policies/pets.html. We consider it a privilege, and not a right, to bring pets onto the campus with certain restrictions. The rights of students, employees and visitors of the school are primary to those of pets and pet owners. Following is a summary of the policy: Anyone with a medical condition, fear of animals or related condition is responsible for notifying the pet owner and the owner is obligated to respect the individual’s concerns and requests. Pets are not allowed in specified areas of the campus, including eating areas, classrooms, laboratories, restrooms and the library; they must be leashed outside a private office. Pets are allowed in private offices only when the owner posts a notice alerting people to the presence of a pet; the pet does not bark, hiss or otherwise annoy others; the pet is caged, on a leash or behind a gate whenever left unsupervised; and the owner accommodates any individual who is not comfortable with the pet. In addition, owners must clean up after their pet. Pets must be in good health with current immunizations, and animals in heat are not allowed. Students, faculty, staff or visitors who violate the policy are notified that their pet can no longer be brought to any part of the campus. Our policy does not apply to seeing/hearing or personal assistant animals for individuals with disabilities.
THE DEPARTMENT OF BIOCHEMISTRY AND MOLECULAR BIOLOGY offers graduate study leading to M.S. and Ph.D. degrees. Students participate in research 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 mechanisms of metal trafficking in cells).
- Fungal, yeast and bacterial biochemistry.
- 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 before 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 in graded courses and 16 derived from an experimental research project (BMB 610); and a written report on the research. Graded courses include 12 credits in BMB 527-528-529, and 16 or more credits in advanced courses (BMB 532-544), student seminars (BMB 594 or 596), and Special Topics (BMB 580). 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, 8 or more credits in advanced courses), and a written thesis based on independent research (BMB 700). 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:

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>BMB 532</td>
<td>Bioenergetics and Membrane Transport</td>
<td>4</td>
</tr>
<tr>
<td>BMB 533</td>
<td>Enzyme Structure, Function and Mechanisms</td>
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<td>BMB 534</td>
<td>Instrumental Methods in Biophysics I</td>
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<td>BMB 540</td>
<td>Advanced Molecular Biology</td>
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<td>BMB 542</td>
<td>Molecular Cell Biology</td>
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Students must register for 12 credits per quarter. These credits typically include student seminars (BMB 594 or BMB 596), Department Seminar (BMB 591), and Research (BMB 600 or BMB 800).

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

**BMB 527 Biochemistry I: Proteins and Enzymes**
Primary, secondary and tertiary structure of proteins; enzyme mechanisms; enzyme kinetics. 4 credits

**BMB 528 Biochemistry II: Introduction to Molecular Biology**
DNA replication, RNA synthesis and protein synthesis; genetic code; gene regulation. 4 credits

**BMB 529 Biochemistry III: Metabolism and Bioenergetics**
Metabolism of carbohydrates, lipids and amino acids; bioenergetics; photosynthesis; oxidative phosphorylation. 4 credits

**BMB 532 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

**BMB 533 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 the 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

**BMB 534 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

**BMB 535 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 both instrumentation and computer simulation techniques. 4 credits

**BMB 537 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

**BMB 538 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

**BMB 539 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

**BMB 540 Advanced Molecular Biology**
An in-depth study of the molecular mechanisms governing the replication, recombination, transcription and translation of genetic material. Emphasis is on experimental approaches that have led to our understanding of these fundamental processes. 4 credits

**BMB 541 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

**BMB 542 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

**BMB 543 Current Topics in Proteomics**
Proteomics is an area of molecular biology which 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 2-dimensional gel electrophoresis, mass spectrometry (ESI-MS, MALDI-TOF), imaging and database. This course will focus on electrophoresis, mass spectrometry and applications, using lectures, student seminars and literature readings. 3 credits

**BMB 544 Introduction to Bioinformatics**
Primary literature of computational biology and hands-on experience in data manipulation from local and remote databases. 3 credits

**BMB 580 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

**BMB 591 Department Seminar: Biochemistry/Molecular Biology**
1 credit, repetitive

**BMB 594 Metabolic Biochemistry Student Seminar**
Presentations and discussions of selected topics from the recent literature and of ongoing research projects in the department. 2 credits, repetitive

**BMB 596 Molecular Biology/Biochemistry Student Seminar**
Presentation and discussion of journal articles from the recent literature in molecular biology, genetics and biochemistry. 2 credits, repetitive

**BMB 600 Research**
Supervised research participation. Variable and repetitive credit

**BMB 610 Nonthesis Research**
Supervised research as a component of the nonthesis M.S. degree. Variable and repetitive credit

**BMB 620 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. 4 credits

**BMB 700 M.S. Thesis Research**
Research toward the thesis for the M.S. degree. Variable and repetitive credit

**BMB 800 Ph.D. Dissertation Research**
Research toward the dissertation for the Ph.D. degree. Variable and repetitive credit

RESEARCH PROGRAMS

**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 neurotransmitters 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 workstation. Data for the latter two techniques are collected at national and international synchrotron radiation facilities. Proteins under investigation include dopamine-B 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 O₂ 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 cysteiny1 side chain (α-Tyr-Cys dimer). The catalytically active enzyme is an intense green color, the 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. Whitaker

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. Whitaker

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. Whitaker

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 andolfactory 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 male 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

Vibrational Spectroscopy of Metalloprotein Active Sites
We are interested in the structural and functional properties of metal ions in enzymes and proteins, and we use electronic, vibrational (especially IR) and EPR spectroscopy to characterize metal-ion active sites. Our laboratory has a sensitive, state-of-the-art Raman instrument: a fast spectograph with a liquid N₂-cooled CCD detector. We also use a combined FT-IR/FT-Raman instrument for protein and model compound studies. Our research focuses on heme (iron porphyrin), non-heme iron and copper enzymes and the roles of their metal ions in enzymatic catalysis. Of particular interest is the biochemistry of O₂. Metalloproteins are involved in O₂ binding (e.g., hemoglobin or hemocyanin) and in oxidative chemistry whereby O₂ is reduced and substrates are oxygenated or oxidized. The investigation of trapped reaction intermediates and model compounds helps us to unravel these complex processes and to define reaction mechanisms. The availability of site-directed mutants permits the alterations in structures and reactivities to be studied. Loehr

Heme Oxygenase
Heme oxygenase is a fascinating system that uses the O₂-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 resulting 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-NHi 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 University of Maryland, examine the structure and activity of several bacterial heme oxygenases. Loehr and Montanine-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 tyrosine 122 to its catalytically important neutral radical form; (ii) methane monoxygenase, 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 Fe³⁺ is oxidized to Fe⁴⁺. A common feature of these enzymes appears to be the formation of an initial peroxo intermediate upon exposure of the reduced enzyme to O₂. In the respiratory protein, hemerythrin, O₂ binding is accomplished by reduction to peroxide, and this reaction is readily reversible. However, 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 Melène-Llocoa

Interaction of Nitric Oxide with Metalloproteins

Nitric oxide (NO) is currently the subject of intense interest due to its role in a diverse range of biological processes. In mammals, it serves as a signaling molecule in the cardiovascular system. This discovery received the Nobel Prize for Medicine in 1998. In bacteria, NO is produced as an intermediate during denitrification — the process by which certain organisms convert nitrate through to N₂ or N₂O. 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 signaling molecule in the cardiovascular system.

This problem is being approached by structural studies on CPTI-polypeptides in the absence of a variety of spectroscopic, biochemical and kinetic techniques. Andrew

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 Neospora crassa arg-2 and Saccharomyces cerevisiae CPTI genes as models. These homologous genes encode the first enzyme in arginine biosynthesis and they are negatively regulated at both 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 CPTI 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 have recently begun 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

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

The rate-limiting step in β-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 CPTI. 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 L-CPTI 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-polyepitope in mammalian mitochondrial membranes. Our laboratory is the first to describe the genetic 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 membrane 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 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. Woldegorgis

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 limited. Molecular genetic and biochemical approaches are applied. 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
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

Prokaryotic Signal Transduction/Gene Regulation

Bacteria can respond in 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

Role of Chaperones/Proteases in the Control of Gene Expression

There is growing evidence that protein complexes that function in protein folding, remodeling and degradation interact directly with the molecular machinery that initiates gene expression. In mammalian, fungal and bacterial cells, components of ATP-dependent protease complexes have been implicated in the control of RNA polymerase activity through direct protein-protein interaction. In the spore-forming bacterium, *Bacillus subtilis*, developmentally regulated transcription during the early stages of sporulation, genetic competence development and antibiotic biosynthesis is profoundly affected by members of the heat shock protein family that normally function as chaperones and multi-component proteases. Evidence from our studies indicates that these proteins operate closely with RNA polymerase during the process of regulated transcription initiation. Our work is aimed at determining the nature of these interactions and their effects on the systems controlling bacterial developmental processes. Zuber

The Mitochondrial ATP-sensitive K+ Channel (mitoKATP)

MitoKATP 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 mitoKATP mediates the actions of potassium channel openers and ischemic preconditioning to protect the heart against ischemia-reperfusion injury. We are working to understand the mechanisms of this effect and the normal physiological role of mitoKATP in heart and brain. We introduced techniques for purification and reconstitution of mitoKATP in lipid vesicles and use this preparation to study the transport kinetics of the channel. We have purified the mitoKATP subunits to homogeneity and will use these to obtain the molecular structure of mitoKATP. 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

Biochemistry of Lignin Degradation

Lignin is the most abundant renewable aromatic polymer, constituting approximately 25 percent of woody plant cell walls. Our multidisciplinary 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 Mn4+ to Mn4+, 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 biorganic 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 are also studying several intracellular enzymes such as quinone reductases, ring-cleaning 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, we are elucidating the molecular mechanisms involved in Mn peroxidase gene regulation. We developed a transcriptional reporter system based on the gene encoding the green fluorescent protein from the jellyfish. Using this system, we are delineating the sequences in the mnp gene promoter involved in the Mn regulation of Mn peroxidase transcription. 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 nitrotoxines. We are...
examining the biochemical pathways, enzymes and regulatory mechanisms involved in the total degradation of these compounds. 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. 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.

Enzymes Involved in Cellulose Oxidation
Cellulose constitutes 40 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. Cellulose-degrading cultures of Phanerochaete chrysosporium produce a unique hemoflavoenzyme, cellubiose dehydrogenase (CDH), which oxidizes cellubiose to cellubionolactone. We have purified CDH to homogeneity in high yields. The amino acids responsible for heme ligation in CDH have been identified in our lab by site-directed mutagenesis, and in collaboration by solving the crystal structure of CDH. In addition, the amino acids in the flavin domain involved in the binding and oxidation of cellubiose have been identified by site-directed mutagenesis and kinetic studies.

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
- High-resolution mass spectrometer
- UV/VIS 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 spectrophotograph 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
FACULTY | BIOCHEMISTRY AND MOLECULAR BIOLOGY | BMB

FACULTY

NIJIAN J. BLACKBURN
Professor and Department Head
Ph.D., Inorganic Chemistry
University of Dundee, Scotland, U.K., 1975
ninian@bmb.ogi.edu

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

COLIN ANDREW
Research Assistant Professor
Ph.D., Chemistry
University of Newcastle Upon Tyne, 1992
candrew@bmb.ogi.edu

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

KEITH D. GARLID
Professor
M.D., The Johns Hopkins University School of Medicine, 1961
Dr. technicae norwegiensis, Physical Chemistry
Norwegian Institute of Technology, 1987
garlid@bmb.ogi.edu

RESEARCH INTERESTS
The structure-function of the mitochondrial ATP-sensitive K+ channel (mitoKATP) and its role in cardioprotection and cardiac physiology; the structure-function of uncoupling proteins; mitochondrial and cellular bioenergetics.

REPRESENTATIVE PUBLICATIONS

MICHAEL H. GOLD
Institute Professor
Ph.D., Biochemistry
State University of New York at Buffalo, 1970
mgold@bmb.ogi.edu

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
REPRESENTATIVE PUBLICATIONS


RESEARCH INTERESTS

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.

RESEARCH INTERESTS
Molecular biophysics of mitochondrial cation transporters and channels, with emphasis on Na+/Ca2+ antipporter and the ATP-dependent k+ channel in cardiac and brain mitochondria; receptor properties and their roles in cellular signaling, bioenergetics and pharmacology.

REPRESENTATIVE PUBLICATIONS


REPRESENTATIVE PUBLICATIONS

RESEARCH INTERESTS
Mammalian chemocommunication: the transport, olfactory and chemical signals of the elephant-unique temporal gland.

MARTINA RALLE
Research Scientist
Ph.D., Chemistry
University of Bonn, Germany, 1993
ralle@bmb.ogi.edu

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

JOANN SANDERS-LOEHRR
Professor Emeritus
Ph.D., Biochemistry
Cornell University, 1969

RESEARCH INTERESTS
Investigation of the role of metal ions in proteins by resonance Raman spectroscopy; oxygen activation and metabolism; active-site structures and redox reactions of iron proteins, copper proteins and quinone-containing proteins.

REPRESENTATIVE PUBLICATIONS


REPRESENTATIVE PUBLICATIONS

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
JOINT FACULTY

DAVID R. BOONE
Environmental Biology
Portland State University

JAMES M. CREGG
Keck Graduate Institute
of Applied Life Sciences

BERNARD A. FOX
Earle A. Chiles Research Institute
Providence Medical Center

STEPHEN B. HALL
Pulmonary and Critical Care Medicine
Oregon Health & Science University

JAMES F. PANKOW
Environmental Science and Engineering
OGI School of Science & Engineering

RICHARD L. STOUFFER
Oregon National Primate Research Center and Dept. of Physiology and Pharmacology
Oregon Health & Science University

PAUL G. TRATNYEK
Environmental Science and Engineering
OGI School of Science & Engineering

ADJUNCT FACULTY

G. DOYLE DAVES
Consultant

KENT HERMSMEYER
Oregon Regional Primate Research Center

JAMES K. HURST
Washington State University

GEORGE D. OLSEN
Oregon Health & Science University

V. RENGANATHAN
Consultant

CARL C. WAMSER
Portland State University

FACULTY | BIOCHEMISTRY AND MOLECULAR BIOLOGY | BMB

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THE DEPARTMENT OF BIOMEDICAL ENGINEERING, currently under development, is one of the promising outcomes of the merger of Oregon Health & Science University and the OGI School of Science & Technology. The merger, which took place on July 1, 2001, created the OGI School of Science & Engineering, where the Department of Biomedical Engineering is housed. Formation of the department has been approved, the curriculum is currently under development, and recruitment has begun for a department head and additional faculty. Admission to the Ph.D. program is expected to begin no later than the fall of 2003.

The program of study will include a core curriculum, electives tailored to specific areas of research, and hands-on research in existing or new laboratories within OHSU. Our vision is to build a nontraditional, first-rate biomedical research and educational program that will prepare students and working professionals for careers in academia or industry.

The existing program in Biomedical Engineering offered through OGI’s Department of Electrical and Computer Engineering (ECE) will be incorporated into the new department. See ECE section for details on this program.

OVERVIEW

The interface between the rapidly changing fields of health, science and technology is a frontier where developments of great importance to human health are emerging. Advances in these high-tech areas are creating new ways for technology to support health care. Although traditional bioengineering areas continue to be important, recent scientific and technological advances in computational neuroscience, tissue engineering, sensor technology, molecular biology, functional genomics, biomaterials, and biological and medical informatics, together with Oregon’s pioneering spirit, will enable us to define a unique bioengineering program to support future clinical medicine and health care delivery.

Biomedical engineering incorporates many fields, including various engineering disciplines, basic science and clinical science. The Department of Biomedical Engineering will be multidisciplinary entity bringing these fields together in a multifaceted culture with a unified vision for research and training. These characteristics will position us to capitalize not only on existing strengths and collaborations but also on opportunities in emerging areas at the interface between medicine and engineering.

RESEARCH

BIOMEDICAL OPTICS

Research in Biomedical Optics is focused on the development of uses for lasers and light in medicine and biology. Examples of ongoing applications in this well-established research program include the use of lasers in clinical diagnosis, nondestructive evaluation of tissues, optical imaging of disease, and light-activated chemotherapy for cancer. Facilities include those for both clinical application and basic research.

CARDIOVASCULAR BIOENGINEERING

Cardiovascular bioengineering (CBE) is a growing area of interest at OHSU. The CBE program will encompass the major areas of cardiovascular biology using engineering tools for investigation. These will include cardiac and vessel behavior, computational fluid dynamics, electrocardiography and electrical signal processing, laser thrombolysis, 4-D embryo modeling, functional magnetic resonance imaging, ultrasound technology and shear stress gene expression modeling.

GENOMICS

Genomics is the study of all the nucleotide sequences in the chromosomes of an organism, including structural genes, regulatory sequences and noncoding DNA segments. The term genomics is also popularly used to include the study of...
relationships between gene structure and biological function on a genome-wide scale. The phenotype of an individual or organism is dependent on the information stored in the chromosomal DNA and expressed during development. Mutations in the germ-line DNA may cause inherited disease or abnormal development. Perturbations in gene regulation during development and adulthood may lead to physiological changes and disease. Genomic research in the Department of Biomedical Engineering involves the identification of the genetic bases of inherited diseases such as Alzheimer’s and Parkinson’s disease, and the genome-wide study of genes and their functions using state-of-the-art techniques such as expression profiling with high-density microarrays.

IMAGING
Magnetic resonance imaging has emerged as a powerful tool for basic and clinical research on the biology of normal and abnormal tissue function, as well as for the diagnosis and treatment of disease. In conjunction with the OHSU Advanced Imaging Research Center, core faculty in biomedical engineering will be hired with research specializations in MR physics, pulse sequence design, image analysis, and tissue structure and tissue dynamics. In addition, a wide range of faculty across the OHSU campus apply a variety of imaging techniques to their basic and clinical research in areas such as neuroscience, cardiology and oncology. Thus, students will have opportunities to develop research and applications in a variety of imaging research settings.

INFORMATICS
Informatics activities at OHSU are wide ranging. Currently they include: managing and analyzing gene expression data, programs in medical informatics and outcomes research, database research, networks and embedded systems and techniques for 3-D visualization. The BME department will serve as a focus for developing technologies that leverage this expertise in such areas as computational bioengineering, medical visualization, integration of genomic and medical information, home health networking and hybrid instrumentation. BME will also contribute to existing curricula in bioinformatics.

NEUROENGINEERING
Basic neuroscience research, clinical neurology and neurosurgery are strong programs within OHSU. The existence of a department of biomedical engineering in this center of neuroscience research and clinical medicine creates rich opportunities for biomedical engineers. They can work with neuroscientists and clinicians to apply emerging scientific knowledge in the development of processes and devices needed for the diagnosis, assessment and treatment of neurological disorders and diseases. Ongoing research opportunities range from very basic molecular biophysics and modeling to systems analysis to drug delivery systems, neuroprosthetics and neurosurgical devices.

POINT-OF-CARE BIOMEDICAL ENGINEERING
Research in this area is focused on the development of health care delivery systems suitable for use in homes, assisted living facilities and other residential settings. Application areas include processes and technologies for the monitoring, evaluation and treatment of people disabled by aging, chronic disease or disability. Research challenges include the development of unobtrusive sensors, wireless communication of multi-rate signals, processing and fusion of signals from multitudes of noisy sensors, and ubiquitous perceptual interfaces.

REHABILITATION AND BIOMECHANICS
Many diseases and disorders of muscle, bone and nervous system result in treatment, immobilization, healing and then rehabilitation. Basic and applied research in the Department of Biomedical Engineering focuses on the normal and abnormal control of movement and musculoskeletal biology. This research is multidisciplinary and highly collaborative with both clinical and basic science departments at OHSU. Currently active research by our faculty has resulted in the development of novel therapeutic devices and procedures that are tested on patient groups provided by collaborating clinicians.

TISSUE ENGINEERING AND BIOMATERIALS
Research in tissue engineering and biomaterials is represented by a multidisciplinary group of materials scientists, biomedical and tissue engineers, chemists, physiologists, dentists and physicians. Faculty projects include the following research: physical biomechanics of dental and orthopedic implants, computational biomechanics of dental implants, dental restorations and vascular stents, dissolution and volatilization from dental alloys, noninvasive and nondestructive evaluation of engineered tissues, laser welding of tissues, natural, protein-based biomaterials, polymer mechanics, micromechanics of biocomposites, thermal analysis, tribology, collagen and other biocomposites, skin scaffolds, bone healing and vascular grafts.
FACULTY
ANTÓNIO BAPTISTA, PH.D.
NINIAN BLACKBURN, PH.D.
KIM BURCHIEL, M.D.
PAUL CORDO, PH.D.
DAVID DAWSON, PH.D.
J. JOB FABER, M.D., PH.D.
JACK L. FERRACANE, PH.D.
BRAHM N. GOLDSTEIN, M.D.
DAN HAMMERSTROM, PH.D.
HYNEK HERMANSKY, PH.D.
MONICA HINDS, PH.D.
JAMES HOOK, PH.D.
FAY HORAK, PH.D.
MARWAN JABRI, PH.D.
STEVE JACQUES, PH.D.
JERI JANOWSKY, PH.D.
SEAN J. KIRKPATRICK, PH.D.
TODD LEEN, PH.D.
JANE MACPHERSON, PH.D.
DAVID MAIER, PH.D.
EDWARD NEUWELT, M.D.
ALFRED L. NUTTALL, PH.D.
MISHA PAVEL, PH.D.
(INTERIM DEPARTMENT HEAD)
ROBERT J. PETERKA, PH.D.
SCOTT PRAHL, PH.D.
SUSAN PRICE, M.D.
P. HEMACHANDRA REDDY, PH.D.
PATRICK ROBERTS, PH.D.
WILLIAM ROBERTS, PH.D.
DAVID J. SAHN, M.D.
RON SAKAGUCHI, D.D.S., PH.D.
MARIE SHEA, M.S.
XUBO SONG, PH.D.
KENT L. THORNBURG, PH.D.
GARY WESTBROOK, M.D.
THE DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING has an internationally acclaimed research program. The breadth and depth of the research is apparent in the research projects and research centers listed below, and in 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, we offer certificates 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
  * APC 515, Data Structures and Discrete Mathematics, may be taken to meet the prerequisite.

ADVANCED PLACEMENT ADMISSIONS FOR M.S. STUDENTS

Students who are currently studying at the OGI School 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 M.S. Core (list follows). Students must earn an overall Grade Point Average of 3.0 and a B or better in each M.S. Core class to be eligible to apply through Advanced Placement:

- CSE 500 Introduction to Software Engineering
- CSE 511 Principles of Compiler Design
- CSE 513 Introduction to Operating Systems
- CSE 514 Introduction to Database Systems
- CSE 521 Introduction to Computer Architecture
- CSE 532 Analysis and Design of Algorithms
- CSE 533 Automata and Formal Languages

If a student applies to the Computational Finance program through advanced placement, the 12 credits earned must include two courses from the Finance Core, together with relevant CSE, ECE, APC or FIN courses.

DEGREE REQUIREMENTS

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

A maximum of 21 credits earned before 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 M.S. 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 (CSE 620).

MASTER OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

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

M.S. CSE CORE COURSES

- CSE 500 Introduction to Software Engineering 3 credits
- CSE 511 Principles of Compiler Design 3 credits
- CSE 513 Introduction to Operating Systems 3 credits
- CSE 514 Introduction to Database Systems 3 credits
- CSE 521 Introduction to Computer Architecture 3 credits
- CSE 532 Analysis and Design of Algorithms 3 credits
- CSE 533 Automata and Formal Languages 3 credits

CSE scientists are using the robotic-controlled "Timbot" to test software that may one day guide robotic vehicles such as cars, buses or airplanes.
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. SOFTWARE ENGINEERING CORE (15 credits)

Required:
CSE 504 Object-Oriented Analysis and Design 3 credits
CSE 58X Any special topics course appropriate to this area

3. SUGGESTED ELECTIVES (12 credits)

Choose four:
CSE 548a Statistical Computing I 2 credits
CSE 555a Mathematical Methods 2 credits
CSE 555b Stochastic Calculus 2 credits
CSE 556a Simulation 2 credits
CSE 556b Modern Optimization Techniques 2 credits
CSE 564 Human-Computer Interaction 3 credits
CSE 566a Empirical Research Methods 3 credits
CSE 58X Special Topics 3 credits
ECE 525 Analytical Techniques in Process and Communication 4 credits
ECE 555 Engineering Optimization 4 credits

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

COMPUTATIONAL FINANCE

1. M.S. CSE CORE (listed above)
2. COMPUTATIONAL FINANCE CORE (16 credits)

Required (choose four):
FIN 541 Principles of Modern Finance 4 credits
FIN 544 Investment and Portfolio Management 4 credits
FIN 551 Options and Futures I 4 credits
FIN 552 Options and Futures II 4 credits
FIN 561 Risk Management 4 credits
FIN 573 Financial Time-Series Analysis 4 credits

3. SUGGESTED ELECTIVES (8 credits)

CSE 509 Object-Oriented Programming 3 credits
CSE 540 Neural Network Algorithms and Architecture 3 credits
CSE 544a Probability and Statistics I 2 credits
CSE 544b Probability and Statistics II 2 credits
CSE 545 Advanced Neural and Adaptive Algorithms 3 credits
CSE 546 Data and Signal Compression 3 credits
CSE 547 Statistical Pattern Recognition 3 credits
CSE 548a Statistical Computing I 2 credits
CSE 548b Statistical Computing II 2 credits
CSE 549b Applied Business Forecasting 4 credits
CSE 555a Mathematical Methods 2 credits
CSE 555b Stochastic Calculus 2 credits

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

DATA-INTENSIVE SYSTEMS

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

Choose four:
CSE 515 Distributed Computing Systems 3 credits
CSE 526 Modern Operating System Design 3 credits
CSE 541 Database Implementation 3 credits
CSE 542 Object Data Management 3 credits
CSE 58X Informational Retrieval and the Internet 3 credits
CSE 58X 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 CSE 504 and OMSE 533.

HUMAN-COMPUTER INTERFACES

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

Required:
CSE 560 Artificial Intelligence 3 credits
CSE 564 Human-Computer Interaction 3 credits

Choose four:
CSE 547 Statistical Pattern Recognition 3 credits
CSE 561 Dialogue 3 credits
CSE 562 Natural Language Processing 3 credits
CSE 563 Multi-Agent Systems 3 credits
CSE 567 Developing User-Oriented Systems 3 credits
CSE 568 Empirical Research Methods 3 credits
CSE 58X Any special topics course appropriate to this area

ECE 58X Hidden Markov Models for Speech Recognition 4 credits
ECE 58X Structure of Spoken Language 4 credits

3. SUGGESTED ELECTIVES (6 credits)

CSE 507 Logic Programming 3 credits
CSE 515 Distributed Computing Systems 3 credits
CSE 540 Neural Network Algorithms & Architecture 3 credits
CSE 569 Scholarship Skills 3 credits

(or) any CSE class not already taken.

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

SOFTWARE ENGINEERING

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

Required:
CSE 503 Software Engineering Processes 3 credits
CSE 504 Object-Oriented Analysis and Design 3 credits
CSE 569 Object-Oriented Programming 3 credits

(or) any CSE class not already taken.

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

NINE AREAS OF EMPHASIS

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

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

Required:
CSE 547 Statistical Pattern Recognition 3 credits
CSE 560 Artificial Intelligence 3 credits

Choose two:
CSE 540 Neural Network Algorithms and Architecture 3 credits
CSE 545 Advanced Neural and Adaptive Algorithms 3 credits
CSE 546 Data and Signal Compression 3 credits
CSE 548a Statistical Computing I 2 credits
CSE 550 Spoken Language Systems 3 credits
CSE 562 Natural Language Processing 3 credits
CSE 564 Human-Computer Interaction 3 credits
CSE 568 Empirical Research Methods 3 credits
CSE 58X Special Topics 3 credits
CSE 58X Any special topics course appropriate to this area

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

COMPUTER SECURITY

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

Required:
CSE 503 Software Engineering Processes 3 credits
CSE 524 TCP/IP Internetworking Protocols 3 credits
CSE 527 Principles and Practices of System Security 3 credits
CSE 58X Cryptography 3 credits
CSE 58X Building Secure Systems 3 credits

3. SUGGESTED ELECTIVES (9 credits)

Choose four:
CSE 515 Distributed Computing Systems 3 credits
CSE 58X Any special topics course appropriate to this area

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

SOFTWARE ENGINEERING

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

Required:
CSE 503 Software Engineering Processes 3 credits
CSE 504 Object-Oriented Analysis and Design 3 credits
CSE 569 Object-Oriented Programming 3 credits

(or) any CSE class not already taken.

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

NINE AREAS OF EMPHASIS

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

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

Required:
CSE 547 Statistical Pattern Recognition 3 credits
CSE 560 Artificial Intelligence 3 credits

Choose two:
CSE 540 Neural Network Algorithms and Architecture 3 credits
CSE 545 Advanced Neural and Adaptive Algorithms 3 credits
CSE 546 Data and Signal Compression 3 credits
CSE 548a Statistical Computing I 2 credits
CSE 550 Spoken Language Systems 3 credits
CSE 562 Natural Language Processing 3 credits
CSE 564 Human-Computer Interaction 3 credits
CSE 568 Empirical Research Methods 3 credits
CSE 58X Special Topics 3 credits
CSE 58X Any special topics course appropriate to this area

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

COMPUTER SECURITY

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

Required:
CSE 503 Software Engineering Processes 3 credits
CSE 524 TCP/IP Internetworking Protocols 3 credits
CSE 527 Principles and Practices of System Security 3 credits
CSE 58X Cryptography 3 credits
CSE 58X Building Secure Systems 3 credits

3. SUGGESTED ELECTIVES (9 credits)

Choose four:
CSE 515 Distributed Computing Systems 3 credits
CSE 58X Any special topics course appropriate to this area

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

SOFTWARE ENGINEERING

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

Required:
CSE 503 Software Engineering Processes 3 credits
CSE 504 Object-Oriented Analysis and Design 3 credits
CSE 569 Object-Oriented Programming 3 credits

(or) any CSE class not already taken.

Please note: Students may not receive credit for both CSE 504 and OMSE 533.
MST 512  Project Management  3 credits
CSE 564  Human-Computer Interaction  3 credits
CSE 567  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 CSE 504 and OMSE 533.

SOFTWARE ENGINEERING FOR INDUSTRY PROFESSIONALS

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

Required:
OMSE 511  Managing Software Development  3 credits
OMSE 521  Using Metrics and Models  3 credits
OMSE 531  Software Requirements Engineering  3 credits
OMSE 533  Software Design Techniques  3 credits

Choose one:
CSE 564  Human-Computer Interaction  3 credits
CSE 567  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 CSE 504 and OMSE 533.

SPOKEN LANGUAGE SYSTEMS

1. M.S. CSE CORE (listed above)
2. SPOKEN LANGUAGE SYSTEMS CORE (12-16 credits)

Choose three:
CSE 550  Spoken Language Systems  3 credits
CSE 561  Dialogue  3 credits
CSE 562  Natural Language Processing  3 credits
ECE 541  Speech Processing  3 credits
ECE 545  Speech Systems  4 credits
ECE 58X  Hidden Markov Models for Speech Recognition  4 credits
ECE 58X  Speech Synthesis  4 credits
ECE 58X  Structure of Spoken Language 4 credits

Choose one of the following or one more from the above list:
CSE 540  Neural Network Algorithms & Architectures  3 credits
CSE 545  Advanced Neural & Adaptive Algorithms  3 credits
CSE 547  Statistical Pattern Recognition  3 credits
CSE 560  Artificial Intelligence  3 credits
CSE 564  Human Computer Interaction  3 credits
CSE 568  Empirical Research Methods  3 credits
ECE 540  Auditory & Visual Processing by Human & Machine  4 credits
ECE 544  Introduction to Signals, Systems and Information Processing  4 credits
ECE 551  Introduction to Digital Signal Processing  4 credits
ECE 552  Digital Signal Processing II  4 credits
ECE 554  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

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

Choose four:
CSE 515  Distributed Computing Systems  3 credits
CSE 524  TCP/IP Internetworking Protocols  3 credits
CSE 526  Modern Operating System Design  3 credits
CSE 527  Principles and Practices of System Security  3 credits
CSE 541  Database Implementation  3 credits
CSE 58X  Internet Technology  3 credits
CSE 58X  Multi-Media Networking  3 credits
CSE 58X  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

COMPUTATIONAL FINANCE PROGRAM DIRECTOR
David Basterfield
503 748-1153
E-mail: basterfield@cse.ogi.edu

PROGRAM ADMINISTRATOR
Shelly Charles
503 748-1257
E-mail: shelly@cse.ogi.edu

The M.S. in Computational Finance is an interdisciplinary program offering students the flexibility to learn technical skills directly relevant to quantitative and computational work in the finance industry. A professional internship track is available (see below).

The student must obtain 48 credits, consisting of 24 credits from the finance core and 24 credits from elective courses. Certificate in Computational Finance available upon completion of four of these courses.

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

FIN 541  Principles of Modern Finance  4 credits
FIN 544  Investment and Portfolio Management  4 credits
FIN 551  Options and Futures I  4 credits
FIN 552  Options and Futures II  4 credits
FIN 561  Risk Management  4 credits
FIN 573  Financial Time Series Analysis  4 credits

2. BREADTH REQUIREMENT (21 CREDITS)

Students may take elective finance courses and electives from other departments at OGI. However, the breadth requirement for the degree is that at least 20 electives must come from at least two of the non-finance tracks. The course lists for each track are representative, not exhaustive. Students may request approval to substitute other OGI courses in place of those listed below.

A. ADVANCED TRAINING IN FINANCE

FIN 547  Global Markets and Foreign Exchange  2 credits
FIN 576  Financial Markets and Trading  2 credits
FIN 558  Advanced Numerical Computing in Finance  2 credits
FIN 58X  Special topics in Computational Finance

B. APPLIED COMPUTING

(Applied Computing Certificate available upon completion of four of these courses)
APC 500a  Introduction to Visual Basic for Applications  2 credits
APC 500b  Advanced Visual Basic for Applications  2 credits
APC 501a  Accelerated Development with Visual Basic I  2 credits
APC 501b  Accelerated Development with Visual Basic II  2 credits
APC 503a  Introduction to Perl Programming  2 credits
APC 503b  Web Development with Perl  2 credits
APC 505a  Applications Programming in C++ I  2 credits
APC 505b  Applications Programming in C++ II  2 credits
APC 506a  Advanced Applications Programming in C++  2 credits
APC 506b  Numeric Programming in C++  2 credits
APC 508a  Applications Programming in Java I  2 credits
APC 508b  Applications Programming in Java II  2 credits
APC 511  Computational Tools  2 credits

C. COMPUTER SCIENCE

CSE 500  Principles of Software Engineering  3 credits
CSE 504  Object-Oriented Analysis and Design  3 credits
CSE 509  Object-Oriented Programming  3 credits
CSE 514  Introduction to Database Systems  3 credits

D. APPLIED MATHEMATICS, STATISTICS AND MACHINE LEARNING

CSE 540  Neural Network Algorithms and Architectures  3 credits
CSE 544a  Probability and Statistics I  2 credits
CSE 544b  Probability and Statistics II  2 credits
CSE 547  Statistical Pattern Recognition  3 credits
CSE 548a  Statistical Computing I  2 credits
CSE 548b  Statistical Computing II  2 credits
CSE 549D  Applied Business Forecasting  4 credits
CSE 555a  Mathematical Methods  2 credits
CSE 555b  Stochastic Calculus  2 credits
CSE 556a  Simulation  2 credits
CSE 556b  Modern Optimization Techniques  2 credits
Foundation Requirements (18 Credits)

Required:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CSE 513 Introduction to Operating Systems</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 521 Introduction to Computer Architecture</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 532 Analysis and Design of Algorithms</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 533 Automata and Formal Languages</td>
<td>3 credits</td>
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Choose one programming language course:

<table>
<thead>
<tr>
<th>Course</th>
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<tbody>
<tr>
<td>CSE 502 Functional Programming</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 507 Logic Programming</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 509 Object-Oriented Programming</td>
<td>3 credits</td>
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<tr>
<td>CSE 531 Foundations of Semantics</td>
<td>3 credits</td>
</tr>
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Choose one interactive and adaptive systems course:

<table>
<thead>
<tr>
<th>Course</th>
<th>Credits</th>
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<tbody>
<tr>
<td>CSE 540 Neural Network Algorithms and Architectures</td>
<td>3 credits</td>
</tr>
<tr>
<td>Course Code</td>
<td>Course Title</td>
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<tr>
<td>CSE 560</td>
<td>Artificial Intelligence</td>
</tr>
<tr>
<td>CSE 564</td>
<td>Human-Computer Interaction</td>
</tr>
</tbody>
</table>

**AREA REQUIREMENTS (18 CREDITS)**

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

**ADAPTIVE SYSTEMS AND APPLICATIONS**

<table>
<thead>
<tr>
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<th>Credits</th>
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<tbody>
<tr>
<td>CSE 540</td>
<td>Neural Network Algorithms and Architectures</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 545</td>
<td>Advanced Neural and Adaptive Algorithms</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 546</td>
<td>Data and Signal Compression</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 547</td>
<td>Statistical Pattern Recognition</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 568</td>
<td>Empirical Research Methods</td>
<td>3 credits</td>
</tr>
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**SYSTEMS SOFTWARE**

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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</thead>
<tbody>
<tr>
<td>CSE 511</td>
<td>Principles of Compiler Design</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 512</td>
<td>Compiling Functional Languages</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 518</td>
<td>Software Design and Development</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 530</td>
<td>Introduction to Mathematical Logic</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 531</td>
<td>Foundations of Semantics</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 567</td>
<td>Developing User-Oriented Systems</td>
<td>3 credits</td>
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**THEORY**

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<tr>
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<tbody>
<tr>
<td>CSE 550</td>
<td>Introduction to Database Systems</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 551</td>
<td>Distributed Computing Systems</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 552</td>
<td>TCP/IP Internetworking Protocols</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 556</td>
<td>Modern Operating System Design</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 557</td>
<td>Principles and Practices of System Security</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 558</td>
<td>Database Implementation</td>
<td>3 credits</td>
</tr>
<tr>
<td>CSE 559</td>
<td>Object Data Management</td>
<td>3 credits</td>
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**COURSE DESCRIPTIONS**

**CSE 500 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.

**CSE 520 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 imperative and object-oriented languages. This course introduces the student to functional notation, recursion, higher-order functions, reasoning about functions, and their parameterized 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.

**CSE 521 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.

**CSE 504 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 500 Object-Oriented Programming is intended as a follow-on course for CSE 504.

**CSE 507 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.

**CSE 509 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.

**CSE 511 Principles of Compiler Design**

This course introduces the basics of building a com-
CSE 512 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

CSE 513 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

CSE 514 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, SQL, relational algebra, 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 mathe-matics and mathematical logic. 3 credits

CSE 515 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: CSE 513, Introduction to Operating Systems. (Also a basic understanding of computer communications problems and protocols.) 3 credits

CSE 518 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 to be covered include program refactor- ing, 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 design and implementation experience. 3 credits

CSE 520 Advanced Computer Architecture
This course is a follow-up to CSE 521. It covers advanced computer architecture topics such as SMP (Shared Memory Multiprocessors) and NUMA (Non-Uniform Memory Access) Architectures. It also looks at new trends in designing high-performance clusters with examples. Specific topics to be covered include: fundamentals of parallel architectures (communication paradigms, programming models, etc.), snoopy-based multiprocessors (cache coherency, bus designs, multilevel caches, etc.), directory-based multiprocessors (NUMA and hybrid architectures), interconnection networks (routing, switch designs, virtual lanes, etc.). Examples of commercial and prototype architectures such as IBM NUMAQ, InfiniBandTM and ServerNet. Prerequisite: CSE 521. 3 credits

CSE 524 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. Provides architectural insight into protocol design issues and operating system implementation techniques, typically in terms of the Berkeley UNIX socket programming model. Provides 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 PSU’s CS 533; familiarity with C programming on modern UNIX computers. 3 credits

CSE 526 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, work-station clusters, adaptive resource management and OS support for multimedia systems. Prerequisites: CSE 513 and CSE 521. 3 credits

CSE 527 Principles and Practices of System Security
In the Internet age, host system security is essential and difficult. This course explains 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

CSE 530 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

CSE 531 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

CSE 532 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 com-
utational geometry, matrix manipulations, string and pattern matching, set algorithms, polynomial computations and the fast Fourier transform. Prerequisites: Data structures and discrete mathematics. 3 credits

CSE 533 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

CSE 534 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. Prerequisite: CSE 532 or CSE 533. 3 credits

CSE 535 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, monoids 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

CSE 540 Neural Network Algorithms and Architectures
This course introduces the fundamentals of connectionist and neural network models. Paradigms for supervised, unsupervised and reinforcement learning are covered. Topics include LMS and backpropagation algorithms, network optimization techniques, theoretical and practical tools to address generalization and complexity control, principal components and independent component analysis, mixture models and clustering. The course aims to develop the student's statistical understanding of the use of neural network techniques. Applications to classification, time series prediction, regression and data clustering are treated using real world data. 3 credits

CSE 541 Database Implementation
This course provides hands-on experience implementing database management systems. Typical topics discussed include benchmarking, transaction processing, file and index implementation, 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

CSE 542 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, implementation and benchmarking techniques. Students will do a project using a commercial product. Prerequisite: CSE 514 or other introductory database course. 3 credits

CSE 544a Probability and Statistics I
This course introduces probability and statistical inference. It examines such topics as the elements of probability, exploratory data analysis, sampling theory, hypothesis testing, linear regression, goodness-of-fit tests and maximum likelihood estimation. The primary analysis tools for this course are S-PLUS, SAS or MATLAB. Prerequisites: Knowledge of calculus, linear algebra and basic differential equations. 3 credits

CSE 544b Probability and Statistics II
This course explores further concepts in probability and statistical inference and builds on the material covered in FIN 521. The course examines topics such as Bayesian inference, nonparametric tests and design of experiments. The primary analysis tools for this course are S-PLUS, SAS or MATLAB. Prerequisite: CSE 544a, Probability and Statistics I, or equivalent. 2 credits

CSE 545 Advanced Neural and Adaptive Algorithms
An advanced treatment of architectures and algorithms for pattern recognition, regression, time-series prediction and data mining. 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. Prerequisite: CSE 540 or instructor permission. 3 credits

CSE 546 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, etc.), 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 interests. Prerequisites: Undergraduate calculus, introductory probability and statistics, some programming experience. 3 credits

CSE 547 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 theoretical and practical tools 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, model-based clustering, feature extraction for dimensionality reduction and for classification. 3 credits

CSE 548a Statistical Computing I
This course introduces modern applied statistics. Topics will be selected from distributions and data summaries, density estimation, generalized linear models, modern nonlinear regression, robust statistics, factor analysis, linear and nonlinear classifiers. The goal is to provide a solid understanding of practical statistical inference methods and proficiency in using modern statistical tools. The primary analysis tools for this course are S-PLUS or SAS. Prerequisite: CSE 544a, Probability and Statistics I, and CSE 555b, Mathematical Methods, or equivalent. 2 credits
CSE 548b Statistical Computing II
This course explores further concepts in modern applied statistics and builds on the material covered in CSE 548a. The course examines topics such as Bayesian classifiers, cluster analysis, decision trees, ensemble learning methods and cross-validation techniques. The goal is to provide a solid understanding of practical statistical inference methods and proficiency in using modern statistical tools. The primary analysis tools are S-PLUS, SAS or MATLAB. Prerequisite: CSE 548a, Statistical Computing I, or equivalent. 2 credits.

CSE 549D Applied Business Forecasting
This Web-based course in applied business forecasting emphasizes generating and implementing business forecasts. It is designed for students who want to know how forecasts are actually developed and utilized, emphasizing modern statistical methods widely used to generate business forecasts. Specific applications to business include forecasting sales, production, inventory, macroeconomic factors such as interest rates and exchange rates, and other aspects of both short- and long-term business planning. Topics include a statistical review, data considerations, model selection, moving averages and exponential smoothing, regression analysis, time-series decomposition, Box-Jenkins (ARIMA) models, optimal forecast combination and forecast implementation. The course utilizes Microsoft Excel-based ForecastX Software for Windows, which accompanies Wilson and Keating’s Business Forecasting (McGraw Hill-Irwin, 4th Edition). Prerequisite: Knowledge of basic statistics and regression analysis is highly recommended but not required. 4 credits.

CSE 550 Spoken Language Systems
Spoken language systems are already being deployed to help people find flight information, trade stock, access e-mail and learn traffic conditions. With the continuing advancements in speech technology, more information and services will become readily available. A simple cell phone will be enough to hook into the information age. This course teaches the fundamentals of spoken language systems. These systems include components for speech recognition, natural language understanding, dialogue management, text generation, speech synthesis and agent architecture. We will examine alternative approaches for doing each of these tasks in terms of their benefits and limitations in building a complete system. Students will combine these technologies to build working spoken dialogue systems, ranging in complexity from simple fill-in-the-slot dialogues, to mixed initiative dialogues, where the user and system work together to accomplish some task. Class projects will be done using the CSLU toolkit, Tcl/Tk, and VoiceXML. 3 credits.

CSE 555a Mathematical Methods
This course reviews the essential mathematical methods required for quantitative analysis in engineering and finance. It examines a selection of topics such as multivariate calculus, differential equations and mathematical 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. 2 credits.

CSE 555b Stochastic Calculus
This course explores the essential mathematical concepts underlying stochastic calculus (continuous stochastic processes). We will cover topics such as stochastic processes, Itô integrals, Itô calculus, martingales and stochastic control. 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: CSE 555a, Mathematical Methods, and CSE 544a, Probability and Statistics I, or equivalent. 2 credits.

CSE 556a Simulation
This course introduces modern, advanced numerical methods for quantitative work in engineering, finance and operations research, focusing on Monte Carlo Simulation. Topics covered include pseudorandom and quasi-random number generators, continuous-time and discrete-event simulation, generation of stochastic processes, variance reduction techniques, bootstrapping, jackknife and other statistical techniques. Students will 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, and CSE 544a, Probability and Statistics I, or equivalent. 2 credits.

CSE 556b Modern Optimization Techniques
This course introduces modern, advanced numerical methods for quantitative work in engineering, finance and operations research, focusing on optimization techniques. We will briefly review traditional methods, such as hill-climbing and dynamic programming, and study in detail new heuristic techniques such as genetic algorithms, differential evolution, simulated annealing, and ant colony and swarm optimization. Students will be introduced to mathematical modeling, and will 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, and CSE 555a, Mathematical Methods, or equivalent. 2 credits.

CSE 560 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.

CSE 561 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.

CSE 562 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.

CSE 563 Multagent Systems
This course covers the emerging theory and practice of multiagent 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 multiagent 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 multiagent system. 3 credits.

CSE 564 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 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.
CSE 567 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

CSE 568 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 or needs to evaluate critically the research of others. Students participate in designing and analyzing data to answer scientific questions and present the results of these activities both orally and in writing.

3 credits

CSE 569 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, how to organize 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

CSE 600 Research
Supervised research activity.

Variable and repetitive credit.

CSE 610 Non-thesis Research
Supervised research for up to 6 credits as a component of the non-thesis master's degree. Students are required to produce concrete research deliverables, including a final report equivalent to a CSE technical report. Each 3 credits of CSE 610 may count as one class to fulfill the M.S. non-thesis graduation requirements.

CSE 620 Professional Internship
These courses provide 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 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

CSE 700 M.S. Thesis Research
Research toward the thesis for the M.S. degree.

Variable and repetitive credit.

CSE 800 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree.

Variable and repetitive credit.

FIN 541 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. In addition, students will learn the nuances of valuing a business. The principal goal of the course is to provide an intuitive foundation of modern finance upon which the student can apply advanced computational techniques. This is accomplished through interaction between the text, instructor, case studies, MATLAB assignments and student presentations/discussions.

4 credits

FIN 544 Investment and Portfolio Management
This course applies quantitative investment analysis in a systematic attempt to outperform the market benchmark. Accordingly, it begins with the tools of traditional investment analysis, such as asset valuation, efficient markets, mean-variance portfolio theory, efficient set mathematics, CAPM and APT, and proceeds to the new discipline of active portfolio management. Specifically, the course examines advanced quantitative portfolio management procedures that are increasingly employed by portfolio and money managers worldwide. Topics include advanced risk modeling, forecasting exceptional returns, constructing and implementing active portfolios, hedge portfolios, and observing and refining portfolio performance. This course requires outside case studies using MATLAB and BARRA On-Campus.

4 credits

FIN 547 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. Course assignments make use of MATLAB.

2 credits

FIN 551 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 on 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 methods. Course assignments require use of MATLAB.

4 credits

FIN 552 Options and Futures II
A continuation of FIN 551, 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. Emphasis is on pricing fixed-income derivatives, credit derivatives and exotic options using numerical solution methods such as finite difference methods, lattice methods and Monte Carlo simulation. Equilibrium and no-arbitrage term structure models for interest rates are presented, from Vasicek through Heath-Jarrow-Morton. In addition, we examine the issues of model calibration and estimation. The course builds on the concepts of stochastic calculus that were covered in FIN 551. Additional topics include arbitrage pricing, equivalent martingale measures and risk neutral valuation. Course assignments require the use of MATLAB. Prerequisite: FIN 551 Options and Futures I, or permission of instructor.

4 credits

FIN 558 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, projectors-SOR method for American options, numerical methods for stochastic differential equations, random number generators, Monte-Carlo methods for European and least-squared Monte-Carlo methods for American options. The course is lab oriented. Prerequisite: FIN 552, Options and Futures II, or permission from instructor.

2 credits

FIN 561 Risk Management
This course explores various aspects of quantitative risk management. Emphasis is on evaluating financial risk using value-at-risk (VAR) models and investigating the growing markets for credit risk derivatives. In addition, applications to energy risk management and insurance are discussed. Specific topics include sources and measurement of risk exposure, methods for calculating value at risk.
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.

APC 500a Introduction to 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 Object-Oriented Programming, the structure of the VBA programming language and built-in functions, enhancing recorded macros using VBA code, introducing the MS Office object models. Prerequisite: Knowledge of a programming language. 2 credits

APC 503a Developing Web Applications with Perl
This course explores how to develop database-driven web applications using CGI and Perl. Topics include HTML refresher, basics of CGI (forms, actions, dynamic forms and sticky fields), advanced CGI (authentication, cookies, client-pull refresh and sessions), CGI security, persistent storage mechanisms (client-side and server-side), and an overview of Perl database access (with SQL). On completion, students will be able to develop web applications with server side automation. Prerequisite: APC 503a, Introduction to Perl programming, or equivalent and knowledge of HTML. Knowledge of SQL is strongly recommended. 2 credits

APC 503b Developing Web Applications with Perl
This course builds further on the concepts introduced in APC 503a. Topics include abstract classes, pure virtuals, exceptions, operator overloading, templates and a brief introduction to design patterns. 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 good position to use these features for design and development of systems using the basic features in C++. Assignments include writing programs and a programming project. Prerequisite: Knowledge of a programming language. 2 credits

APC 505a Applications Programming in C++ I
This course introduces programming in C++, which is used widely for developing engineering and business applications. It introduces the C++ language and talks about fundamental concepts such as classes, composition and inheritance, polymorphism, virtuals, overloading, overriding and streams. 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 good position to contribute to the design and development of systems using the basic features in C++. Assignments include writing programs and a programming project. Prerequisite: Knowledge of a programming language. 2 credits

APC 505b Applications Programming in C++ II
This course builds further on the concepts introduced in APC 505a. Topics include abstract classes, pure virtuals, exceptions, operator overloading, templates and a brief introduction to design patterns. 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 good position to use these features for design and development of systems using C++. Assignments include writing programs and a programming project. Prerequisite: APC 505a, Applications Programming in C++, or equivalent. 2 credits

APC 506a Generic Programming and the C++ Standard Template Library
Generic programming is a paradigm that expresses algorithms and data structures in a broadly adaptable, interoperable form that results in efficient software construction. This course will introduce C++ templates and the concepts fundamental to generic programming. We will then explore the design and use of the C++ Standard Template Library (STL). The course is suitable for students in science, commercial software development and finance who wish to further their understanding of this important paradigm in C++ programming. Assignments will include writing programs that use the STL as well as classes that implement their own generic programming features. Prerequisite: APC 505b, Applications Programming in C++, or equivalent. Although the course will not focus on object-oriented development, a good understanding of object-oriented principles is important for students to compare and contrast to their
understanding of generic programming as taught in this course. 2 credits

APC 506b Numerical Programming in C++
This course explores techniques for the effective and efficient implementation of numerical methods using C++. The C++ language is often used in high-performance systems and applications, but there have also been challenges to its use in performance-critical applications where fast performance and high degrees of accuracy are primary goals. Topics include floating point computation and approximations, partial evaluation and expression templates, matrix factorization and the use of some popular C++ numeric libraries. The course is suitable for students in science, industrial engineering and finance who need to know how to use C++ most effectively for numeric programming. Prerequisite: APC 503b, Applications Programming in C++, II, or equivalent. 2 credits

APC 508a Applications Programming in Java I
This course introduces Java 2 technology and object-oriented programming. Topics include the software development process, learning the Java syntax and libraries, and the writing of object-oriented Java programs that include arrays, inheritance, overloaded methods, polymorphism and containment. Assignments include writing programs, applets and a final project using the Java GUI. Pre-requisite: knowledge of a programming language. 2 credits

APC 508b Applications Programming in Java II
This course is designed for students comfortable with the Java language and writing programs in Java. It focuses on more advanced Java topics, including the Swing toolkit, stream I/O, multi-threading, networking and writing client/server applications. Assignments include a series of programs leading up to a project designing a distributed socket-based client and server. Prerequisites: APC 508a, Applications Programming in Java I, or equivalent. 2 credits

APC 511 Computational Tools for Engineering and Finance
This course introduces essential programming skills needed for engineering and finance. It provides a comprehensive introduction to computing in MATLAB. 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. Examples and assignments in MATLAB will be used as a vehicle for introducing topics in numerical analysis, including some standard methods, numerical precision, and convergence and algorithm complexity. Some classes may be held in the computer lab. Programming assignments focus on the practical use of MATLAB. Short course offered selected mornings from September 10 to 23, 2002. Prerequisite: Knowledge of a programming language. 2 credits

APC 515 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 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: APC 505 or equivalent knowledge of C or C++. 2 credits

OREGON MASTER OF SOFTWARE ENGINEERING COURSE OFFERINGS

OMSE 500 Principles of Software Engineering
This course introduces software engineering. It focuses 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 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. 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

OMSE 512 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

OMSE 513 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

OMSE 521 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

OMSE 522 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 of how they are applied. Prerequisite: OMSE 500. 3 credits

OMSE 525 Software Quality Analysis
This course covers processes, methods and techniques for developing quality software, for assessing software quality and for maintaining quality. 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

OMSE 531 Software Requirements Engineering
This course covers the principles, tools and techniques for requirements elicitation, specification and analysis. The 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. Prerequisite: OMSE 500. 3 credits

OMSE 532 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. Prerequisite: OMSE 500. 3 credits
OMSE 533 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 of design decisions on the functional and nonfunctional 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. Prerequisite: OMSE 500. CSE students may not receive credit for both CSE 504 and OMSE 533 because there is significant overlap in content. 3 credits

OMSE 535 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 covers verification and integration of foreign code, testing technique 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. Prerequisite: OMSE 500. 3 credits

OMSE 551 Strategic Software Engineering
Whereas 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: all previous OMSE courses. 3 credits

OMSE 555 Software Development Practicum I
The development practicum enables 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 solution. 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, review- ers 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

OMSE 556 Software Development Practicum II
The development practicum enables 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 solution. 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 is designing a new agent communication language (AGENTTALK) and multiagent architecture. Unlike DARPA’s current language (KOML), 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 facilities, 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

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, Lauchbury

Digital Government
DOT is collaborating with the U.S. 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 “similarity search” between locations. The forest project also includes participants from the MST and ESE departments at OGI, from the University of Nevada, Las Vegas, and from the private sector. Delcambre, Maier, Toccacino, Phillips, Stockler, Koch, 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, Lauchbury

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, Lauchbury, Sheard

Machine Learning and Adaptive Systems
Our work in machine learning, neural computation, evolutionary computation, adaptive systems and cognition includes theoretical, algorithmic and practical aspects. Research in theory, architectures and algorithm design includes supervised, unsupervised, and reinforcement learning, genetic algorithms, generalization theory (model selection and pruning, invariant learning, theoretical characterization), stochastic optimization, local and mixture models, time series, control, and context-sensitive learning. Practical application domains include speech and image processing, medical screening technology, environmental forecasting and observation systems, anomaly detection for aeronautics, aircraft control, sensor fusion and finance. We explore applications of evolutionary computation for design optimization, automatic programming, and modeling of evolutionary systems. Hermansky, Leon, Mitchell, Moody, Favel, Song, Wan

Multimodal Systems
Multimodal interfaces enable more natural and efficient interaction between humans and machines by supporting multiple coordinated channels
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, McNamee, 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 "multiplex" 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 by itself for dictation and command control applications. 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.

Tan, 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: SLIMPcad, 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

RESEARCH CENTERS

CENTER FOR HUMAN-COMPUTER COMMUNICATION

Kimberly Tice, Center Administrator
503 748-7806

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 the OGI School.

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 help users accomplish tasks and can reason about how and where to carry out 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**
Kelly Atkinson, Center Administrator
503 748-1336
kelly@cse.ogi.edu
Sheri Dhuyvetter, Center Administrator
503 748-1476
sherid@cse.ogi.edu

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 ("programming as if properties mattered"). Project *Timber* is developing new means of programming embedded applications that involve both time-critical and critical-rate tasks.

Dr. Tim Sheard is the 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 Launuchbury of the OGI School, 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/.

**DATABASE AND OBJECT TECHNOLOGY LABORATORY**
Jo Ann Binker, Center Administrator
503 748-1272
binker@cse.ogi.edu

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 multidisciplinary 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.

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

**SYSTEMS SOFTWARE LABORATORY**
Cynthia Pfaltzgraff, Center Administrator
503 748-7109
pfaltz@cse.ogi.edu

The Systems Software 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 the OGI School, and Dr. Molly Shor of Oregon State University.

**FACILITIES**
The 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 allow the computing environment at CSE to be flexible and responsive in meeting the department's changing needs.

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, is 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 eight 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.
REPRESENTATIVE PUBLICATIONS


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

REPRESENTATIVE PUBLICATIONS


RESEARCH INTERESTS
International monetary theory and empirical models of exchange rate determination, time-series analysis and forecasting and pedagogical tools in finance.

REPRESENTATIVE PUBLICATIONS


PHIL COHEN
Professor, Co-Director
Center for Human-Computer Communication
Ph.D., Computer Science
University of Toronto, 1978
pcohen@cse.ogi.edu

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

Crispin Cowan
Assistant Research Professor
Ph.D., Computer Science
University of Western Ontario, 1995
crispin@cse.ogi.edu

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

REPRESENTATIVE PUBLICATIONS

Lois Delcambre
Professor
Ph.D., Computer Science
University of Western Ontario, 1982
lmd@cse.ogi.edu

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

REPRESENTATIVE PUBLICATIONS

Richard E. (Dick) Fairley
Professor and Associate Dean of Graduate Education
Ph.D., Computer Science
UCLA, 1971
dfairley@cse.ogi.edu

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
REPRESENTATIVE PUBLICATIONS


RESEARCH INTERESTS

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

WU-CHANG FENG
Assistant Professor
Ph.D., Computer Science
University of Michigan, 1999
wuchang@cse.ogi.edu

REPRESENTATIVE PUBLICATIONS


RESEARCH INTERESTS

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

WU-CHI FENG
Associate Professor
Ph.D., Computer Science
University of Michigan, 1996
wuchi@cse.ogi.edu

REPRESENTATIVE PUBLICATIONS


RESEARCH INTERESTS

Databases and knowledge-base systems, information integration, management of semi-structured data, Web information systems and Internet applications.

JULIANA FREIRE
Assistant Professor
Ph.D., Computer Science
State University of New York at Stony Brook, 1997
juliana.freire@cse.ogi.edu

RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS


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
Associate Professor
D.Phil., Computation
University of Oxford, 1992
mp@cse.ogi.edu

RICHARD B. KIEBURTZ
Professor
Ph.D., Electrical Engineering
University of Washington, 1961
dick@cse.ogi.edu

JOHN LAUNCHBURY
Professor
Ph.D., Computing Science
University of Glasgow, 1990
jlb@cse.ogi.edu

TODD K. LEEN
Professor
Ph.D., Physics
University of Wisconsin, 1982
tleen@cse.ogi.edu

RESEARCH INTERESTS
Modeling neurobiological systems. Applications to anomaly detection, environmental systems monitoring, and data coding. Modeling neurobiological systems.

REPRESENTATIVE PUBLICATIONS


REPRESENTATIVE PUBLICATIONS

John Matthews
Assistant Professor
Ph.D., Computer Science
Oregon Graduate Institute, 2000
johann@cse.ogi.edu

REPRESENTATIVE PUBLICATIONS

Melanie Mitchell
Associate Professor
Ph.D., Computer Science
University of Michigan, 1990
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RESEARCH INTERESTS
Artificial intelligence, machine learning, cognitive science and complex systems. Computer modeling of perception and analogy-making. Theory and applications of evolutionary computation. Collective computation in spatially extended systems such as cellular automata and neural models. History of science and technology.

REPRESENTATIVE PUBLICATIONS

John E. Moody
Professor
Ph.D., Theoretical Physics
Princeton University, 1984
moody@cse.ogi.edu

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
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


DAVID C. STEERE
Assistant Professor
Ph.D., Computer Science
Carnegie Mellon University, 1997
dcs@cse.ogi.edu

RESEARCH INTERESTS
Operating systems, mobile computing, distributed information systems.

REPRESENTATIVE PUBLICATIONS

JONATHAN WALPOLE
Professor
Ph.D., Computer Science
University of Lancaster, 1987
walpole@cse.ogi.edu

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
JOINT FACULTY

**DR. ANTONIO BAPTISTA**  
Environmental Science and Engineering  
OGI School of Science & Engineering

**DR. FRANÇOISE BELLEGARDE**  
University of Franche Comte, France

**DR. DAN HAMMERSTROM**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. HYNEK HERMANSKY**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. JODY HOUSE**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. MISHA PAVEL**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. LEONARD SHAPIRO**  
Department of Computer Science  
Portland State University

**DR. XUBO SONG**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. ANDREW TOLMACH**  
Department of Computer Science  
Portland State University

**DR. JAN P. H. VAN SANTEN**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. ERIC WAN**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

**DR. YONGHONG YAN**  
Electrical and Computer Engineering  
OGI School of Science & Engineering

PART-TIME FACULTY

**DR. CHARLES CONSEL**  
University of Bordeaux

**DR. DAVID G. NOVICK**  
University of Texas, El Paso

**ADJUNCT FACULTY**

**DR. LOUGIE ANDERSON**  
Gemstone Systems Inc.

**MR. JON BATCHELLER**  
Synopsys, Inc.

**MR. ROBERT BAUER**  
Rational Software Corp.

**DR. C. MIC BOWMAN**  
Intel Corporation

**DR. TED BRUNNER**  
Tektronix Inc.

**DR. CHRISTOPHER DUBAY**  
Oregon Health & Science University

**DR. EARL ECKLUND**  
Objective Technology Group

**MR. ROY HALL**  
Crisis in Perspective

**DR. DAVID HANSEN**  
George Fox University

**DR. JAMES LARSON**  
Intel Corporation

**MR. SCOTT LYMAN**  
Merix Corporation

**DR. ERIC MEIJER**  
Microsoft

**DR. GIL NEIGER**  
Intel Corporation

**MR. SANJEEV QAZI**  
Intel Corporation

**MS. NIVRUTI RAI**  
Intel Corporation

**MR. RAMAKRISHNA SARIPALLI**  
Network Elements

**MR. DAN SAWYER**  
OGI School of Science & Engineering

**MR. BRUCE SCHAFFER**  
Oregon College of Engineering and Computer Science

**MR. RANDAL SCHWARTZ**  
Stonehenge Consulting

**DR. TATIANA SHUSTERMAN**  
Rensselaer Polytechnic Institute

**DR. RICHARD SPROAT**  
AT&T Labs, New Jersey

**MS. ELISABETH SULLIVAN**  
TruSec Solutions

**DR. ANDREW TOLMACH**  
Portland State University

**MR. ROBERT UVA**  
Ambling Software, Inc.

**MR. PERRY WAGLE**  
Computer Science and Engineering  
OGI School of Science & Engineering

**DR. MAZIN YOUSIF**  
Intel Corporation
The primary mission of the Department of Electrical and Computer Engineering is to provide innovative and 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.

To meet these goals, the department offers a wide variety of formal courses in our focus 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
- Biomedical Optics
- Biomorphic Engineering
- Digital Signal Processing
- Display Technology, including Thin Film Transistors and Phosphors
- Electro-Optic Systems
- Home Health Research and Engineering
- Human Information Processing
- Human-Machine Interface
- Image and Video Processing
- Information Fusion
- Machine Learning
- Micro-Electrical-Mechanical Analysis (MEMS)
- Neural Networks Optical Remote Sensing
- Pattern Recognition
- Processing for Ultra Shallow Device Technology
- Robotics
- Semiconductor Electronic Devices
- Semiconductor Materials, Characterization and Processing
- Speech Recognition, Enhancement and Synthesis
- Sensors
- Systems Dynamics
- Technology Transfer
- Transient Thermal Processing
- VLSI Architecture for Intelligent Computing

The research activities of the department create a number of opportunities for students to participate, via M.S. and Ph.D. thesis research or student projects, in the research of most of the faculty. Students may become involved in relatively fundamental investigations (such as 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 development laboratory. The department has close ties to local industry, particularly Intel. 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 ECE department and other local educational and corporate organizations host invited talks and seminars on topics of interest in the field of electrical engineering. Although not required for graduate credit, we recommend that all ECE students attend these informative meetings. Seminar schedules are generally posted in the department each quarter. Additionally, the ECE department and Portland State University’s Department of Electrical and Computer Engineering jointly sponsor the Portland Area Semiconductor Seminar Series (PASSS) and the Information Sciences Seminar Series (ISSS). These seminars are free of charge and 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

The Department of Electrical and Computer Engineering at the OGI School offers both a Master of Science degree and 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 the OGI School or another acceptable institution of higher education.

Admission requirements are the same as the general OGI School requirements. The TOEFL is required of all international student applicants for both the M.S. and Ph.D. programs. However, the GRE is not required for the part-time M.S. program or the full-time M.S. program in the ECE department. 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.

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.

DEGREE REQUIREMENTS

MASTER OF SCIENCE (M.S.) PROGRAM

The M.S. program 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 48 credits. It 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 toward the M.S. degree. Courses taken outside of the OGI School’s ECE department must also be taken for graded credit; Pass/No Pass is not acceptable.

Courses taken from other OGI School departments or from other institutions must be approved by both the student’s faculty advisor and the ECE department administrator. A minimum grade point average of 3.0 must be maintained throughout the degree program. A student’s course of study should be reviewed and approved by a faculty advisor. Students are limited to 12 credits per quarter unless they obtain a waiver from their advisor.

NON-THESIS OPTION

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

NON-THESIS PROJECT OPTION

The non-thesis project option requires completion of at least 48 graded credits, comprising at least 40 credits of course work and at least 8 credits of research (ECE 610). 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. For the non-thesis project the student must submit a written report to satisfy the research grade requirements. In selecting this option the student must work with a faculty advisor to formulate an appropriate project.

THESIS OPTION

The M.S. thesis option requires completion of at least 32 credits of graded course work and at least 16 credits of graded research (ECE 700). 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. The student must submit the thesis in writing and defend it orally. Thesis research credits earned toward an M.S. degree must be graded. At a minimum, the thesis committee must include three OGI School faculty, one person from outside the OGI School, and any other committee members deemed practical. All thesis committee members must hold Ph.D. degrees.

SUMMER PROJECTS

Although not required, students may want to 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 may often be 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, making them ideal preparation for a career in engineering. Projects are done as Special Topics courses, ECE 580-ECE, 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 the OGI School. Students may petition for transfer of up to 18 credits from the following institutions: Portland State University, Oregon State University and the University of Oregon. Students petitioning for acceptance of transfer credits should provide (1) written request, (2) detailed course descriptions from institution catalogs and/or web site, and (3) original transcript(s) verifying credit hours and grades earned.

Upon approval from the department head, students may apply a maximum of 21 credits from other OGI School departments toward their degree. Acceptance of all transfer credits will be subject to review and approval by the ECE department’s Curriculum Committee. In certain cases, preapproval of transfer credit courses is recommended to avoid transfer of courses not relevant to department’s academic program. Transfer credits will not replace the degree/credit requirement of 24 credits of graded courses from the OGI School’s ECE department curriculum. Cross-listed courses may not be used as part of these 24 credits.

PH.D. PROGRAM

The OGI School offers a Ph.D. degree program in Electrical Engineering from the ECE department. Admission to the Ph.D. program generally requires a prior M.S. in Electrical Engineering, Computer Engineering or a related field, whether from the OGI School or 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 usually taken within 12 months of enrolling in the program, and may be scheduled at any time of year. The amount of course work to be completed before taking the qualifying exam depends on the individual's level of preparation at entry. At minimum, three graded courses from the OGI School's ECE department must be completed before taking the exam.

After passing the qualifying exam, the student works with the SPC 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.

There is a two-year residency requirement for Ph.D. students.

**ECE CURRICULUM FOCUS AREAS**

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

- Semiconductor Devices, Materials and Processing
- Signal, Speech and Image Processing
- Communications and Networking
- Computer Engineering and Design
- Biomedical Engineering

Students should refer to the ECE department’s 12-month Curriculum Plan to learn what courses may be offered in the 2002-2003 academic year. There are recommended core courses and tracks for most focus areas.

**SEMICONDUCTOR DEVICES, MATERIALS AND PROCESSING**

<table>
<thead>
<tr>
<th>Recommended core classes</th>
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</thead>
<tbody>
<tr>
<td>1. ECE 515 Introduction to Semiconductors</td>
</tr>
<tr>
<td>2. ECE 580-DOE Statistical Process Control and DOE</td>
</tr>
<tr>
<td>3. Choose one device class from:</td>
</tr>
<tr>
<td>ECE 512 Advanced MOSFET Analysis I: DC Models</td>
</tr>
<tr>
<td>ECE 516 Fundamental Semiconductor Device Structures</td>
</tr>
<tr>
<td>ECE 580-OSD Operation of Semiconductor Devices</td>
</tr>
</tbody>
</table>

The following courses are recommended for anyone who wishes to specialize in a particular area of microelectronics.

**SEMICONDUCTOR DEVICES/CIRCUITS**

| ECE 512 Advanced MOSFET Analysis I: DC Models |
| ECE 513 Advanced MOSFET Analysis II: Dynamic Models |
| ECE 514 MOSFET Modeling for VLSI Circuit Design |
| ECE 516 Fundamental Semiconductor Device Structures |
| ECE 517 Advanced Semiconductor Devices: Structures and Materials |
| ECE 571 Analog Integrated Circuit Design |
| ECE 572 Digital Integrated Circuit Design |
| ECE 574 CMOS Digital VLSI Design I |
| ECE 575 CMOS Digital VLSI Design II |

**SEMICONDUCTOR PROCESSING AND MATERIALS**

| ECE 535** Thin Film Deposition and Applications in Semiconductors |
| ECE 560 Microelectronic Device Fabrication I |
| ECE 561 Microelectronic Device Fabrication II |
| ECE 562 Microelectronic Device Fabrication III |
| ECE 563* Plasma Processing of Semiconductors I |
| ECE 568 Failure and Reliability in Microelectronics |
| ECE 580-EMI Electroplating for Microelectronic Interconnects |
| ECE 580-MPE Modern Photolithographic Engineering |
| ECE 580-RFB** Reliability and Failure of Electronic Devices, Packages and Assemblies |
| ECE 580-SMVI Simulation and Modeling of VLSI Interconnects |
| ECE 580-TP Technology of Photoresists |

**SEMICONDUCTOR MATERIALS AND DEVICE CHARACTERIZATION**

| ECE 565 Analytical Scanning Electronic Microscopy |
| ECE 566 Focused Ion Beam Technology |
| ECE 567 Transmission Electronic Microscopy |
| ECE 568 Failure and Reliability in Microelectronics |
| ECE 569** Electronic Materials and Device Characterization |

**MEMS AND SENSORS**

| ECE 580-CCM Capstone Course — MEMS and Microsensors Project |
| ECE 580-FSM Fundamentals of Sensors and MEMS Fabrication |
| ECE 580-ISM Introduction to Sensor Microfabrication |
| ECE 580-MEM Microelectromechanical Systems |
| ECE 580-SSM Semiconductor Sensors |

The following classes are required for Ph.D. students and are electives for MS students. However, these are recommended for MS students planning to continue with our Ph.D. program.

| ECE 507 Introduction to Electromagnetics for Modern Applications |
| ECE 508 Electromagnetics for Modern Applications II |
| ECE 509 Electromagnetics for Modern Applications III |
| ECE 510* Introduction to QM for Electrical and Comp. Eng. |
| ECE 511* Advanced QM for Electrical and Comp. Eng. |

**SIGNAL, SPEECH AND IMAGE PROCESSING**

**RECOMMENDED BASIC CORE CURRICULUM:**

**Required:**

- **ECE 540 Auditory and Visual Processing by Human and Machine**
- **ECE 580-HMM Hidden Markov Models for Speech Recognition**
- **ECE 580-SSL Structure of Spoken Language**
- **ECE 580-SSY Speech Synthesis**
- **CSE 554 Spoken Language Systems**
- **CSE 564 Human-Computer Interaction**

**SPEECH SYSTEMS**

| ECE 540 Auditory and Visual Processing by Human and Machine |
| ECE 580-HMM Hidden Markov Models for Speech Recognition |
| ECE 580-SSL Structure of Spoken Language |
| ECE 580-SSY Speech Synthesis |
| CSE 554 Spoken Language Systems |
| CSE 564 Human-Computer Interaction |

**IMAGE PROCESSING**

| ECE 540 Auditory and Visual Processing by Human and Machine |
| ECE 542 Introduction to Image Processing |
There are several specializations:

**ECE 552** Digital Signal Processing II

**ECE 580-IE** Internet Engineering

**ECE 580-MC** Multimedia Communications

**ECE 554** Adaptive and Statistical Signal Processing

**ECE 542** Introduction to Image Processing

**ECE 551** Introduction to Digital Signal Processing II

**ECE 552** Digital Signal Processing II

**ECE 554** Adaptive and Statistical Signal Processing

**ECE 580-BSP** Biomedical Signal Processing Communication

**ECE 526** Introduction to Communication

**ECE 580-AC** Analog CMOS Design

**ECE 580-CN** Introduction to Computer Networks

**ECE 580-WCSI** Wireless Communication Systems I

**CSE 524** TCP/IP Networking Protocols

**CSE 521** Introduction to Computer Architecture

**CSE 522** Advanced Computer Architecture

**CSE 526** Introduction to Operating Systems

**OSU-ECE 527** VLSI System Design

Students are encouraged to perform an M.S. project (of at least 8 credits) that involves design.

**BIOMEDICAL ENGINEERING**

Biomedical engineering is a rapidly developing, broad field of study at the interface between engineering and basic biology and medicine, such as biomedical signal processing, imaging, sensing, biomaterials, information technology, bioinformatics and many other areas. The ECE biomedical engineering program collaborates with other departments in the OGI Schools of Science and Engineering, Medicine, Dentistry and Nursing to offer students a variety of research and classroom opportunities to acquire breadth and depth of knowledge and expertise in this field.

In particular, ECE currently has a core of expertise in two areas, Biomedical Optics and Tissue Engineering, providing research opportunities and courses in optical sensing, imaging and image analysis, laser-tissue interactions, biomechanics and tissue engineering. Research activities are expanding to cover biomedical sensors and instrumentation, biomedical signal processing and analysis, computational neuroscience, data-mining and technology in health care delivery. The latter includes intelligent rehabilitation and assistive technologies for future health care 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. Courses available range from introductory courses in biology and medicine, biomedical sensors and instrumentation, biomedical optics and laser-tissue interactions, biomaterials, biomechanics, neuroscience,
molecular engineering, audio and video processing by humans and machines, biomedical signal processing, biological pattern recognition and data-mining, 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.

Note: Students electing this focus area are encouraged to consult with their advisor as to which recommended courses are most appropriate for their goals.

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
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<tbody>
<tr>
<td>ESE 550</td>
<td>Environmental Microbiology</td>
</tr>
<tr>
<td>ESE 500</td>
<td>Introduction to Discrete Methods</td>
</tr>
<tr>
<td>CSE 564</td>
<td>Human-Computer Interaction</td>
</tr>
<tr>
<td>CSE 548</td>
<td>Introduction to Probability and Statistical Inference</td>
</tr>
<tr>
<td>ECE 510</td>
<td>Introduction to Quantum Mechanics for Electrical and Computer Engineers</td>
</tr>
</tbody>
</table>

Other OGI School Courses |
CSE 540: Neural Network Algorithms and Architectures |
CSE 547: Statistical Pattern Recognition |
ESE 550: Environmental Microbiology |
ESE 570: Principles of Toxicology and Risk Assessment |

* May be offered in alternating years, beginning 2002-03 |
** May be offered in alternating years, beginning 2003-04 |
implanted channels (including buried channels), as well as those due to small channel dimensions (channel length modulation, effective modification of threshold voltage in short and narrow channels, velocity saturation, series resistance effects, thin oxide/shallow depletion effects). Breakdown and punch-through are discussed qualitatively. Prerequisites: basic electrostatics, semiconductors and circuits. 4 credits

ECE 513 Advanced MOSFET Analysis II: Dynamic Models
Based on ECE 512 the dynamic large-signal and small-signal models of MOSFET operation are developed for digital and analogue applications respectively. Large-signal modeling is analyzed in detail for quasi-static operation (neglecting transit-time effects) in terms of the charges flowing in and out of all four MOSFET terminals covering the various charge conditions in the semiconductor (accumulation to inversion); non-quasi-static modeling is introduced to include transit-time effects in high-speed applications and is illustrated for a channel in strong inversion. Small-signal modeling for the description of equivalent circuit elements starts with a simplified quasi-static analysis allowing medium frequencies at all channel conditions (weak to strong inversion). Then this model is extended to high frequencies in a complete quasi-static mode that includes transcapacitors at highest frequencies near gain cut-off. Non-quasi-static modeling is discussed and applied to channels in strong inversion. Finally, noise models are developed to supplement the derived equivalent circuits with the proper noise source elements. Pre-requisite: ECE 512. 4 credits

ECE 514 MOSFET Modeling for VLSI Circuit Design
A comprehensive study of state-of-the-art compact models used in circuit simulators for VLSI design and their underlying physics. Topics covered include: high speed and high frequency (non-quasi-static) models, quantum effects, high field and hydrodynamic effects. Substrate current and gate current modeling with applications for reliability modeling in circuit simulators and circuit design impact. Discussion of device scaling issues, fundamental limits to mos device and circuit performance. A review of novel device architectures for future mos devices, in particular SOI devices, double gate devices, their physics and operation in terms of analytic models. Study of parameter extraction, optimization and device characterization techniques required for developing compact models. Development of statistical and mismatch models for the mosfet. Radio frequency models for the mosfet and S parameter characterization. Review and comparison of existing mosfet models such as BSIM4, EFLK, PGIM. Implementation of mos models in circuit simulators. Project work will include evaluating various models in SPICE, and their impact on circuits, as well as understanding device operation using a 2D device simulator (MINIMOS) and a coupled 1D Schrodinger-Poisson Solver (SPIN). 4 credits

ECE 515 Introduction to Electronic Materials
The fundamental properties and concepts needed to understand electronic materials are introduced in this course. We begin with crystals, their structure and bonding, and thermal properties. We then examine electron interactions in metal and semiconductor crystals. The physics behind the energy bandgap in semiconductors are examined, and used ultimately to derive the energy band structure, effective mass and equilibrium carrier statistics. Next, we use these statistics to define carrier transport in semiconductor materials. Finally, we study and understand dielectrics and insulators, magnetic properties, superconductivity and the 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 quantum mechanics is not required, taking the course will help achieve a more advanced understanding of the concepts discussed in this class. 4 credits

ECE 516 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 expanded and clarified. 4 credits

ECE 517 Advanced Semiconductor Devices: Structures and Materials
The complex interplay between materials properties, fabrication technologies and device performance is 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

ECE 520 Transmissionline-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), multiconductor transmission lines in multilayered dielectric systems ([LL] and [C] matrices). Numerical analysis of multiconductor transmission-line networks (method of moments technique), Crosstalk. 4 credits

ECE 521 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 multiport 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

ECE 522 Introduction to Communication
An overview: sources, channels and limits to communication, signals and spectra, distortionless transmission, linear and nonlinear distortion, transmission loss. Random Signals: probability and random variables, probability functions, statistical averages, probability models, random processes, random signals. Signal transmission with noise: noise models, signal-to-noise ratio, pulse detection and matched filters. Analog communication: bandpass systems and signals, double-sided amplitude modulation (AM), modulators and transmitters, suppressed-sideband amplitude modulation, frequency conversion and demodulation, frequency/phase modulation (FPM), transmission bandwidth and distortion, generation and detection of FM/PM, interference, receivers for FM/PM, frequency division multiplexing, a case study of analog communication systems, noise in analog communication systems. 4 credits

ECE 525 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), Chebyshev inequality, Chernoff bound, central limit theorem, stationary processes and linear systems, mean square estimation, Poisson process, Gaussian process, Markov process and series representations. MATLAB and the MATLAB Statistics Tool Box are used in this course. 4 credits

ECE 526 Introduction to Digital Communication
Introduction to communications systems, components, signals and channels, sampling, quantization, pulse amplitude modulation (PAM), pulse code modulation (PCM), quantization noise, time division multiplexing, delta modulation. Digital communications: baseband signals, digital PAM, eye diagram, equalization, correlation coding, error probabilities in baseband digital transmission, bandpass transmission, digital amplitude shift keying (ASK), frequency shift keying (FSK), phase shift keying (PSK), quadrature shift keying (QPSK), error probabilities in bandpass digital transmission, a case study of digital communication systems. Introduction to information theory: fundamental limits in communications, channel capacity and channel coding, signal compression. 4 credits

ECE 527 Introduction to Digital Communication
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. Course offered every other year; next session, academic year 2002-03. 4 credits

ECE 533 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. Course offered every other year; next session, academic year 2002-03. 4 credits

ECE 534 Biomedical Optics III: Engineering Design
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 among 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. Course offered every other year; next session, academic year 2002-03. 4 credits

ECE 535 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 electoloss 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

ECE 536 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

ECE 540 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, incorporate these data in models, and apply these models to engineering problems. The anthropomorphic (humanlike) signal processing approach is illustrated on engineering models of perceptual phenomena. 4 credits

ECE 541 Signal Processing for Multimedia Applications
The course covers the concept of signal as a carrier of information and basic principles of processing of cognitive signals. Using speech as an example of cognitive signal, it goes through fundamentals of human speech production and perception, properties of speech signal and some techniques for signal processing for multimedia engineering. Emphasis is on active research in auditory modeling that exploits special properties of speech to improve performance of speech technology in practical applications. The course is intended for those who have a good undergraduate-level knowledge of mathematics and physics but who need an introduction to or refreshing of fundamental concepts of signals, systems and human information processing to master specialized multimedia topics in speech and image processing, classification and transmission. 4 credits

ECE 542 Introduction to Image Processing
This 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, multiresolution representation, edge detection, texture characterization and motion analysis. This 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. Numerous examples show how to apply these techniques. Prerequisite: ECE 551. 4 credits

ECE 543 Introduction to Digital Video Processing
This course introduces digital video processing for multimedia systems. It begins with video capture, image formation, analog and digital video signals 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 will gain working knowledge of these video techniques through class projects. Familiarity with digital signal processing and transform methods is desirable. Prerequisite: ECE 542. 4 credits

ECE 544 Introduction to Signals, Systems and Information Processing
This course provides the essential mathematical tools and analytical techniques 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 useful properties that the time perspective alone does not reveal. Basic applications in information processing, communication and control 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, because 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. The student becomes 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

ECE 545 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. The course covers techniques for processing the speech signal for speech coding and synthesis, enhancement of degraded speech, speech recognition, speaker recognition and language identification. 4 credits

ECE 550 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. The course develops and uses a general framework for treating time-varying linear systems. Major emphasis is placed, however, on the time-invariant systems, whose structure and dynamics are investigable and knowable to the 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. The 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 — are 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 today’s computer and information processing fields. DSP provides the core building block from cell phones to modems, HDTV to video conferencing, and speech recognition to MP3 audio. This course 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 non-recursive (FIR) digital filters, and applications of the Fast Fourier Transform (FFT) to convolution, spectral analysis and audio processing. Prerequisite: ECE 544 or equivalent.

4 credits

ECE 552 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

ECE 554 Adaptive and Statistical 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 performance 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 latter 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. Prerequisite: ECE 551 plus an undergraduate level course in probability and statistics.

4 credits

ECE 555 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 science and 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 available optimization strategies, customize given algorithms to your own specific applications, and even write your own routines entirely from scratch. 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 that utilize random heuristics, including: genetic algorithm, dynamic evolution and simulated annealing. Time permitting, dynamic programming and the optimal control problem will be introduced.

4 credits

ECE 557 Computer-Aided Analysis of Circuits
This 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

ECE 558 High Speed Interconnect Design
Electrical analysis, design and validation of interconnect for high-speed signal processing 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

ECE 559 Design with Programmable Logic
Programmable logic, such as FPGA and PLD devices, has become a major component of digital design. This course discusses 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. Prerequisite: ECE 573 or consent of instructor.

4 credits

ECE 560 Microelectronic Device Fabrication I
This course is the first in a 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 discussed. This includes realistic process flows, physical metrology, device structure and electrical behavior, trade-offs, etc. The course is intended to serve both working process engineers and matriculating graduate students.

4 credits

ECE 561 Microelectronic Device Fabrication II
The second class of this series emphasizes metallization and dielectrics. Metallization issues include silicides, barrier layers, interconnects (e.g., Cu), multilevel metallization, and low k dielectrics. This is 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

ECE 562 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 is 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, which includes several devices such as BICMOS, and memories. Finally yield and reliability statistics as related to microelectronic device fabrication are discussed. Class assignments include computer simulation of device fabrication and testing.

4 credits

ECE 563 Plasma Processing of Semiconductors I

4 credits

ECE 565 Analytical Scanning Electron Microscopy (SEM)
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, metalo-graphic grinding and focused ion beam-produced transverse cross sections, planar sections, coating techniques
for nonconductors, sampling of powders and isolation of contaminants are among the topics. 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 within a six-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 are the basis for a grade. 4 credits

**ECE 567 Transmission Electron Microscopy**

Electron microscopy is a continually evolving discipline that 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. Information is often critical to the understanding of material properties. Principles, methods and application of transmission electron microscopy to crystalline materials are covered, as well as the construction and design of electron microscopes, electron diffract, reciprocal lattice and Ewald Sphere construction. Kinematic and dynamic theories of image formation will be introduced. Combining lectures and hands-on laboratory practice, students will be introduced to the use of sample preparation equipment and an analytical transmission electron microscope. Students will be expected to carry out basic experiments on selected materials that illustrate fundamental concepts of the lecture. The lecture portion of this course can be presented on site at companies within a six-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 are the basis for a grade. 4 credits

**ECE 566 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 within a six-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 are the basis for a grade. 4 credits

**ECE 569 Electronic Materials and Device Characterization**

This class is designed for engineers and scientists who wish to understand the basic principles 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 covered are contact resistance, carrier mobility and lifetime, defects, oxide and interface trapped charges, as well as series resistance, channel lengthwidth, threshold voltage and hot carriers in MOSFETs. This class includes some lab time. 4 credits

**ECE 570 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 within a six-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 are the basis for a grade. 4 credits

**ECE 571 Analog Integrated Circuit Design**


**ECE 572 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

**ECE 573 Introduction to Computer Logic Design**

This course constitutes a basic introduction to the design and implementation of computer logic. Basic principles of discrete logic are 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 Verilog hardware description language. Though some of this material is generally found in undergraduate curriculums, this course covers this material in greater depth and at a pace appropriate for graduate credit. This course or its equivalent is a prerequisite to all other ECE Electronics Design courses. Prerequisite: the C programming language. 4 credits

**ECE 574 CMOS Digital VLSI Design I**

This introduction to CMOS digital IC design 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/Flop-Flops) and subsystem design (adders, multipliers, etc.). 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

**ECE 575 CMOS Digital VLSI Design II**

Concentration on advanced digital VLSI circuit design techniques. Architecture and microarchitecture 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

**ECE 577 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

**ECE 580-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 here. Special Topics courses are subject to change and are offered intermittently. For course descriptions for Special Topics offered during the current term, please view http://ece.ogi.edu/special.html.

ECE 580-AC Analog CMOS Integrated Circuit Design
ECE 580-ACD Selected Topics in Analog IC Design
ECE 580-AFA Introduction to Functional Analysis and its Application
ECE 580-BSP Biomedical Signal Processing
ECE 580-CCM Capstone Course — MEMS and Microsensors Project
ECE 580-CLI Computational Approaches to Laser Interaction with Biological Tissues
ECE 580-CLT Computational Approaches to Laser Interaction in Biological Tissues
ECE 580-CN Introduction to Computer Networks
ECE 580-COD Introduction to Computer Organization and Design
ECE 580-DCS Digital Fiber Optical Communication Systems
ECE 580-DGC Design of Digital Communication Circuits
ECE 580-DOE Statistical Process Control and DOE
ECE 580-ECE Special Topics in Electrical and Computer Engineering
ECE 580-EMI Electroplating for Microelectronic Interconnects
ECE 580-FSM Fundamentals of Sensors and MEMS Fabrication
ECE 580-HMM Hidden Markov Models for Speech Recognition
ECE 580-IB1 Biomedical I
ECE 580-IB2 Biomedical II
ECE 580-IE Internet Engineering
ECE 580-IN Introduction to Nanomaterials
ECE 580-ISM Introduction to Sensor Microfabrication
ECE 580-LCD Introduction to Liquid Crystal Displays
ECE 580-MC Multimedia Communications
ECE 580-MCM Materials Characterization for Microelectronic Device Fabrication
ECE 580-MEC Microwave Engineering Concepts
ECE 580-MEM Micro-Electro-Mechanical Systems
ECE 580-MPE Modern Photolithographic Engineering
ECE 580-ONE Optical Non-destructive Evaluation
ECE 580-OSD Operation of Semiconductor Devices
ECE 580-POG Physical and Geometric Optics
ECE 580-RFD Reliability and Failure of Electronic Devices, Packages, and Assemblies
ECE 580-SDL Statistical Learning and Data Mining
ECE 580-SMV Simulation & Modeling of VLSI Interconnect
ECE 580-SE5 Semiconductor Sensors
ECE 580-SSL Structure of Spoken Language
ECE 580-SY3 Speech Synthesis
ECE 580-TP Technology of Photoreists
ECE 580-WCS Wireless Communication Systems

ECE 580-ACD Selected Topics in Analog IC Design
ECE 580-AFA Introduction to Functional Analysis and its Application
ECE 580-CLI Computational Approaches to Laser Interaction with Biological Tissues
ECE 580-CLT Computational Approaches to Laser Interaction in Biological Tissues
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ECE 580-DOE Statistical Process Control and DOE
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ECE 580-FSM Fundamentals of Sensors and MEMS Fabrication
ECE 580-HMM Hidden Markov Models for Speech Recognition
ECE 580-IB1 Biomedical I
ECE 580-IB2 Biomedical II
ECE 580-IE Internet Engineering
ECE 580-IN Introduction to Nanomaterials
ECE 580-ISM Introduction to Sensor Microfabrication
ECE 580-LCD Introduction to Liquid Crystal Displays
ECE 580-MC Multimedia Communications
ECE 580-MCM Materials Characterization for Microelectronic Device Fabrication
ECE 580-MEC Microwave Engineering Concepts
ECE 580-MEM Micro-Electro-Mechanical Systems
ECE 580-MPE Modern Photolithographic Engineering
ECE 580-ONE Optical Non-destructive Evaluation
ECE 580-OSD Operation of Semiconductor Devices
ECE 580-POG Physical and Geometric Optics
ECE 580-RFD Reliability and Failure of Electronic Devices, Packages, and Assemblies
ECE 580-SDL Statistical Learning and Data Mining
ECE 580-SMV Simulation & Modeling of VLSI Interconnect
ECE 580-SE5 Semiconductor Sensors
ECE 580-SSL Structure of Spoken Language
ECE 580-SY3 Speech Synthesis
ECE 580-TP Technology of Photoreists
ECE 580-WCS Wireless Communication Systems

ECE 591 Independent Study
May be taken only during student's final quarter of graduate program for a maximum of 3 credits. Student works with professor on selected topic(s). Requires preapproval of professor, ECE department, as well as formal agreement between student and professor outlining objectives and expectations of independent study topic.

ECE 600 Prequalifying Ph.D. Research
Supervised research participation. Prequalifying Ph.D. research prior to passing ECE department qualifying exam. Variable and repetitive credit

ECE 610 MS Nonthesis Project Research
Supervised research for up to eight credits as a component of the non-thesis 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 approval of the department head and the student's SPC. Variable and repetitive credit

ECE 620 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 careers. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students & Scholars before enrolling in ECE 620. Enrollment requires a faculty advisor and is limited by the number of internships available. Variable and repetitive credit

ECE 700 M.S. Thesis
Research toward the thesis for the M.S. degree. Variable and repetitive credit

ECE 800 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. By the end of the decade, manufacturers will be routinely manufacturing chips with over one billion transistors. 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 the current techniques and methodologies of science and engineering. Yet natural evolution has produced very sophisticated information processing systems, and the information analysis performed by the human brain, or even by the brains of simple animals, is far superior to what currently can be achieved by state-of-the-art human-developed techniques.

A new research area now coalescing is devoted to consolidating and refining existing solutions and finding better solutions to these transformation problems. The term Intelligent Signal Processing (ISP) is 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;
- Understanding the issues involved in scaling neural models to very large configurations; and
- Pulse-based analog circuit design

CENTER FOR INFORMATION TECHNOLOGY (CIT)
Digital signal processing has made a significant impact on human lives since its introduction several decades ago. Industries are 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 & Science University.

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, including 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 complements CSLU by developing advanced signal processing techniques used in Signal Processing for Multimedia Engineering. 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 (CSLU)**

The research program of the Center for Spoken Language Understanding (CSLU) encompasses a broad range of speech technologies. 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.

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.

An important new direction of CSLU is basic speech technology research with a medical or educational focus. For example, CSLU obtained a three-year grant from the National Science Foundation to work on innovative voice transformation technologies to make speech spoken by people suffering from dysarthria more intelligible. CSLU also works on new technologies that is used for creating multimodal, interactive reading tutors for children with reading or hearing problems. Plans are under way to expand this focus into analysis of speech from autistic children, stuttering and apraxia, as well as analysis of non-native speakers learning English.

CSLU is also highly active in the development and distribution of a wide variety of software systems (the “CSLU Toolkit”) and 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 Fan and Eric Wan. Other center faculty include Professors Todd Leen, Ryno Hermansky and Yabo Song. The center receives support from government agencies including NSF, DARPA, NIH and ONR, as well as industrial sources. For additional information, visit the CSLU web site: http://cslu.cse.ogi.edu.

**RESEARCH PROGRAMS**

**Advanced Lithography**

Lithography is the key technology pacing the evolution of microelectronics, and maskless lithography is of particular interest for the future as optical masked schemes reach the end of their capability. In particular massively parallel arrays of electron emitters can be used to achieve practical throughput for direct-write e-beam systems. Research is ongoing to develop a viable multibeam electron source technology for use in large scale manufacturing of semiconductor devices. By using semiconductor technology in combination with new cathode materials and approaches, it should be possible to generate arrays allowing significantly enhanced printing speed and improved pattern fidelity. Berghard, 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 caused by 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. Particular 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, 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 at the OHSU Medical Center campus. Jacques, Kirkpatrick, Pfahl, Song

**Electronic Materials**

An active research program in electronic materials growth and characterization focuses 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 gap 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 and the physical properties of the films and their electromigration lifetimes. Freeouf, McCarthy, Solanki

**Image, Video Processing and Analysis**

Our interest in image and video processing covers both low-level processing and high-level analysis. Recently, we have been developing image and video analysis techniques that are on the boundary between machine learning and computer vision. We use insights from statistics, stochastic systems and information theory to produce new algorithms for longstanding problems. The goal is to understand the fundamentals of these problems and to achieve performance that is more robust, accurate and efficient. Current projects include information fusion, the incorporation of contextual information for image recognition, model-based image segmentation, enhancement and 3D reconstruction, and Bayesian integrated motion analysis for autonomous navigation. Song, Pave

**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. In addition, a major research thrust is the development of robust recognition algorithms based on information fusion. Practical application domains include adaptive signal processing, pattern recognition, speech recognition, image processing, control systems, macromechanics and finance. Jabri, Leen, Moody, Pavel, Song, Wan
Optical Remote Sensing
Analytical and experimental studies are exploring 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

Speech and Speaker Recognition in Adverse Communication Environments.
Our research on acoustic processing of speech focuses on human-like processing of speech in realistic telecommunications environments to ensure reliable recognition of speech in adverse conditions, like those encountered in the current mobile cellular telephony. Speech is a special signal that evolved to be heard well. Subsequently, it is likely that human hearing represents the optimized way of its processing and understanding, and emulating human hearing may help improve speech technology. This spurred our interest in modeling human-like processing of speech by modern discrete signal processing techniques. Our research includes aspects of digital signal processing and of statistical pattern recognition as well as aspects of human hearing psychology and physiology. 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 the desktop and into mobile devices. Since most online 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. This is an interdisciplinary field that draws elements from linguistics, computer science, machine learning, human perception and digital signal processing. At CSLU, we conduct research at all levels of TTS, ranging from signal processing to statistical modeling of intonation and text analysis of e-mail messages. We further work on special applications such as small footprint TTS and speech synthesis for individuals with speech problems. Van Santen

VLSI Architecture for Intelligent Computing
Some of the most important 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 being studied, including neuromorphic structures, with the intent of enhancing the representation and manipulation of knowledge in silicon. Hammerstrom, Jabri

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:

COMPUTING RESOURCES
- Windows 2000 computer lab with workstations and server
- Sun Enterprise 3500 departmental computer server
- Unix lab with Solaris workstations and X-terminals
- 8 Node Beowulf Computer Cluster

CIRCUIT DESIGN
- Computer design lab with eight stations, each consisting of a PC workstation, an Altera UP1 board, Altera Nios development board, TI DSP development board
- VLSI and FPGA circuit design software
- Digital television lab

MATERIALS AND ELECTRONIC CHARACTERIZATION
- Far-infrared Fourier spectrometer
- Parallel field-vibrating sample magnetometer
- 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
- C-V, I-V measurement facilities
- Electrical characterization (Hall)
- Recombination Lifetime System suitable for bulk and thin film studies
- Two spectroscopic ellipsometry systems, 250-750 nm and 140-300 nm
- Process and device two-dimensional simulators, three-dimensional simulators, Monte Carlo simulators
- Work function and high intensity photo-current stability measurement equipment

MICROSCOPY
- Inverted and upright optical photomicroscopes
- Field electron and ion microscopes
- Focussed Ion Beam micromachining and microforming capabilities
- Analytical scanning electron microscope — Heating, straining specimen stage
- Analytical scanning/transmission electron microscopes — Heating specimen stage
- High-resolution electron and ion microprobes
- Scanning auger microprobe microscopy
- Scanning confocal microscopy
- Ion mill, chemical jet-milling, sample preparation facilities, microtome
- Complete JCPDF x-ray and electron powder diffraction database
- Electron diffraction and image simulation program
- Digital video capture for in-situ microscopy experiments
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. Field electron emissions and FED displays. Silver and tungsten metalization. Moisture evolution from oxide.

REPRESENTATIVE PUBLICATIONS
Moisture evolution from oxide Silver and tungsten metalization. Processing for thin film deposition emitted electron beams. Plasma fabrication using multiple photolithography for both mask making and IC microcircuit fabrication using Selected area processing for field emission microscopy and surface physics and chemistry;
**DAN HAMMERSTROM**  
Doug Strain Professor  
Ph.D., Electrical Engineering  
University of Illinois, 1977  
strom@ece.ogi.edu

**RESEARCH INTERESTS**  
Biologically inspired computation. VLSI chip design for image processing, digital video, signal processing and intelligent signal processing. Parallel computer architecture and microarchitecture. Technology transfer.

**REPRESENTATIVE PUBLICATIONS**  

**HYNEK HERMANSKY**  
Professor and Director  
Center for Information Technology  
Dr. Eng., Electrical Engineering  
University of Tokyo, 1983  
hynek@ece.ogi.edu

**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**  

**J. FRED HOLMES**  
Professor Emeritus  
Ph.D., Electrical Engineering  
University of Washington, 1968  
jfred@ece.ogi.edu

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

**REPRESENTATIVE PUBLICATIONS**  

**JOHN-PAUL HOSOM**  
Assistant Professor  
Ph.D., Computer Science and Engineering, Oregon Graduate Institute of Science & Technology, 2000  
hosom@ece.ogi.edu

**RESEARCH INTERESTS**  

**REPRESENTATIVE PUBLICATIONS**  
**JODY HOUSE**
Assistant Professor  
Sc.D., Electrical Engineering  
Massachusetts Institute of Technology, 1998  
jhouse@ece.ogi.edu  

**RESEARCH INTERESTS**  
Electronic and photonic device design for microsensor applications with a current concentration on embedded sensors and microfluidics.

**REPRESENTATIVE PUBLICATIONS**  


**MARWAN JABRI**
Gordon and Betty Moore Professor of Microelectronics  
Ph.D., Electrical Engineering  
University of Sydney, 1988  
marwan@ece.ogi.edu  

**RESEARCH INTERESTS**  
Artificial intelligence and intelligent signal processing. The understanding of the principles by which humans and/or other organisms perceive the environment, process sensory signals, reason, make decisions and learn. The development and application of biologically inspired information engineering. The design of integrated systems for intelligent signal processing.

**REPRESENTATIVE PUBLICATIONS**  


**STEVEN L. JACQUES**
Professor  
Ph.D., Biophysics and Medical Physics  
University of California, Berkeley, 1984  
sjacques@ece.ogi.edu  

**RESEARCH INTERESTS**  

**REPRESENTATIVE PUBLICATIONS**  


**ROBERT S. JAFFE**
Instructor  
Ph.D., Electrical and Computer Engineering  
Portland State University, 1988  
jaffe@ece.ogi.edu  

A full-time instructor in ECE, Jaffe 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.
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. Other interests include experimental investigations into the micro-mechanics of synthetic biomaterials used to replace or augment damaged or pathological tissue.

REPRESENTATIVE PUBLICATIONS

RESEARCH INTERESTS
Mechanisms of change in micro-electronic metallization and insulator thin films, SEM and TEM in-situ testing to improve thin film processing and reliability, multibeam electron lithography, development of focused ion beam processes for fabrication of structures on the micron, sub-micron and nano-scales to be used in sensors and electromechanical devices, solid phase epitaxy, GaAs metallizations, materials characterization techniques using analytical electron microscopy and focused ion beam technology.

REPRESENTATIVE PUBLICATIONS

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, in particular point-of-care biomedical engineering.

REPRESENTATIVE PUBLICATIONS
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


RESEARCH INTERESTS

Micro-electro-mechanical systems (MEMS) and nano-electro-mechanical systems (NEMS) and their design and use, particularly the mechanics, materials and interaction of contacting surfaces, i.e. tribology of microsystems. Mimicry of organic biological mechanical sensory systems in inorganic manmade materials. 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


RESEARCH INTERESTS

Atomic layer deposition, copper electrodeposition and electromigration, multilevel metallization, high k gate dielectrics, inorganic and organic electroluminescent devices, polycrystalline thin film transistors.

REPRESENTATIVE PUBLICATIONS


RESEARCH INTERESTS

Digital image and video processing, statistical pattern recognition, machine learning, sensor fusion, computer vision, information theory and coding, biomedical engineering.

REPRESENTATIVE PUBLICATIONS


**JAN P.H. VAN SANTEN**
Professor and Center Director of CSLU
Ph.D., Mathematical Psychology
University of Michigan, 1979
vansanten@ece.ogi.edu

**RESEARCH INTERESTS**
Speech timing, intonation, signal processing, statistical analysis of text and speech corpora, and text-to-speech (TTS) system evaluation.

**REPRESENTATIVE PUBLICATIONS**

**ERIC A. WAN**
Associate Professor
Ph.D., Electrical Engineering
Stanford University, 1994
ericwan@ece.ogi.edu

**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**

**YONGHONG YAN**
Associate Professor
Ph.D., Computer Science and Engineering
Oregon Graduate Institute, 1995.
yan@cse.ogi.edu

**RESEARCH INTERESTS**
Human-computer interface design, spoken language system, large vocabulary speech recognition, computer vision, real-time embedded system and speech signal processing.

**REPRESENTATIVE PUBLICATIONS**


JOINT FACULTY

DR. ROB DAAASC
Electrical Engineering
Portland State University

DR. ANDREW FRASER
Portland State University

DR. TODD LEEN
Computer Science and Engineering
OGI School of Science & Engineering

DR. SHIH-LIEN LU
Intel Corp.

DR. JOHN E. MOODY
Computer Science and Engineering
OGI School of Science & Engineering

DR. NELSON MORGAN
Electrical Engineering & Computer Sciences
University of California

DR. MINGDE YAN
Chemistry
Portland State University

ADJUNCT FACULTY

JOHN C. ABELE
Lewis and Clark College

SHARIAR S. AHMED
Intel Corp.

CHEDLEY AOURIRI
Intel Corp.

AHMED RAHHAL-ARABI
Intel Corp.

SHEKHAR BORKAR
Intel Corp.

STEVE BRAINERD
Integrated Device Technology, Inc.

ROB CONTOLINI
Novellus

DOUGLAS C. DRAPER
Portland Community College

STEPHEN R. EARLY
Consultant

YOUSSEF A. EL-MANSY
Intel Corp.

REINHART ENGLEMANN
Consultant

DAVID EVANS
Sharp Microelectronics Technology Inc.

WAYNE K. FORD
Intel Corp.

MARK FRANK
Conexant

HOWARD HECK
Intel Corp.

DAE MANN KIM
Pohang Institute of Science & Technology, Korea

ROY KRAVITZ
Radisys Corporation

WILLIAM A. MACKIE
Linfield College

V. DAKSHINA MURTY
University of Portland

KARTIK RAOL
Intel Corp.

EDWARD F. RITZ, JR.
Consultant

LAWRENCE RUBY
University of California, Berkeley

LYNWOOD W. SWANSON
FEI Co.

STEWARD S. TAYLOR
Maxim

THOMAS THOMAS
Intel Corp.

TRAN THONG
Microsystems Engineering, Inc.

LYNWOOD W. SWANSON
FEI Co.

STEWARD S. TAYLOR
Maxim

THOMAS THOMAS
Intel Corp.

TRAN THONG
Microsystems Engineering, Inc.
THE DEPARTMENT OF ENVIRONMENTAL SCIENCE AND ENGINEERING (ESE) is one of the oldest stand-alone environmental science and engineering programs in the country, and offers graduate studies in water, soil and air sciences. Founded more than 25 years ago, the department is known for 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.

The department offers graduate studies leading to the degrees of Doctor of Philosophy (Ph.D.) and Master of Science (M.S.). The M.S. degree has both thesis and non-thesis options. All of our programs may be pursued full-time or part-time. 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, consisting of laboratory, computational, theoretical and/or field studies. Thesis students are involved in all aspects of departmental research and have ready access to modern instrumentation and computers.

The Ph.D. program can be completed in four to five years, and the M.S. thesis option takes approximately two years to complete. The M.S. non-thesis program can be completed in 12 months.

Students in any of the degree programs may concentrate their studies in the following areas:

- Environmental Science and Engineering (ESE) (traditional program)
- Environmental Information Technology (EIT)

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 & Engineering’s admission requirements, except for the minimum TOEFL score. For applicants whose native language is not English, the department requires TOEFL scores of at least 600 for the written test or 250 for the computer-based test. Students who earned undergraduate or graduate 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 may also be submitted but 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. Prospective students are encouraged to communicate with individual faculty members before applying.

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 each of the following environmental media groups:

1. Surface Waters ESE 520; ESE 530; ESE 537; ESE 539
2. Groundwater ESE 540; ESE 541; ESE 542; ESE 543

Students following the EIT track will in
general have further requirements specific to that track. The additional requirements will be defined by the student’s SPC (Student Program Committee).

All full-time students are required to take Environmental Science Seminar (ESE 599) each quarter except summer. 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 may not be used to 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 the distribution courses 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 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) 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.

For the M.S. non-thesis degree, five distribution courses must be taken as outlined above. Students must complete additional courses for a total of at least 45 credit hours, selected with the approval of the SPC. 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.

**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 in Fall 2001, and the M.S. thesis and non-thesis options in EIT will begin in Fall 2002. The EIT program combines the expertise and course work found in ESE and in the Computer Science and Engineering (CSE) and Electrical and Computer Engineering (ECE) departments at the OGI School of Science & Engineering at OHSU. 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 for the M.S. thesis and non-thesis options described above, except that students in the EIT program complete approximately 20 percent of their course work 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, see http://www.ese.ogi.edu/eit/.

**TUITION**

Tuition for the full-time M.S. non-thesis program is $19,620 for the 2002-2003 academic year, which is typically spread equally over the first four quarters. A part-time non-thesis M.S. program is available to meet the needs of working students, and interested students are encouraged to contact the Department of Graduate Education for additional information. A $100 deposit is required with the return of your acceptance to reserve your place in our department. This deposit is nonrefundable and will be applied toward your tuition.

**COURSE OFFERINGS**

**ESE 500 Introduction to Discrete Methods**

This course is an introduction to discrete methods for environmental fluid dynamics. Lectures cover the theory and application of methods for the numerical solution of initial-value, boundary-value and mixed initial-boundary-value problems. Prerequisite: Calculus. 4 credits
ESE 504 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.  4 credits

ESE 506 Environmental Systems Analysis
Introduction to techniques of systems analysis applied to environmental quality management. Emphasis is on development and application of mathematical models with computer simulation and optimization. Analysis includes 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.  4 credits

ESE 508 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

ESE 510 Aquatic Chemistry
General acid/base concepts (mono- and polyprotic systems); pH; making activity corrections; numerical calculations; titration concepts as applied to natural systems; buffer intensity; dissolved CO2 chemistry; acidity and alkalinity in open CO2 systems; minerals and their role in controlling natural water chemistry; solubility characteristics of oxide and hydroxides; introduction to redox chemistry in natural systems; p-e-pH diagrams.  4 credits

ESE 514 Distribution and Fate of Organic Pollutants
Discussion of the physico-chemical processes that control the partitioning of organic chemicals in the environment. This introductory course considers all environmental compartments, water, soil and air, and partitioning between these phases. Recommended prerequisite: ESE 510. 4 credits

ESE 516 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 511 and ESE 514. 4 credits

ESE 519 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, oxides 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

ESE 520 Introduction to Environmental Observation and Forecasting Systems
This course introduces environmental observation and forecasting systems and their application toward 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

ESE 522 Introduction to Spatial Sciences
Students will learn theoretical and practical applications of geo-spatial sciences within the context of Environmental Sciences and Engineering. Geographic Positioning Systems (GPS) will be studied while performing practical, hands-on laboratory experiments using the latest in GPS equipment. Classroom discussions will focus on relating location on the Earth's surface to a common grid. Horizontal and vertical datum, theoretical spheroids and ellipsoids, geoids and map projections will be discussed. Spatial relationships, or analysis, of continuous and categorical data will be addressed through the application of standard statistics and probability. ARCGIS, a popular Geographic Information System (GIS) software tool, will be stressed. 4 credits

ESE 523 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. Fundamentals of aerial photogrammetry, single-band, and multispectral and thermal infrared data will be addressed. Concepts of image statistics, radiometric and geometric corrections, spatial filtering and special transformations like the Normalized Difference Vegetation Index are explored. Supervised and Unsupervised classification schemes will be discussed as will change detection. The course pedagogy is designed to address the needs of the advanced Environmental Science and Engineering graduate student. While there is no prerequisite, the course incorporates many topics from ESE 505, “Introduction to Spatial Science.” It is therefore recommended that students unfamiliar with classification methods and the fundamental concepts of Geographic Information Systems complete ESE 505 or equivalent. 4 credits

ESE 530 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

ESE 532 Modeling Coastal Circulation and Transport I
This course introduces the students to the process of modeling coastal circulation and transport. Topics include review of governing equations and of state-of-the-art models, in-depth analysis of selected models, and hands-on solution of benchmark problems. Prerequisites: ESE 500 or ESE 508, and ESE 530. Contents revised for 2002-2003. 4 credits

ESE 533 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: ESE 532. Alternate years, contents revised for 2003-2004. 4 credits

ESE 537 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). 2 credits

ESE 540 Groundwater and Watershed Hydrology
Hydrologic cycle, principles of unsaturated and saturated flow in the subsurface; characterization of groundwater/surface interactions, water balance, modeling of watershed-scale processes. 4 credits

ESE 541 Groundwater Modeling

ESE 542 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

ESE 543 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 2002-2003. 4 credits

ESE 550 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. In 2002-2003, may be offered in combination with ESE 554. 4 credits

ESE 554 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, microbiological factors, and medium properties that determine the pathways and kinetics of biodegradation. Recommended preparation: ESE 550. 4 credits

ESE 560 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 2002-2003. 4 credits

ESE 562 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 2002-2003. 4 credits

ESE 570 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, dose-response relationships, deterministic and probabilistic risk assessments, responses of various receptors to different contaminants, and environmental management decisions. 3 credits

ESE 58X 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 Program Committee. Variable and repetitive credit

ESE 580 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

ESE 586 Environmental Law and Regulation
A survey of environmental law and regulation essential to practicing scientists and engineers. The course introduces the substance of environmental and natural resource law and also weaves in process (such as rule making and permit writing) and practical skills (such as environmental management and negotiation). 3 credits

ESE 587 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 its 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 2002-2003. 3 credits

ESE 589 Special Topics: Advanced Topics in Field Sampling and Analysis
An intensive capstone course that integrates field processes with theory from previous lecture material. Approximately one 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

ESE 598 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 (ESE 599). Students enroll for this course with their advisor’s approval. 1 credit

ESE 599 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

ESE 600 Research
Research toward the dissertation for the Ph.D. degree before completing the comprehensive examinations. Variable and repetitive credit

ESE 610 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 may be applied to a degree. Variable and repetitive credit

ESE 620 Professional Internship
This course provides an opportunity to earn credit for relevant work experience in industry. Students gain valuable experience that allows them both to apply the knowledge gained in the classroom and to prepare for their 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 may be applied to a degree. Variable and repetitive credit

ESE 700 M.S. Thesis Research
Research toward the M.S. thesis degree. Variable and repetitive credit

ESE 800 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree after completing the comprehensive examinations. Variable and repetitive credit

RESEARCH PROGRAMS
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, Chawla, external collaborators

CORIE: A Pilot Estuarine Observation and Forecasting System
Since 1996, we have been developing CORIE, an observation and forecasting system for the Columbia River estuary (http://www.ccalmr.ogi.edu/CORIE). The motivation is twofold. 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 observation and forecasting 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. Baptista, Chawla, Zhang, Zulauf

Quality-Scalable Information Flow Systems for Environmental Observation and Forecasting
Recent advances in computer power and connectivity have fueled the development of real-time Environmental Observation and Forecasting Systems (EOFs). These systems will revolutionize the way scientists share information about the environment and represent an unprecedented opportunity to break traditional information
barriers separating scientists from society at large. Incipient forms of EOIFS are already in use in areas of strong social relevance, but they tend to be small-scale, application- and domain-specific, stand-alone systems. There is a need to evolve toward multipurpose, shared systems designed to adapt flexibly to evolving needs of information consumers. To meet this need, we have assembled an interdisciplinary team, including computer science and environmental science researchers and a heterogeneous base of pilot users. Our goals include (a) developing missing integration concepts and technologies for EOIFS, (b) closing the loop between environmental models and sensors, (c) using, evaluating and refining a pilot EOIFS, and (d) developing pilot multilevel educational programs. Baptista, Walpole, Maier, Leen, Feng and Feng

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. 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 transport 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 three-year cooperative agreement to maintain, update and distribute the CORMIX user manual, conduct technical training workshops on mixing zone models, and provide technical assistance to CORMIX model users. The CORMIX water-quality model has approximately 1,000 users worldwide, their feedback through technical support and training workshops directly supports current model development activities. Doneker

Internal Circulation in Tidal Channels and Straits

This project, funded by the Office of Naval Research, seeks to use waterfet data analysis techniques and novel modeling strategies to improve our conceptual understanding of estuarine circulation and scalar transport. Continuous waterfet transforms allow resolution of time variation in tidal processes in each frequency band. The project 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

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 sol 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-phase. 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

Distribution of Organic Compounds Between the Gas and Urban Aerosol Particle 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$_3$). 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

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. Ongoing 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.eso.ogi.edu/mtbe/. Pankow, Tratnyek, Johnson

Global Distributions and Mass Balances of Halocarbons, Nitrous Oxide and Other Trace Gases

Gases such as Cl$_2$F$_2$ (F-11), CCl$_2$F$_2$ (F-12) and CHClF$_2$
Studies of Past Atmospheres
Atmospheric gases such as N₂O, CO₂, CO, CH₃Cl, carbonyl sulfide (OCS), and CH₄ 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 (N₂O, CO₂, CH₄). 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.

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 (CH₃Cl) and methyl iodide (CH₃I) 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 CCl₃F (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.

Studies of Atmospheric Methane
Considerable evidence has been accumulated showing that methane (CH₄) is increasing in the atmosphere, most likely as an indirect result of growing human population. In the future, such an increase of CH₄ 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 manmade fluorocarbons 11 and 12. In this project, experimental and theoretical research is focused on statistical trend analyses for the global increase of CH₄, its seasonal variation, sources and sinks, models of its effect on the CO, O₃, and OH cycles and its role in the future of the environment.

Development of Experimental Methods for Trace 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.

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 CH₄, N₂O, CH₄, Cl₃, H₂S, isoprene and other hydrocarbons.

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.

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.

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.

Human-Health Assessment of Water Quality
A national effort is under way 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.

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 the technique in the field. For more information on this work, see http://cgr ese.ogi.edu/iron.

Remediation of Explosives-Contaminated Groundwater
There are numerous facilities where military operations have resulted in contamination of groundwater with explosives such as TNT and RDX. Both TNT and RDX react rapidly with zero-valent iron, suggesting that permeable reactive barriers of zero-valent iron might be useful in remediation of these sites. However, the products of these reactions with zero-valent iron may not present a satisfactory remediation end-point. Therefore, we are investigating the kinetics and mechanisms of this reaction in the experiments performed in the laboratory and in the field. See http://cgr ese.ogi.edu/iron/.

Reduction Reactions of Organic Pollutants in Anaerobic Environments
Some organic pollutants undergo rapid reduction in anaerobic sediments, soils and groundwater. 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 to identify and quantity 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

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 corporate sponsors and 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.

For additional information about CGR, contact:

DR. RICHARD JOHNSON
Phone: 503 748-1193
E-mail: rjohnson@ese.ogi.edu

CENTER FACULTY
Richard Johnson, Associate Professor
James E. Pankow, Professor
Patricia L. Toccalino, Assistant Professor
Paul Tratnyek, Associate Professor

LEAP EQUIPMENT
• Five tanks: one 10m x 10m x 3m, two 10m x 10m x 5m, one 10m x 2.5m x 0.5m, and one 8m x 2.5m x 0.5m
• 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 manmade 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:

ANTÓNIO M. BAPTISTA
Phone: 503 748-1193
E-mail: baptista@ese.ogi.edu
CCALMR Web site: www.ccalmr.ogi.edu/

CCALMR RESEARCH FACILITIES

CCALMR 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:

REAL-TIME DATA ACQUISITION NETWORK

The pilot nowcast-forecast system CORIE includes a real-time data acquisition network with 12 multisensor 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. CCALMR operates a 21-foot research vessel, the R/V CORIE.

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)
• Optical backscatter sensors (Bowing Associates)
• Wind gauges (Coastal Leasing)
• High-density thermistor chains (CCALMR)
• Differential GPS (Trimble)
• Spread spectrum radio data modems (FreeWave)

BIOGEOCHEMICAL ROTATING ANNUAL FLUME (RAFL)

RAFL, 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:

• Three-dimensional Acoustic Doppler Velocimeter (Sontek)
• DO (Orion) and pH/ISE (Orion)
• DLK-100 Potentiostat (AS)
• Solid State Au/Hg amalgam microelectrodes
• Bipotentiosat equipped with rotating disk electrode (Pine)
RESEARCH INTERESTS
Integrated understanding and prediction of hydromorphic 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

ROBERT L. DONEKER, P.E.
Assistant Professor
Ph.D., Environmental Engineering
Cornell University, 1989
doneker@ese.ogi.edu

RESEARCH INTERESTS
Development of decision support systems for environmental simulation modeling, engineering design optimization and natural resource management. Current research focuses on development of technology transfer systems with emphasis on water-quality modeling and control of point and non-point source pollutant transport.

REPRESENTATIVE PUBLICATIONS

DAVID A. JAY
Associate Professor
Ph.D., Physical Oceanography
University of Washington, 1987
djay@ese.ogi.edu

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

RICHARD L. JOHNSON
Associate Professor, Director,
Center for Groundwater Research
Ph.D., Environmental Science
Oregon Graduate Center, 1985
rjohnson@ese.ogi.edu

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
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

RESEARCH INTERESTS
Human and ecological risk assessments, water-quality assessments, contaminant fate and transport in various environmental media.

REPRESENTATIVE PUBLICATIONS AND TECHNICAL REPORTS
JOINT FACULTY

DR. JAMES HUNTZICKER
Center for Professional Development
OGI School of Science & Engineering

ADJUNCT FACULTY

DR. MARY ABRAMS
DEQ Laboratory Division
Oregon Department of Environmental Quality

DR. DAVID BOONE
Department of Environmental Biology
Portland State University

DR. NORMAN EDER
Conkling Fiskum & McCormick, Inc.

DR. WILLIAM FISH
Department of Environmental Sciences and Resources
Portland State University

DR. ASLAM KHALIL
Department of Physics
Portland State University

KENNETH ROSENBAUM, J.D.
Environmental Law Institute (Visiting Scholar)
Washington, D.C.

DR. JOHN C. WESTALL
Department of Chemistry
Oregon State University

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Ph.D., Physical Oceanography
University of Delaware

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Memorial University of Newfoundland

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University of Wollongong, Australia

MICHAEL ZULAUF
Associate Research Scientist
Ph.D., Meteorology
University of Utah

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Duke University

BOB WATKINS
Research Technician
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Washington State University

MICHAEL WILKIN
Research Associate
B.S., Oceanography and Geology
University of Southampton, U.K.
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 Online, 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 School campus is not feasible. Course delivery is based on interactive Web pages, multimedia lectures and lessons, faculty-managed chat, and online discussions, all in a seamless, browser-centric environment. Students may 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 online). Courses offered online are identified with a “D” following the course number. For further information, visit the MST Web site at www.ogi.edu/MST/ for updates.

Individual Courses

Each MST course is designed as a valuable professional development experience for working professionals. Project Management, Quality Management, and Building Effective Organizations in Science and Technology, for example, may be taken as stand-alone courses. We encourage nonmatriculated students to join our courses for career development in specific areas.

For-Credit Certificate
Management in Science and Technology

The MST department offers a six-course certificate in Management in Science and Technology. The following five courses, plus an additional MST elective course chosen in consultation with a faculty advisor, are required:

<table>
<thead>
<tr>
<th>Course Code</th>
<th>Course Title</th>
<th>Credits</th>
</tr>
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<tbody>
<tr>
<td>MST 501/501D</td>
<td>Managerial and Financial Accounting for Science and Technology</td>
<td>4 credits</td>
</tr>
<tr>
<td>MST 503/503D</td>
<td>Marketing in Science and Technology</td>
<td>4 credits</td>
</tr>
<tr>
<td>MST 510/510D</td>
<td>Principles and Trends in Technology Management</td>
<td>3 credits</td>
</tr>
<tr>
<td>MST 512/512D</td>
<td>Project Management</td>
<td>4 credits</td>
</tr>
<tr>
<td>MST 520/520D</td>
<td>Managing in Science and Technology</td>
<td>4 credits</td>
</tr>
</tbody>
</table>

Elective to be chosen after consultation with faculty advisor 3-4 credits

Additional topical certificate programs are in the University approval process; please see the Web site www.ogi.edu/MST/ for updates.

Non-Credit Certificates

The MST department also offers certificate programs that do not award academic credit.

Executive Education for High-Tech Fast-Trackers

A Partnership between OGI, PSU and AEA

The OGI School of Science & Engineering at OHSU, the Portland State University School of Business Administration and the Oregon Council of the American Electronics Association (AEA) will launch an executive education program for the high-technology industry in early 2003.

Designed for the next generation of high-technology executives, the program provides knowledge, skills and tools essential for executive development. The program features three value drivers:

- Nationally known high-technology executives and academics as primary instructors.
- Content directly relevant to people about to enter the executive ranks.
- A local cohort program offering ample opportunity for participants to build a network of others with executive aspirations.

The program is presented in workshop format, with four one-day sessions in February, March, April and May on finance, leadership and management, strategy and marketing. Each day features two workshop sessions, lunch with the instructors, and

MST’s academic year culminates in a business plan competition before fellow students and judges from the business community.
dinner and social hour with a special guest, usually a prominent local executive. To promote building the cohort community between sessions, an online discussion group will be moderated by the PSU or OGI faculty member. This program does not award academic credit.

INDUSTRIAL DESIGN
This custom certificate program introduces participants to the full scope of product design 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.

Topics 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. This program does not award academic credits. Interested groups should contact the department head at fphillip@admin.ogi.edu.

REMOTE CLASSROOM SITES AND ALLIANCES
To reach a wider student population and to provide easier access to MST on-site courses, we have a remote classroom location at the Wilsonville Training Center. Currently, one or two MST courses per term are offered at the WTC. Please refer to the MST department’s Web site at www.ogi.edu/MST/ for updated course schedules.

Wilsonville Training Center
29353 Town Center Loop East
Wilsonville, OR 97070

The Management in Science and Technology department has established an alliance with the Engineering Technology Management graduate program at Portland State University. Students from either degree program may cross-register and receive full course credit transferable to his or her matriculated degree program. ETM students need prior approval from their faculty advisors.

ADMISSION REQUIREMENTS
Admission requirements for degree programs are the same as the general requirements for the institution. In addition, the MST department requires:

- A bachelor’s, master’s 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 TOEFL 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 are strongly urged to 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 52 credits with an average of B or better, up to four courses or 16 credits taken in the department before matriculation may be used toward the degree requirements. Most students will complete the degree program with between 52 and 55 credit hours.

MST Core Sequence
All M.S. students must take the MST core sequence, consisting of the following courses or their equivalent (35 credits). The courses listed below are offered both on campus and online. Either is acceptable for the M.S. in Management in Science and Technology degree. If you intend to take only online courses, please see the Distance Degree Requirements after this section.

MST 504/504D Marketing: Going to Market (online version unavailable) 4 credits
MST 511/511D Quality Management 3 credits
MST 514/514D Issues in R&D Management 3 credits
MST 522/522D Building Effective Organizations in Science and Technology 3 credits
MST 540/540D International Management in Science and Technology 3 credits
MST 541/541D Seminar in Leadership and Negotiation 3 credits

ELECTIVES: Any course in the above list not already taken and/or any of the following (6-8 credits):

CSCE 555 Engineering Optimization 4 credits
CSCE 577 Principles of Technology Development and Introduction to Manufacturing 3 credits
CSCE 504 Uncertainty Analysis 4 credits
CSCE 586 Environmental Law and Regulation 3 credits
CSCE 563 Software Engineering Processes 3 credits
CSCE 549 Applied Business Forecasting 3 credits
CSCE 568 Empirical Research Methods 3 credits
FIN 541 Principles of Modern Finance 4 credits
FIN 544 Investment and Portfolio Management 4 credits
FIN 547 Global Markets and Foreign Exchange 2 credits
FIN 551 Options and Futures I 4 credits
FIN 552 Options and Futures II 4 credits
FIN 558 Advanced Numerical Computing in Finance 2 credits
FIN 561 Risk Management 4 credits
FIN 573 Financial Time-Series Analysis 4 credits
FIN 576 Financial Markets and Trading 2 credits
MST 515 Supply Chain Management: Advanced Modeling 3 credits
MST 516 Global Logistics and Financial Management 3 credits
MST 517 Supply Chain Management: Advanced Modeling 3 credits
MST 521/522D Human Resource Management in Science and Technology 3 credits
MST 523 New Products Development 4 credits
MST 524 eBusiness Strategy and Roadmap 4 credits
MST 531 Software Commercialization 3 credits
MST 542 Seminar in Social Issues in Management 3 credits
MST 543 Commercialization Practicum 3 credits
MST 544/544D Strategic Alliances 3 credits
MST 58X Special Topics (special electives offered on a one-time 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 (12 credits):

FIN 541 Principles of Modern Finance 4 credits
FIN 551 Options and Futures I 4 credits
FIN 561 Risk Management 4 credits

Electives: three of the following courses are required (9 credits)

FIN 544 Investment and Portfolio Management 4 credits
FIN 547 Global Markets and Foreign Exchange 2 credits
FIN 552 Options and Futures II 4 credits
FIN 558 Advanced Numerical Computing in Finance 2 credits
FIN 573 Financial Time-Series Analysis 4 credits
FIN 576 Financial Markets and Trading 2 credits

**Managing in the Software Industries Sequence**

MST Core Sequence plus the following two courses are required (6 credits):

MST 531 Software Commercialization 3 credits
CSE 500 Introduction to Software Engineering 3 credits

Electives: Four of the following courses are required (12-15 credits):

CSE 503 Software Engineering Processes 3 credits
CSE 504 Object-Oriented Analysis and Design 3 credits
CSE 514 Introduction to Database Systems 3 credits
CSE 518 Software Design and Development 3 credits
CSE 560 Artificial Intelligence 3 credits
CSE 564 Human-Computer Interaction 3 credits
CSE 567 Developing User-Oriented Systems 3 credits
MST 504 Marketing: Going to Market 3 credits

**MST Online 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 Online degree requirements. Students must complete a minimum of 52 credits with an average of B or better.

**MST Online Core Sequence**

All M.S. students must take the MST core sequence, consisting of the following courses or their equivalent (35 credits):

MST 501D Managerial and Financial Accounting for Science and Technology 4 credits
MST 502D Financial Management 4 credits
MST 503D Marketing in Science and Technology 4 credits
MST 510D Principles and Trends in Technology Management 3 credits
MST 512D Project Management 4 credits
MST 513D Manufacturing Practices and Management 3 credits
MST 520D Managing in Science and Technology 4 credits
MST 530D Strategic Management and Planning 4 credits
MST 550D Capstone Project: Business Plan 4 credits
MST 590D Effective Business Writing 1 credit

**OR**

MST 591D Professional Writing for Non-native Speakers 1 credit

**Area of Emphasis — Online Degree**

MST currently offers only one area of emphasis, Managing the Technology Company, to students who take only online classes.

**Managing the Technology Company Online Sequence**

MST Online Core Sequence plus three of the following four courses are required (9 credits)

MST 511/511D Quality Management 3 credits
MST 522/522D Building Effective Organizations in Science and Technology 3 credits
MST 540/540D International Management in Science and Technology 3 credits
MST 541 Leadership and Negotiation 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.

**Course Descriptions**

**MST 501, 501D, 501W 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.

**MST 502, 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, the 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 a balance between understanding theoretical foundations and techniques of practical application. Prerequisite: MST 501.

**MST 503, 503D Technology Marketing: Planning for Market**

The course introduces the 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 and draw from students’ work experiences in technology, engineering, manufacturing and science.

**MST 504 Going to Market: Delivering Value to Customers and Shareholders**

The course complements and completes the marketing knowledge and expertise gained through MST
MST | MANAGEMENT IN SCIENCE AND TECHNOLOGY

503. Integrating lectures, class discussions, case studies, videos and individual papers and team projects, the course emphasizes developing the detailed implementation plan to bring products or services to market. The course drillls down into the operational specifics of pricing, promotion, sales, advertising and customer relationship management, e-business and web marketing, supply chain and distribution logistics, channel alliance building and implementation standards, metrics and controls. The course is essentially practical and interactive. It will not turn students into marketing geniuses but will provide an understanding of the tools, mechanics and management of operational marketing implementation processes in high-technology environments. It is aimed at both high technology firms and those that are heavy users of high technology. The goal is to show how to turn strategy into practice by implementing the marketing plan begun in MST 503, developing the specifics of a product or service's business model and persuasively outlining the blueprint of the business case. 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 from both the vendor and buyer points of view, and also consider internal technology development for internal use. Other topics 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 covered 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, behavioral and operational management aspects, excluding sophisticated statistical analysis, of TQM. Classroom discussion, based on the participants' experiences and assigned readings from the textbook, is primary. Lectures generally serve 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
This introductory course addresses the field of project management from a management perspective rather than an engineering or mathematical perspective. Accordingly, we adopt the life cycle of a project and structure this course in three segments: Project Initiation, Project Implementation and Project Conclusion. The class is conducted in a seminar/workshop environment, with guest speakers on real-life project experiences. One of the 4 credits is dedicated to Effective Presentation Skills.

MST 513, MST 513D Manufacturing Practices and Management
This course introduces key practices in manufacturing management. We will address issues faced by a typical vice president of operations, from strategic direction through tactics to daily control. Key topics include supply chain management and various techniques in planning and execution. 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 invited speakers from both small and large companies. 3 credits

MST 515 Supply Chain Management
Supply Chain Management (SCM) 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. SCM is a system approach to managing the entire flow of information, materials, products and funds to and from suppliers and end-customers. 3 credits

MST 516 Global Logistics and Financial Management
Today's global business environment presents problems for managing the logistics of activities involved in physically moving raw materials, inventory and finished goods inventory from point of origin to point of consumption. SCM is a system approach to managing the entire flow of information, materials, products and funds to and from suppliers and end-customers. 3 credits

MST 517 Supply Chain Management: Advanced Modeling
This course introduces the use of mathematical programming in supply chain modeling. The primary emphasis is 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, including 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 520, MST 520D, MST 520W Managing in Science and Technology
This course develops participants' ability to understand and influence human behavior within technology-intensive organizations. By studying and applying four theory-based frames (structural, human resource, political and symbolic), students learn to identify and fill gaps in their current understanding of challenging organizational situations. The course also analyzes the influence processes and network of relationships required for managing large, technology-intensive organizations, both as individuals and in teams, in a fast-changing environment. Self-assessment, networking and developmental relationships are explored as means of developing influence and impact. 4 credits

MST 521, MST 521D Human Resource Management in Science and Technology
This course focuses on how managers can work with and use the human resource (HR) management function to create value and deliver results. Specifically, we focus on how managers can improve productivity in three areas: 1) policies and practices for managing people, 2) hiring and motivating workers, and 3) rewarding and appraising workers. Students in this course will have the opportunity to develop and practice skills and abilities in these three areas. 3 credits

MST 522, MST 522W, 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, 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 from those presented. Cases and actual examples are 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 in product development organizations or those who support
such organizations. Technology integration and innovative environments are critical to developing profitable products in today's technology-oriented companies. The course will review cases and articles addressing key issues in new product development. Topics such as Disruptive Technologies, Technology Integration, Concurrent Engineering and Managing Technological Innovation will be covered. Students will form teams and develop a plan for a new product. The plan will include risk assessments in areas such as manufacturing, design, test and so on. The team will make several presentations throughout the course. 4 credits

**MST 524 eBusiness: Strategy and Roadmap**

Information and technology are changing the business world. To succeed in this new environment, all companies, from established industry leaders to startups, must understand the new level of threats and develop strategies that take full advantage of the opportunities technology offers. Successful companies are pursuing focused e-business strategies that build new kinds of enterprises. These enterprises are (re)designed to attract, serve and retain customers, manage suppliers, and inform and empower employees better than ever before. The course offers a practical understanding of what it takes to develop the "digital enterprise." The first part addresses the issue of developing a robust business model that capitalizes on the new opportunities. The second covers the e-business architecture and applications (such as customer relationship management, supply chain management, selling chain management) and how to develop and implement the e-business strategy. Cases and articles will illustrate the successful strategies and techniques used by leading companies. Previous courses highly recommended: MST 503, MST 530. 4 credits

**MST 530, MST 530D Strategic Management and Planning**

This course focuses on the analysis of fast-changing ("hyper-velocity") competitive environments and on the decision-making process leading to the formulation and implementation of strategy. The class explores using time, knowledge and technologies as competitive advantages, managing strategic change, and developing strategic plans for a future that cannot be known with certainty. Several models for strategy formulation, such as Game Theory, Portfolio Analysis, the Five-Forces and Competing on the Edge will be examined. Because the ultimate test of strategy in the business world is running a company, class teams will play a computer simulation of operating a business in a dynamic, competitive environment. Prerequisites: MST 502/502D, MST 503/503D, MST 520/520D. 4 credits

**MST 531 Software Commercialization**

This course examines the structure of the software industry, problems of marketing privately developed software, and commercializing software from the government and nonprofit sectors. Because the business models for hardware and software companies differ, 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, 540D, 540W 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**

The course examines the relationship between issues and responsibilities, and government regulations and influences. First, the course examines different frameworks for individual decision making in an organizational setting. Next, it examines the impact of organizational policies and practices, and the words and actions of managers on the behavior of individuals within those organizations. 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 work in teams with real technologies. Student teams 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 make one or more field trips to these institutions. The technologies may be in the areas of environment, 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 543 project as a preliminary exercise for the Capstone project. MST students may choose to use their 543 project as a preliminary exercise for the Capstone project. 3 credits

**MST 544, 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 compiles best practices in strategic alliance formation and implementation distilled from approximately 40 high-performance international and domestic strategic alliances. It offers a well-articulated framework applicable across a broad range of alliance types. The objective 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**

The objective of the Capstone course is to provide an opportunity to demonstrate, through an integrative project, knowledge gained from other course work taken in the MST program. Students, in teams of three to five, will plan, research, prepare and present a business plan in both written and oral form. Prerequisites: MST 501, MST 502, MST 503, MST 512, MST 520, MST 530 and instructor approval. 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

**MST 590, MST 590D Effective Business Writing for Management**

This course reviews several aspects of conventional punctuation and grammar that address the needs of the participants. In addition, attention is given to style for clear, concise communication necessary in business writing. Class size is limited to 10 students. 1 credit

**MST 591, MST 591D Professional Writing for Non-native Speakers**

This course is an intensive review of English grammar and sentence structure with a focus on formal English for professional purposes. Some attention is paid to the academic essay as well as business writing. Class size is limited to 10 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.
FACULTY

FRED YOUNG PHILLIPS
Professor and Department Head
Ph.D., Management Science/ 
Business Administration
University of Texas at 
Austin, 1978
fphilip@admin.ogi.edu

RESEARCH INTERESTS
Market research, marketing 
innovation and high-technology 
products, managing the new 
products development process, 
incubation and commercialization 
of new technologies, strategic and 
innovative use of computers

REPRESENTATIVE PUBLICATIONS
- Innovative use of computers in 
  e-learning courses.
- Advanced lithography for 
  semiconductor fabrication.

MARIANNE KOCH
Visiting Associate Professor
Ph.D., Human Resource 
Management and 
Industrial Relations
Columbia University, 1989
koch@admin.ogi.edu

RESEARCH INTERESTS
The human side of technology 
transfer; work/family policies and 
practices; coaching faculty in the 
development and teaching of 
e-learning courses.

REPRESENTATIVE PUBLICATIONS:
- M. Koch and A. Meyer, 
  “Adoption of Innovations in 
  Hospitals: Exploring the Validity of a 
  Multi-Stage Model,” forthcoming, 
  International Journal of Technology 
  Management; also in Academy of Management 
  Best Papers Proceedings, August 1996.
- M. Koch and G. Hundley, “The Effects 
  of Unionism on Recruitment and 
  Selection Practices,” Industrial 
  Relations, vol.36, no.3, pp. 349-370, 
  1997.
- M. Koch and R. McGrath, “Improving 
  Labor Productivity: Human Resource 
  Management Policies Do Matter,” 
  Strategic Management Journal, vol.17, 
  pp. 335-354, 1996. Awarded an Anbar 
  Electronics Intelligence Citation of 
  Excellence Award for 1997.
- M. Koch, Hiring Practices and Labor 
  Productivity, Garland Publishing, Inc., 

C. NEIL BERGLUND
Professor/Joint Appointment 
with Department of Electrical 
and Computer Engineering
Ph.D., Electrical Engineering 
Stanford University, 1964 
berglund@ece.ogi.edu

RESEARCH INTERESTS
Management of technology, and 
advanced lithography for 
semiconductor fabrication.

REPRESENTATIVE PUBLICATIONS
- J. Ye, M. Takac, C.N. Berglund, 
  G. Owen and R.F.W. Pease, “An Exact 
  Algorithm for the Self-Calibration 
  of Precision X-Y Stages,” Conference on 
  Electron, Ion and Photon Beam 
  Technology and Nanofabrication, 
  May 1996.
- W. Wang, J. Ye, A.B. Owen, C.N. 
  Berglund and R.F.W. Pease, “Field 
  Distortion Characterization Using 
  Linewidth or Pitch Measurement.” 
  J. Vac. Sci. Technol. B13(6), 
  November-December 1995.
- J. Ye, C.N. Berglund and 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 and R.F.W. Pease, 
  “Field Distortion Characterization Using 
  Linewidth or Pitch Measurement,” 
  J. Vac. Sci. Technol. B13(6), 
  November-December 1995.
- J. Ye, C.N. Berglund, J. Robinson and 
  R.F.W. Pease, “Review of Mask Errors 
  on a Variety of Pattern Generators,” 
  IEEE Transactions on Semiconductor 
  Manufacturing, 8(3), pp. 319-325, 
  August 1995.
- J. Ingino, G. Owen, C.N. Berglund, 
  R. Browning and R.F.W. Pease, 
  “Workpiece Charging in Electron 
  Beam Lithography,” J. Vac. Sci. 
  Technol., B12(3), pp. 1367-1371, 
  May-June 1994.

JACK RAITON
Senior Fellow
MBA, Finance and Statistics 
University of Washington, 1967
raiton@admin.ogi.edu

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 
B.S. in mathematics from Oregon 
State University in 1966 and his 
M.B.A. in finance and statistics 
from the University of Washington 
in 1967. He attended Harvard 
University’s three-year 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
Senior Advisor
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 U.S. Department of Energy.

AREAS OF EXPERTISE
Technology management, commercialization of technologies, R&D management, strategic planning.

NICOLE STECKLER
Associate Professor
Ph.D., Organizational Behavior
Harvard University, 1990
steckler@admin.ogi.edu

RESEARCH INTERESTS
Information sharing across organizational boundaries; leading organizational change; interpersonal communication and influence in organizations; and tools for diagnosing and improving leadership effectiveness.

REPRESENTATIVE PUBLICATIONS

ALVIN H. TONG
Professor
Ph.D., Electrical Engineering
University of Minnesota, 1967
tong@admin.ogi.edu

Alvin Tong teaches Project Management and the Capstone Project (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 30 years of working experience in the computer and related industries, 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 14 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 high-tech science-based industrial parks.

REPRESENTATIVE PUBLICATIONS
ADJUNCT FACULTY

KEN ANTHONY
Rapid Innovations

JEAN CLAUDE BALLAND
JCB Associates

MARK CHEN
Softtech Innovation LLC

TUGRUL DAIM
Intel Corporation

DEAN DERRAH
InFocus Systems

RICHARD DORF
University of California at Davis

DAVID DRAKE
Catalyst Communications, Inc.

WILLIAM DRESSELHAUS
Dresselhaus Design Group

TOM FLORA
Stockamp & Associates

RICHARD FOURNIER
Kaiser Foundation
Healthplans Northwest

RICHARD GOLDGAR
Texas Education Agency

STEPHEN GOMES
CEO2, Inc.

JULIAN GRESSER
LogosNet

JILL B. KELLY
JK Editing

KEITH LARSON
Intel Corporation

RITA LAXTON-BENZAN
IMMEDIAD’s ChildRom Productions

KATHY MANGEL-DAVIS
Professionally Speaking

MICHAEL MCLEAN
AC Transit

DEIORDRE MENDEZ
Foreign Business Management Consultants

MIGUEL MENDEZ
Industry Consultant

RAJ MERCHANT
Strategy@work

PAUL NEWMAN
Cooper Mountain Research, Inc.

RICHARD PRINS
Group 3

JESSE REEDER
Leadership Dynamics

YONG-IN SHIN
Intel Corporation

JAY SHUTTER
Momentum Research Group

LESLIE SMID
IBM

THOI TRUONG
Emery Worldwide

HARVEY UTECH
Nike

JOHN WALLNER
Tektronix, Inc.
OHSU is an equal opportunity, affirmative action institution.
OHSU includes four schools, two hospitals, numerous primary care and specialty clinics, multiple research institutes, and several public service and outreach units.