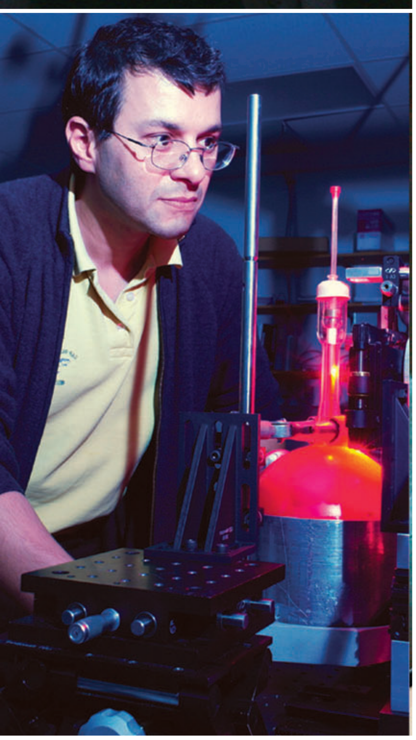
04/05 CATALOG



OGI SCHOOL OF SCIENCE & ENGINEERING

www.ogi.edu/catalog

Revised November 2004

OHSU

OREGON HEALTH & SCIENCE UNIVERSITY

OGI School of Science & Engineering

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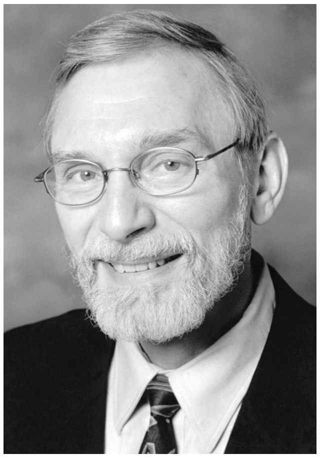
Photography by Jerome Hart, David Moore, Rick Rappaport, Anne Rybak and Jeff Schilling.

A LETTER FROM THE DEAN



It's about the connections between a healthy environment and a healthy population. It's about computers that think like people do, and are reliable enough to trust with the safety of our communities. It's about helping our seniors live longer, more satisfying lives. It's about cultivating business leaders who can guide Oregon's high-technology companies through today's changing markets. At the OGI School of Science & Engineering, it's all about building healthier, better-informed and more secure communities in Oregon and beyond. Virtually everything we do — be it graduate education, research, industrial collaboration, or community outreach — is aimed at solving important societal problems, and at putting these solutions into the hands of those that need them most. Are you interested in expanding your science and engineering knowledge in this type of environment? As a component of Oregon Health & Science University, our school welcomes high-caliber students who seek to apply advanced technologies in real-world situations. This electronic catalog is designed to tell you everything you need to know about pursuing a graduate degree at OGI.

As you scroll through the catalog, you may be surprised at the wide range of programs offered through such a small school. Since OGI's inception more than 40 years ago, the school's small size has been one of its key strengths. We offer an enviable faculty/student ratio of 1/1.9 for Ph.D. students. Despite our size, OGI awards a significant percentage of Oregon's graduate degrees in high-technology fields, and our highly productive faculty generates approximately $16 million in research support each year from government and industrial sources. OGI is small enough to remain responsive to changing needs in the fields we serve, and to foster collaborative, interdisciplinary research across a broad — yet synergistic — range of scientific endeavors.

The following seven accredited Masters degrees are offered through four academic departments: Biochemistry and Molecular Biology (BMB), Biomedical Engineering (BME), Computer Science and Engineering (CSE), Electrical Engineering (EE), Environmental Science and Engineering (ESE), Management in Science and Technology (MST) and Software Engineering (OMSE). Students can earn accredited doctoral degrees in BMB, BME, CSE, EE and ESE. OGI also offers graduate-level certificates in Management in Science and Technology, Health Care Management and Software Engineering. We are proud of our diverse population of full- and part-time students, who learn in an environment where fundamental knowledge is balanced with a focus on practical problem solving. OGI is committed to following discoveries from concept all the way through to fruition, leveraging the commercial potential of our technologies wherever possible to serve the broadest possible cross-section of the public. At OGI, it's all about making a difference. I've tried to give you an idea of how we make a difference in our region and beyond. Now, I invite you to read for yourself how OGI can make a difference to you.

Ed Thompson, Ph.D.
OHSU Vice President and Dean
OGI School of Science & Engineering

WELCOME

HISTORICAL BACKGROUND

The OGI School traces its origins to the early 1960s, when Mark Hatfield, then Oregon's governor, and an advisory committee of industrial and educational leaders recommended creating an independent institution for graduate education and research in the Portland area. In 1963 they established the Oregon Graduate Center for Study and Research. In 1989, the center was renamed the Oregon Graduate Institute of Science and Technology.

Over the next decade, OGI awarded more than 1,000 graduate degrees, offered hundreds of continuing education classes and workshops, and pursued more than $100 million in research, most of it federally funded. Now in its fourth year as a school of Oregon Health & Science University (OHSU), OGI continues as a premier provider of high-quality graduate science and engineering education, with more than 500 students working full- or part-time toward master's or Ph.D. degrees, and more than $18 million in research annually.

OHSU is a health and research university dedicated to graduate education, research and health care. The university educates some 2,500 students each year and in 2003 brought in more than $221 million in research dollars - a figure that is expected to grow by 15 to 20 percent annually. About 1,500 scientists are working on basic and applied research projects throughout OHSU. Its merger with OGI has broadened the mission of the institution to encompass new research frontiers where technology and engineering converge with health care and biomedicine.

The OGI School of Science & Engineering remains committed to its historical purpose: to educate students and conduct high-quality research in science and engineering and to serve as a resource for Oregon's high-technology industry. The merger both strengthens OGI's traditional research-based programs and enables the school to expand in new directions. In 2002, with a $4 million grant from the M.J. Murdock Charitable Trust, the school established a Department of

Biomedical Engineering.'The merger also facilitates cross-disciplinary collaboration at the interface of science, engineering, health and the environment.

OGI is part of OHSU's West Campus, which also includes the Vaccine and Gene Therapy Institute, the Neurological Sciences Institute and the Oregon National Primate Research Center. The West Campus is about 12 miles from OHSU's central campus on Portland's Marquam Hill.

MISSION

The mission of the OGI School of Science & Engineering is to carry out advanced research in science, engineering and management that responds to important social, environmental and industry needs; to offer outstanding graduate and professional educational opportunities; and, by so doing, to contribute to the region's economy and well-being.

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 and the OGI School of Science & Engineering are 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.

ACADEMIC CALENDAR 2004 | 2005

FALL QUARTER 2004

August 9	Registration begins for Fall Quarter
September 20-24	New student orientation week
September 26*	Last day to register without late fees
September 27	Fall Quarter instruction begins
October 4	Student account balances due
October 22*	Last day to add/drop classes
November 8	Registration begins for Winter Quarter
November 25-26	Thanksgiving holiday (no classes, OGI offices closed)
December 6-10	Final exams
December 24	Christmas holiday (OGI offices closed)

WINTER QUARTER 2005

November 8	Registration begins for Winter Quarter
December 31	New Year's holiday (OGI offices closed)
January 2*	Last day to register without late fees
January 3	Winter Quarter instruction begins
January 10	Student account balances due
January 17	Martin Luther King Jr.'s Birthday (no classes, OGI offices closed)
January 28*	Last day to add/drop classes
February 7	Registration begins for Spring Quarter
February 21	President's Day (no classes, OGI offices closed)
March 15-18	Final exams (Monday, March 14th will be a regular class day to account for two Monday holidays earlier this quarter)

SPRING QUARTER 2005

February 7	Registration begins for Spring Quarter
March 27*	Last day to register without late fees
March 28	Spring Quarter instruction begins
April 4	Student account balances due
April 22*	Last day to add/drop classes
May 2	Registration begins for Summer Quarter
May 30	Memorial Day holiday (no classes, OGI offices closed)
June 1	Commencement
June 6-10	Final exams

SUMMER QUARTER 2005

May 2	Registration begins for Summer Quarter
June 19*	Last day to register without late fees
June 20	Summer Quarter instruction begins
June 27	Student account balances due
July 4	Independence Day holiday (no classes, OGI offices closed)
July 15*	Last day to add/drop classes
August 29-September 2	Final exams
September 5	Labor Day holiday (no classes, OGI offices closed)

*Management in Science and Technology weekend and distance learning courses have unique late registration and add/drop deadlines. Please refer to OGI's course schedule for the specific MST registration information.

ABOUT THIS CATALOG

This catalog is as accurate as possible as of July 1, 2004. 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, course descriptions and program requirements. This document should not be construed as forming the basis of a contract.

Additional student and academic policies are listed in the OGI Student Handbook located at www.ogi.edu/students/studenthandbook.pdf.

OVERVIEW

ACADEMIC DEPARTMENTS

The OGI School of Science & Engineering has four academic departments: Biomedical Engineering (BME), Computer Science and Electrical Engineering (CSEE), Environmental and Biomolecular Systems (EBS) and Management in Science and Technology (MST).

Students benefit from cross-disciplinary research and education as faculty members take part in research projects outside their main department. This encourages the exchange of ideas across related research areas and provides the fullest use of the wide range of instrumentation available at the school.

DEGREE PROGRAMS

The OGI School of Science & Engineering offers M.S. and Ph.D. degrees in:

- Biochemistry and Molecular Biology
- Biomedical Engineering
- Computer Science and Engineering
- Electrical Engineering
- Environmental Science and Engineering
- Management in Science and Technology (M.S. degree only)

CERTIFICATE PROGRAMS

The following certificate programs are available:

Department of Management in Science & Technology

- Health Care Management
- Management in Science and Technology

Oregon Masters in Software Engineering Program

- Principles of Software Engineering
- Software Analysis and Design
- Software Quality Engineering

STUDENTS NOT SEEKING DEGREES

Any qualified student may take courses at OGI, in a part-time capacity, without enrolling in a degree program. Up to 21 credits completed prior to matriculation (enrollment in a degree program), either taken at OGI or transferred from another institution, may be accepted toward degree requirements. To earn a degree from the OGI School, a student must first be formally admitted to a degree program.

ACCREDITATION

Oregon Health & Science University and the OGI School of Science & Engineering are 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, 8060 165th Avenue NE, Suite 100, Redmond, WA 98052-3981.

ADMISSIONS

ADMISSIONS REQUIREMENTS

The following requirements apply to all Masters and Ph.D. programs at the OGI School, unless otherwise indicated. Individual academic programs may have specific requirements in addition to those shown below and can be found in the department sections of the catalog.

- To apply for any degree program at the OGI School, an applicant must have previously earned a four-year bachelor's, or equivalent, degree, although a student may be provisionally admitted prior to that time. An international applicant with a three-year bachelor's degree from a foreign country should have his/her academic credentials evaluated by an external evaluation company in order to determine equivalency to a four-year, U.S. bachelor's degree.
- The Graduate Record Examination (GRE) may be required. See Departmental sections for specific requirements.
- Official transcripts from each college or university previously attended.
- Three original letters of recommendation. The letters should attest to the student's ability to succeed in a graduate program. Recommendation letters must be signed and preferably mailed directly from the author. If sent in by the student, the recommendation letter must be in a sealed envelope. For guidance, a recommendation form is available at www.ogi.edu/graduate_edu/forms/recommendation_letter.pdf.

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 documentation 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 for all applicants whose native language is not English, except for those who have earned a degree from a U.S. institution. The OGI School will accept either the paper-based test or the computer-based test. Required scores for individual programs are discussed in the department sections of this catalog. 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.
- $65 nonrefundable application fee, which is valid for one year and cannot be waived or deferred.
- Official transcripts from each prior college or university attended. The transcripts must arrive in a sealed envelope and should be mailed directly to the Department of Graduate Education.

- Three letters of recommendation.
- Official GRE scores (if applicable, see Department sections). The institutional code for OGI is 4592.
- TOEFL 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.

Please send completed applications, transcripts and other application materials to:

Department of Graduate Education
OGI School of Science and Engineering
20000 N.W. Walker Road
Beaverton, Oregon 97006-8921
Phone: 503 748-1382
Toll-free: 800 685-2423
Fax: 503 748-1285
E-mail to: admissions@admin.ogi.edu

Due dates: Applications are considered on a year-round basis. It is highly recommended that domestic students submit their applications 10 weeks prior to the quarter in which they would like to begin, 15 weeks for international students. Priority is given in the admission and financial support processes to those applications received by March 1.

Start date: The academic year formally begins in September and students are encouraged to start the academic program at that time. However, mid-year admissions may be offered. Generally, Ph.D. students are admitted for Fall quarter and as full-time students.

STUDENT VISAS

Information on student visas and other immigration services can be found on the Web site for OHSU's Office of International Services, www.ogi.edu/admissions/immigration/.

TUITION AND FINANCES

TUITION AND FEES

For the 2004-2005 academic year, tuition and fees are as follows:

Non-degree students, Masters students and Ph.D. students:

Credits	Tuition
1	$625
2	$1250
3	$1875
4	$2500
5	$3139
6	$3766
7	$4393
8	$5020
9	$5690
10-12	$625/credit (Non-degree students) No additional charge for Masters and Ph.D. students.
13 +	$625/credit (Non-degree and Master's Students) No additional charge for Ph.D. students.

The above tuition and fee amounts include OHSU's activity, building, and incidental fees. These fees are mandatory and cannot be reduced for students who do not intend to use a specific resource or service.

DEPOSITS

Upon acceptance as a master's student into the Biochemistry and Molecular Biology or Environmental Science and Engineering programs, applicants must pay a $100 deposit to reserve a place in the program. Deposits will be applied toward tuition and are nonrefundable.

HEALTH INSURANCE

Full-time, admitted students are required to either enroll in OGI's student medical insurance or provide proof of other medical insurance coverage. The student is responsible for the full cost of OGI's insurance coverage and may purchase additional coverage for family members. Contact the Graduate Education Department for current premium rates. Part-time students are not eligible for OGI's student insurance.

FINANCIAL AID

Generally, entering full-time Ph.D. students are eligible for financial support through a combination of tuition scholarships, OGI scholarships, 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 the school or individual academic departments to entering full-time master's students. No additional application is required.

Subsidized and Unsubsidized Federal Stafford Loans are available to eligible students who are formally admitted to a master's or Ph.D. program at the OGI School of Science & Engineering. Students must be enrolled for at least five credits each quarter and must be either U.S. citizens or eligible non-citizens. For application materials and additional information, contact the Financial Aid Office at OHSU at 503-494-7800 or 800-775-5460 or e-mail to:finaid@ohsu.edu. Information about financial aid may also be found on OHSU's Web site at www.ohsu.edu/finaid/.

The "Free Application for Student Aid" (FAFSA) forms may be found at www.fafsa.ed.gov/. Use Federal School Code 004883 when completing the FAFSA form.

REFUND POLICY

To receive a refund, a student must drop a course within the available timeframes listed below:

Quarter-long Courses: A 100% tuition refund will be given if a student drops a quarter-long course by the end of the second week of the quarter. Dropping before the end of the fourth week of the quarter will result in a 50% refund. No refunds will be provided for dropping a course after the fourth week of the quarter.

MST Compressed Weekend Courses: A 100% refund will be given if an MST weekend course is dropped by the Friday following the first weekend of class. Dropping by the Friday following the second weekend of class will result in a 50% refund. After that, there is no refund for dropping a compressed weekend course.

Online Courses: Dropping an online course by he end of the second week following the beginning of the course will result in a 100% refund. There is no 50% refund timeframe for online courses. No refund will be issued for dropping an online course after two weeks.

ACCESS AND DISABILITIES SERVICES

OHSU/OGI believes that a diverse student body enhances the educational opportunities for all students and is beneficial to the graduate experience at large. If you are a student with a documented disability or you think you might experience a disability and believe you will need accommodations while at OHSU/OGI, we encourage you to contact the Director of the Office for Student Access. The Office for Student Access provides accommodations, information, support, advise and resources institution-wide. The Office for Student Access works in conjunction with the Program Accommodation Liaison (PAL) designated from each individual school to ensure equal access to all the programs and services offered by that individual school.

Graduate programs are extremely rigorous and fast-paced. Accommodations that may have worked in your undergraduate program may no longer be effective in this environment. For further assistance or information, please contact the Director of the Office for Student Access at 503-494-0082 or the OGI PAL in the Graduate Education office at 503-748-1581. All information regarding a student's disability is kept in accordance with relevant state and federal laws.

COURSE NUMBERS

Effective Fall Quarter 2003, the OGI School renumbered many of its courses to better align course numbers with the Oregon Health & Science University standard numbering scheme. To assist in relating the new course numbers to courses offered in the past, a course number "crosswalk" is available online at www.ogi.edu/graduate_edu/schedule/crosswalk.cfm.

5xx Graduate courses offered primarily in support of master's programs. May be used towards a doctoral program as appropriate.

6xx Graduate courses offered primarily in support of doctoral programs. May be used towards a master's program as appropriate.

Courses listed as 5xx/6xx are applicable to both a master's program as well as a doctoral program. Master's, certificate and non-degree students should register for the 5xx class and doctoral students should register for the 6xx class when available.

The following standard course numbers may be included in each program's course offerings. Refer to the individual program for further details.

501/601	Master's Non-Thesis Research/PhD Pre-qualifying Research
502/602	Independent Study
503/603	Master's Thesis Research/PhD Dissertation Research
504/604	Internship
505/605	Reading and Conference
506/606	Special Topics Courses
507/607	Seminar
508/608	Workshop
509/609	Practicum

400-LEVEL COURSES

Occasionally, OGI will offer a 400-level course for personal or academic development. Courses designated by a 400-series number are not considered graduate level courses and will not satisfy any degree requirements. These courses will appear on the transcript.

ACADEMIC POLICIES

The following is a list of selected OGI School of Science & Engineering academic policies. A more comprehensive listing can be found in the OGI School Student Handbook at 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. Management in Science and Technology (MST) courses may not be audited.

Any request to change credit/audit status must be submitted in writing to the Graduate Education Office. Requests received during the first six weeks of the quarter do not need the instructor's signature. Students may change status after the first six weeks and before the final exam (or last class meeting for classes without exams) by submitting a request that includes the instructor's written permission. Status cannot be changed after the final exam (or last class meeting for classes without exams).

CONFIDENTIALITY OF STUDENT RECORDS

With the passage of the Federal Family Educational Rights and Privacy Act (FERPA) of 1974, Oregon Health & Science University 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/OHSU, 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/OHSU officials and certain authorized federal and state authorities.

Directory Information. OGI/OHSU can release certain public domain information, known as directory information, unless a student has filed a written request in the OGI Registrar's Office to restrict his/her directory information. OHSU limits directory information to the student's full name, addresses, e-mail addresses, phone numbers, 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.

Each student has the right to designate directory information as not being subject to release without his or her consent, except as otherwise permitted by law. OHSU's Registrar's Office shall provide to each student a form entitled "Request to Restrict Directory Information" to be used by the student to designate that directory information may not be released without the student's consent. If the student does not submit the completed form by the date indicated, OHSU may release directory information pertaining to that student.

CONTINUOUS ENROLLMENT

Unless on approved leave of absence, a Ph.D. or master's student who has begun work on his/her thesis/dissertation must register and pay for at least one research credit per quarter, in addition to any other registered course credits, in order to maintain matriculated status. A student is considered to have begun work on his or her thesis/dissertation when he or she first registers for 503 - Master's Thesis Research (for master's students) or 603 - Ph.D. Dissertation Research (for Ph.D. students). Continuous enrollment is not required of master's students not pursuing a thesis, or of master's or Ph.D. students who have not initially registered for 503 or 603 research (as appropriate). If a Ph.D. or master's thesis student graduates (including EPC approval) before the last day to register in a term, continuous enrollment for that term is not required.

CREDIT LOAD PER QUARTER

Twelve credits per quarter are considered a normal course load for full-time, degree-seeking students, although nine or more is considered full time status. 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. A student may not register for more than 12 credits in a quarter without his or her academic department's approval. Audit credits do not count towards full-time status. Students registering for fewer than 9 credit hours are considered part time and are not eligible for student benefits, such as health insurance.

DROPPING A COURSE

To drop a course a student must officially modify his/her registration by either dropping the course online or by contacting the Department of Graduate Education in writing. Notifying the instructor of the intention to drop or withdraw from a course is not sufficient and may result in a failing grade and full responsibility for the tuition. Refunds and transcripts are based on the date the registration is officially modified, not the date of last attendance. Courses dropped during the designated refund period (see Refund Policy under Tuition and Fees) will not appear on the transcript. Courses dropped outside of the refund period will be listed on the transcript as a withdrawal. Students may withdraw from OGI courses at any time before the final exam or the last class meeting for classes without final exams.

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 as determined by each academic program.

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 and grade value points.

The following value point scale is employed at the OGI School:

A = 4.00	B = 3.00	C = 2.00
A- = 3.67	B- = 2.67	C- = 1.67
B+= 3.33	C+= 2.33	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)
X = No basis for grade

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.

Incompletes. An Incomplete must be completed by the end of the quarter following the quarter 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" 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). The petition should be specific, include a date by which the grade will be assigned and submitted to the Graduate Education Department in writing.

LEAVE OF ABSENCE

Approved Leave: A student matriculated in a degree program and in good academic standing may apply for a leave of absence from school. A leave of absence must be approved by the student's academic department and documented with the Graduate Education Department. Approved leave status is granted for a specific period of time and an extension to the leave must be re-approved. While on leave of absence a student may not use university resources, such as the library, computing facilities, advisor or department services. The time a student spends on approved leave will not be included in the time limits to complete a degree.

Unapproved Leave: Students failing to notify OGI of their leave will be placed on inactive status following 4 consecutive quarters of not completing a class. At that point matriculated students will be notified of their status and asked to clarify their intentions regarding the completion of their degrees. If a student has not enrolled in classes or requested an approved leave within four additional quarters that student will be administratively withdrawn from the program. Once withdrawn, if the student wishes to resume his/her work towards a degree, he/she must reapply to the program, submitting a new application and paying a new application fee. Reapplication will be subject to the admissions requirements in place at that time and department review and acceptance in accordance with the department's current admissions practices. If readmitted, the student will be subject to the degree requirements in effect at time of re-matriculation. The time a matriculated student spends on unapproved leave will be included in the time limits to complete a degree.

Important Note: Students must be aware that other requirements, regulations or restrictions (such as but not limited to: visa status, department scholarships, financial aid and health insurance eligibility) may impose different enrollment requirements than those allowed under OGI's Leave of Absence policy. It is the student's responsibility to register for the appropriate number of credits that may be required in accordance with their particular situation.

MATRICULATED VS. NON-MATRICULATED

A matriculated student is formally admitted and enrolled in a degree program. A non-matriculated student has not applied and been admitted to a degree program. In order to receive a degree from the OGI School of Science & Engineering, a student must be matriculated into a degree program. Students are encouraged to matriculate prior to completing 21 credits since no more than 21 credits taken as a non-matriculated student will be applied towards degree requirements (see Pre-Matriculation Credits Applied Toward a Degree policy below).

MEASLES IMMUNIZATION POLICY

Every full-time student who was born on or after January 1, 1957, must provide the OGI School with evidence of having received a sufficient measles vaccination (Rubeola). Students are expected to submit a completed Immunization Form when they first register for classes at OGI. The complete Measles Immunization Policy and Immunization Form are available from the Graduate Education Department or online at www.ogi.edu/graduate_edu/forms/.

ON-SITE (RESIDENCY) PH.D. REQUIREMENTS

The OGI School has a two-year on-site residency requirement for Ph.D. programs. 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 acceptance to a degree program at OGI may be applied toward degree requirements. This maximum may include a combination of up to 12 transfer credits (18 from Portland State University, the University of Oregon and Oregon State University) 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

Anyone may register for classes at OGI, regardless of their admissions status into a degree program. Each quarter, a class schedule is published listing the courses being offered with their dates, times and locations. To access a current class schedule online, visit www.ogi.edu/schedule/.
All students attending a class must be registered for that class. A student will not earn a grade or credits for the class if he or she is not registered for that class.

A student may register for classes online at www.ogi.edu/studentaccounts/. Online registration is available seven days a week during established registration times. Alternatively, if a student prefers to register in person, he or she may do so at the OGI Graduate Education Department.

TIME LIMITS TO COMPLETE A DEGREE

A master's degree must be completed within seven years from the quarter of matriculation. A Ph.D. degree must be completed within five years from the time the student passes the Ph.D. qualifying exam. Petitions for extensions to the time limit must first be approved by the department and then submitted to the Educational Policy Committee for final approval.

TRANSCRIPTS

A student's official transcript is a formal, written record of all courses, grades and degrees earned while at OGI/OHSU. Requests for transcripts must be in writing with a signature, submitted either by fax, mail or in person to the OHSU Registrar's office. Official transcripts are on special paper and have the official OHSU seal. Official transcripts cost $8 per copy when ordered 48 hours in advance. For quicker service or a faxed official transcript the fee is $10. A request form for an official transcript can be found at www.ohsu.edu/registrar/transcriptreq.pdf.

TRANSFER CREDITS

The OGI School of Science & Engineering accepts transfer credits from accredited institutions that have not, or will not, be applied toward another degree. Up to 12 credits may be transferred to OGI (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. Only courses with a B (3.0) or better grade may be transferred to a student's OGI academic record. Transfer credit grades are not calculated in the OGI grade point average. Credits graded on a Pass/No Pass basis may not be transferred.

WITHDRAWING FROM A DEGREE PROGRAM

At anytime prior to earning a degree a student may choose to withdraw from his/her academic program. To withdraw from the program a student should notify his/her academic department in writing of his/her intent to withdraw. The student is also required to fill out and submit the OGI Exit form and arrange a financial aid exit interview (if appropriate). Additionally, OGI asks withdrawing students to complete the Learning Outcomes Assessment Survey to provide valuable feedback regarding our programs and educational experiences.

Once withdrawn, if the student wishes to resume his/her work towards a degree, he/she must reapply to the program, submitting a new application and paying a new application fee. Reapplication will be subject to the admissions requirements in place at that time and department review and acceptance in accordance with the department's current admissions practices. If readmitted, the student will be subject to the degree requirements in effect at time of re-matriculation.

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, in 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, which are located on the Marquam Hill Campus in downtown Portland. OGI is part of OHSU's 300-acre West Campus, which also includes the Neurological Sciences Institute, the Oregon National Primate Research Center and the Vaccine and Gene Therapy Institute. The OGI campus consists of modern buildings that provide spacious laboratories, faculty and administrative offices and a research library.

Providing a striking setting for collaborative, interdisciplinary research and education, the 80,000 square-foot Bronson Creek Building is the newest addition to OGI's campus landscape. Acquired by OHSU in 2002, the modern three-story brick structure is the new home of the OGI administration, members of the West Campus Services team, and OGI's departments of Biomedical Engineering, Computer Science and Electrical Engineering and Management in Science and Technology.

LIBRARY

The Samuel L. Diack Library's collection includes more than 21,000 monographic titles (including 4,000 electronic books in computer science and business) and over 500 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. These resources are supplemented by the OHSU Library's holdings of more than 74,000 monographs and 1,200 print and electronic journal subscriptions.

OGI students can access the OHSU Library's electronic collections from OGI and can use the print collections by visiting the hill campus or requesting materials be sent to OGI. A proxy server allows access to the libraries' electronic collections from off campus. Materials unavailable from the OHSU libraries are obtained on interlibrary loan for faculty, staff and students at no cost. 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 Cascade Alliance allows for direct-request borrowing from 26 institutions in Oregon and Washington, including the University of Oregon, Oregon State University, Portland State University and the six baccalaureate institutions in Washington, e.g., University of Washington and Washington State University. The PORTALS consortium includes libraries in the Portland metropolitan area such as Portland State University and Reed College.

The 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.

COMPUTER FACILITIES

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

HOUSING

The OGI School is situated amid a large residential area and relies on the numerous apartment complexes in the area for housing students. In addition, due to excellent public transportation on bus or light-rail, additional housing opportunities are available throughout the city, including student housing at Portland State University in downtown Portland. The Graduate Education Department maintains a list of local apartment buildings, available at www.ogi.edu/graduate_edu/students/housing/. The OGI Student Council has a Web site for current, new and prospective OGI students who are looking for housing information, roommates, and other related information at cse.ogi.edu/council/forums.html. Additional housing information for the area around OHSU can be found at www.ohsu.edu/academic/acad/housing/.

STUDENT COUNCIL

The OGI Student Council sponsors and coordinates at least one major social event each quarter, open to everyone at the school. These events have included a coffeehouse with live music performed by students, faculty and staff from the school community, an annual International Food and Cultural Fair, the fall orientation picnic and numerous educational forums. Through collaboration with the OHSU Student Council, additional activities, such as periodic skiing and rafting trips, are also available to OGI students. Many student events throughout OHSU are open to all students at the four OHSU schools. More information on OGI's Student Council is available on their Web site, cse.ogi.edu/council/or by e-mail at scouncil@admin.ogi.edu.

OVERVIEW OF OGI ACADEMIC PROGRAMS

OGI prepares its graduates to become leaders in knowledge-driven professions by providing a learning environment strongly focused on collaborative, interdisciplinary research. OGI students learn to reach across traditional academic boundaries to seek the knowledge and resources needed to solve important technological problems. Our curriculum is organized to facilitate this type of educational experience, where students may choose from a number of challenging paths to reach their goal of a degree in a particular discipline. This program-focused curriculum encourages students to work closely with their advisors to select a course of study that matches their specific needs, strengths and career objectives. The following listing summarizes OGI's current academic programs and directs the reader to the corresponding academic department(s) offering that program.

OGI prides itself on its strong student-faculty relationships. Here, EBS graduate Ameer Tavakoli celebrates his Ph.D. hooding with professors Nicole Steckler (MST) and Patricia Toccalino (EBS).

BIOCHEMISTRY AND MOLECULAR BIOLOGY PROGRAM

See **Department of Environmental and Biomolecular Systems**, page 37

Doctor of Philosophy in Biochemistry and Molecular Biology

Master of Science in Biochemistry and Molecular Biology

BIOMEDICAL ENGINEERING PROGRAM

See **Department of Biomedical Engineering**, page 15

Doctor of Philosophy in Biomedical Engineering

Master of Science in Biomedical Engineering

Biomaterials Track
Biomedical Optics Track
Neuroengineering Track
Speech and Language Engineering Track

COMPUTER SCIENCE AND ENGINEERING PROGRAM

See **Department of Computer Science and Electrical Engineering**, page 23

Doctor of Philosophy in Computer Science and Engineering

Master of Science in Computer Science and Engineering

Adaptive Systems Track
Human-Computer Interfaces Track
Software Engineering Track
Software Engineering for Industry Professionals Track
Spoken Language Systems Track

Master of Software Engineering

Software Engineering Graduate Certificates

Principals of Software Engineering
Software Analysis and Design
Software Quality Engineering

ELECTRICAL ENGINEERING PROGRAM

See **Department of Computer Science and Electrical Engineering**, page 23

Doctor of Philosophy in Electrical Engineering

Master of Science in Electrical Engineering

COMPUTER ENGINEERING AND DESIGN CONCENTRATION:

Computer Architecture Track
Circuit Design Track
Signal Processing Track

SIGNALS AND SYSTEMS CONCENTRATION:

Signal and Image Processing Track
Machine Learning Track
Speech Processing Track

ENVIRONMENTAL SCIENCE AND ENGINEERING PROGRAM

See **Department of Environmental and Biomolecular Systems**, page 37

Doctor of Philosophy in Environmental Science and Engineering

Environmental Information Technology Track

Master of Science in Environmental Science and Engineering

Environmental Information Technology Track

MANAGEMENT IN SCIENCE AND TECHNOLOGY PROGRAM

See **Department of Management in Science and Technology**, page 53

Master of Science in Management in Science and Technology

Managing the Technology Company Track
Managing in the Software Industries Track
Managing Information Systems Track

Master Graduate Certificates

Health Care Management
Management in Science & Technology

Department of Biomedical Engineering

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THE DEPARTMENT OF BIOMEDICAL ENGINEERING integrates the disciplines of engineering, basic biomedical science, and clinical science. Our graduate educational program is designed to provide a broad education across these disciplines as well as knowledge and in-depth research training in a specialty field. In our rigorous curriculum, a quantitative engineering approach is applied to the study of medically related systems and topics. Our program prepares students for careers in academia, industry, and government.

The OGI/OHSU Department of Biomedical Engineering offers students both didactic education and nontraditional learning modes. Students can do advanced basic research in leading laboratories and they can do research projects that relate directly to patients, working under medical supervision to develop and apply new technology in the clinics or in laboratories that study patients.

Two degrees are offered:

- Master of Science in Biomedical Engineering
  - *Biomaterials Track*
  - *Biomedical Optics Track*
  - *Neuroengineering Track*
  - *Speech and Language Engineering Track*
- Doctor of Philosophy in Biomedical Engineering

ADMISSION REQUIREMENTS

Admissions requirements are the same as the general requirements of the OGI School with the following additions.

- A Bachelor of Science degree or Master of Science degree in physics, mathematics, engineering or other quantitative science discipline is required. Highly qualified individuals with degrees in biology may be considered if they have demonstrated adequate quantitative skills.
- The GRE test is required for both M.S. and Ph.D. applicants unless a waiver is specifically authorized.
- The preferred minimum TOEFL score is 620 paper/250 computer.

Suggested preparatory prerequisites to the Biomedical Engineering program include: courses in anatomy/physiology, one year of college biology, organic chemistry, calculus through differential equations and linear algebra, one year of calculus-based physics, basic programming skills in a higher-level language and some experience with numerical analysis software.

DEGREE REQUIREMENTS

During the first year, both M.S. and Ph.D. students will focus on the core courses (listed below) required for the Biomedical Engineering program. During the student's first year, a Student Program Committee (SPC) composed of three faculty members will be formed for each student. This committee will work with the student to advise a course of study consistent with both the student's interests and the need for broad knowledge in biomedical engineering and knowledge in the student's chosen specialty. For students working on a thesis or dissertation, during the second year the student will transition to a thesis committee composed of five faculty members, including one or more from another department or university.

MASTER OF SCIENCE IN BIOMEDICAL ENGINEERING

The M.S. degree requires a total of 61 credits, comprised of 23 credits of core courses, 21 credits from elective courses and 17 or more research credits on an original research project. A student's SPC should approve the selection of elective courses and research project prior to beginning the class or project.

The M.S. degree may be earned as a non-thesis or thesis option. The non-thesis option requires an original research project resulting in a written report. The thesis option requires original thesis research resulting in a written thesis and oral defense.

Research Engineer Pavel Chytil and Prof. Tamara Hayes make adjustments to a sensor-equipped walker in the BME Department's Point-of-Care Engineering Laboratory.

BME CORE COURSES (23 credits)

All M.S. students must complete the following core courses:

BME 505	Readings in Biolomedical Engineering	1 credit/term for 3 terms during 1st year
MINF 515	Ethical, Legal, and Social Issues in Medical Informatics	2 credits

LIFE SCIENCES

BME 511	Biochemistry for Biolomedical Engineering	3 credits
BME 517	Systems Physiology	3 credits

MATHEMATICS AND STATISTICS

MATH 510	Multivariate Calculus and Differential Equations	3 credits
MATH 517	Probability and Statistics	3 credits

SIGNALS AND SYSTEMS

BME 513	Biomedical Signal Processing	3 credits
BME 514	Biomedical Instrumentation – Signals and Sensors	3 credits

TRACKS

The following specialized tracks are available to students or they may consult with their SPC to define a custom program.

BIOMEDICAL OPTICS TRACK

- BME CORE COURSES (listed above)
- SUGGESTED ELECTIVES (21 credits)

BME 522	Biomedical Optics I: Tissue Optics	3 credits
BME 523	Biomedical Optics II: Laser Tissue Interactions	3 credits
BME 524	Biomedical Optics III: Engineering Design	3 credits
BME 525	Biomedical Photomechanics	3 credits
BME 527	Computational Approaches to Light Transport in Biological Tissues	3 credits
BME 528	Physical and Geometrical Optics	3 credits
EE 525	Introduction to Electromagnetics for Modern Applications	4 credits
EE 526	Electromagnetics for Modern Applications II	4 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 584	Introduction to Image Processing	3 credits

Other appropriate Biomedical Optics courses as approved by the SPC

BIOMATERIALS TRACK

- BME CORE COURSES (listed above)
- SUGGESTED ELECTIVES (21 credits)

BME 525	Biomedical Photomechanics	3 credits
BME 541	Mechanicals of Biological Tissues I	3 credits
BME 542	Mechanicals of Biological Tissues II	3 credits
BME 543	Advanced Tissue Engineering Techniques	3 credits
BME 544	Advanced Biomaterials	3 credits
BME 545	Biocompatibility — Host-Implant Interactions	3 credits
EE 511	Analytical Scanning Electron Microscopy	3 credits
EE 512	Focused Ion Beam Technology	3 credits
EE 513	Transmission Electron Microscopy	3 credits

Other appropriate Biomaterials courses as approved by the SPC

Students may consider the following course from another university

ME 555	Finite Element Modeling and Analysis (Portland State University)

NEUROENGINEERING TRACK

- BME CORE COURSES (listed above)
- SUGGESTED ELECTIVES (21 credits)

BME 561	Neuronal Control Systems	3 credits
BME 562	Motor Control Systems	3 credits
BME 563	Mathematical and Computational Modeling of Biological Systems	3 credits
BME 564	Methods in Neuromedicine	3 credits
BME 565	Introduction to Computational Neurophysiology	3 credits
BME 566	Biomedical Signal Processing II	3 credits
BME 567	Visual Sensory Systems	3 credits
BME 568	Auditory and Visual Processing by Human and Machine	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 584	Introduction to Image Processing	3 credits
NEUS 623	Introduction to Neuroanatomy	3 credits
NEUS 624	Cellular Neurophysiology	4 credits

Other appropriate Neuroengineering courses as approved by the SPC

SPEECH AND LANGUAGE ENGINEERING TRACK

- BME CORE COURSES (listed above)
- SPEECH AND LANGUAGE ENGINEERING CORE (9 credits)

Choose three:

BME 568	Auditory and Visual Processing by Human and Machine	3 credits
BME 572	Speech Synthesis	3 credits
CSE 551	Structure of Spoken Language	3 credits
CSE 552	Hidden Markov Models for Speech Recognition	3 credits

- SUGGESTED ELECTIVES (12 credits)

BME 571	Speech Systems	3 credits
CSE 540	Neural Network Algorithms and Architectures	3 credits
CSE 547	Statistical Pattern Recognition	3 credits
CSE 550	Spoken Language Systems	3 credits
CSE 561	Dialogue	3 credits
CSE 562	Natural Language Processing	3 credits
EE 580	Linear Systems	3 credits
EE 581	Intro to Signals, Systems, and Information Processing	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 586	Adaptive and Statistical Signal Processing	3 credits
MATH 519	Engineering Optimization	3 credits

Other appropriate Spoken Language Engineering courses as approved by your SPC.

Students may consider the following course from another university

SySc 545	Information Theory (Portland State University)

OTHER ELECTIVES — ALL TRACKS

BME 502	Independent Study	various credit
BME 504	Professional Internship	various credit
BME 506	Special Topics Courses	various credit
BME 507	Biomedical Engineering Seminar	1 credit/term
BME 566	Biomedical Signal Processing II	3 credits
BME 581	Fourier Analysis	3 credits

DOCTOR OF PHILOSOPHY IN BIOMEDICAL ENGINEERING

In addition to the general OGI requirements for a Ph.D., the BME Ph.D. degree requirements are satisfied in three parts:

BME COURSES: Students are required to complete the BME core courses as listed below. Particularly well-prepared students may petition the BME department to waive one or more courses based on demonstrated graduate-level knowledge of the course content. A student's SPC may require additional elective courses depending on the student's prior education, experience and preparedness for the Ph.D. qualifying exam.

ADVANCEMENT TO PH.D. CANDIDACY: A Ph.D. student is required to pass a Ph.D. qualifying exam. The two-part examination is normally taken 12 to 24 months after initial enrollment. The first part tests the student's knowledge of the biological sciences, engineering and mathematics as they relate to the field of biomedical engineering. The second part consists of an oral, public presentation of a thesis proposal — intended to test knowledge in the student's chosen specialty.

DISSERTATION RESEARCH AND DEFENSE:
After successful completion of the Qualifying Exam, the SPC will work with the student to develop a research plan and schedule for the dissertation. The student will be required to register for appropriate research credits throughout the research, presentation and submission process. The dissertation must constitute significant, original research resulting in a written document of publishable quality and must be successfully defended in an oral presentation.

BME CORE COURSES

All Ph.D. students must complete the following core courses or receive a department waiver:

BME 605	Readings in Biomedical Engineering	1 credit/term for 3 terms during 1st year
MINF 615	Ethical, Legal, and Social Issues in Medical Informatics	2 credits

LIFE SCIENCES

BME 611	Biochemistry for Biomedical Engineering	3 credits
BME 617	Systems Physiology	3 credits

MATHEMATICS AND STATISTICS

MATH 610	Multivariate Calculus and Differential Equations	3 credits
MATH 617	Probability and Statistics	3 credits

SIGNALS AND SYSTEMS

BME 613	Biomedical Signal Processing	3 credits
BME 614	Biomedical Instrumentation – Signals and Sensors	3 credits

RESEARCH PROGRAMS

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.
Jacques, Kirkpatrick, Prahl, Song

Cardiovascular Biomedical Engineering

Cardiovascular biomedical engineering (CBE) is a growing area of interest at OHSU. The CBE program encompasses several specialty areas using engineering tools for investigation. The specialty areas include cardiac and vessel mechanics, computational fluid dynamics, electrocardiography and electrical signal processing, 4-D embryo modeling, functional magnetic resonance imaging, ultrasound technology, cellular mechano-transduction and gene expression, blood-material interactions, thrombosis, laser thrombolysis, and hemostasis.
Baptista, Chugh, Ellenby, Faber, Goldstein, Gruber, Hanson, McNames, Sahn, Thong, Thornburg

Imaging Research

Imaging technology is now central to the diagnosis and treatment of nearly all diseases and is critical for drug development, evaluation of treatment effects as basic science on the biology of normal and abnormal tissue function. Core faculty will be hired in biomedical engineering with research foci in medical imaging. In addition, a wide range of faculty across the OHSU campus use imaging in their basic and clinical research. Thus, students will have an opportunity to implement imaging engineering research in a variety of biomedical research settings. Particular areas of concentration at OHSU are Neuroimaging, Cardiac Imaging and Cancer Imaging.
Janowsky, Neuwelt, Sahn, Spencer, Szumowski, Wang

Informatics Research

Informatics activities at OHSU are wide ranging; currently they include: managing and analyzing gene expression data; programs in medical informatics and outcomes research; basic research in databases; networks and embedded systems; and techniques for 3-D visualization. BME, in conjunction with the Department of Computer Science and Electrical Engineering and the Department of Medical Informatics, works to develop and apply technologies 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.
Delcambre, Dubay, Hersh, Hook, Jimison, Maier, Pentacost, Sheard

Neuroengineering Research

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.
Baumann, Burchiel, Cohen, Cordo, Hammerstrom, Hayes, Hitzeman, Jabri, Larsson, Neuwelt, Nuttall, Pavel, Peterka, P. Roberts, W. Roberts, Song, Welsh, Westbrook

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.
Fried-Oken, Hammerstrom, Hayes, Horak, Jimison, Krohn, Maier, Pavel

Rehabilitation and Biomechanics Research

Many diseases and disorders of muscle, bone and the nervous system result in treatment, immobilization, healing and 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.
Cordo, Hart, Herzberg, Horak, Jabri, Klein, Nutt, Orwoll, Peterka, P. Roberts, Shea

Tissue Engineering and Biomaterials Research

Research in tissue engineering and biomaterials is represented by a multi-disciplinary 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, dissolution and volatilization from dental alloys; non-invasive and non-destructive 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; blood vessel substitutes, vascular grafts, and endovascular stents.
Dawson, Ferracane, Gregory, Hanson, Herzberg, Hinds, Kirkpatrick, McCarthy, Mitchell, Sakaguchi, Shea, Winn

FACILITIES

The Department of Biomedical Engineering occupies approximately 23,000 square feet on the third floor of the Bronson Creek building, a modern building on the OHSU/OGI West Campus, and additional space in the Murdock and Vollum buildings and the Oregon National Primate Research Center on that campus. The department's space accommodates "wet" labs with biosafety hoods as well as other lab space. The department is equipped with a modern computer network system, serviced by OGI's and OHSU's Information Technology Groups. Student workstations are equipped with high-speed network connections. Special facilities, such as a simulated residential health care facility are also available. Video teleconferencing facilities are available to allow students and faculty to interact with others at seminars and other events on OHSU's Marquam Hill Campus.

Some students' research projects are carried out in laboratories in other OHSU departments or in local industries. Available facilities in which students may do research projects include: Oregon Medical Laser Center, Advanced Imaging Center, Oregon Hearing Research Center, Neurological Sciences Institute, and Heart Research Center, as well as the many labs in the basic science departments and institutes of OHSU.

FACULTY

STEPHEN HANSON

Professor and Department Head
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RESEARCH INTERESTS

Thrombosis and vascular healing responses are being evaluated in animal models to identify key hemostatic mechanisms, blood component interactions with natural and synthetic surfaces and the effects of blood-flow phenomena. Our ultimate goals are to develop more effective anti-thrombotic and anti-arteriosclerotic drug therapies, and to improve the performance of prosthetic cardiovascular devices.

REPRESENTATIVE PUBLICATIONS

Gruber, A.G., Hanson, S.R., "Factor XI-dependence of surface-initiated and tissue factor-initiated thrombus propagation in vivo," *Blood* **102**: 953-955, 2003.

Hanson, S.R., "Blood Coagulation and Blood-Materials Interactions," in *Biomaterials Science, 2nd Edition* (Ratner, B.D., Hoffman, A.S., Schoen, F.J., Lemons, J.E., Eds.), Academic Press, New York, in press, 2003.

Gruber, A., Cantwell, A., DiCera, E., Hanson, S.R., "The W215A/E217A Mutant of Thrombin Shows Safe and Potent Anticoagulant and Antithrombotic Effects in vivo. *J Biol Chem* **277**(31), 27581–4, 2002.

Verheye, S., Markou, C.P., Salame, M.Y., Wan, B., King, S.B., Robinson, K.A., Chronos, N.A., Hanson, S.R., "Reduced Thrombus Formation by Hyaluronic Acid Coating of Endovascular Devices," *Arterioscler Thromb Vasc Biol* **20**, 1168–1172, 2000.

Markou, C.P., Lutostansky, E.M., Ku, D.N., Hanson, S.R., "A Novel Method for Efficient Drug Delivery," *Ann Biomed Eng* **26**, 502–511, 1998.

Hanson, S.R. and Sakariassen, K.S., "Blood Flow and Antithrombotic Drug Effects," *Am Heart Journal* **135**, S132–S145, 1998.

WILLIAM J. ROBERTS

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RESEARCH INTERESTS

Neuroengineering. Neuronal mechanisms of pain. Influence of sympathetic nervous system on sensory functions. Electrical stimulation for pain relief. Motor systems.

REPRESENTATIVE PUBLICATIONS

Bon, K., Wilson, S.G., Mogil, J.S., Roberts, W.J., "Genetic Evidence for the Correlation of Deep Dorsal Horn fos Protein Immunoreactivity with Tonic Formalin Pain Behavior *Journal of Pain*. **3**,181–189, 2002.

Gillette, R.G., Kramis, R.C., Roberts, W.J., "Suppression of Activity in Spinal Nociceptive 'Low Back' Neurons by Paravertebral Somatic Stimuli in the Cat," *Neurosci Lett.* 1998 Jan 23;**241**(1), 45–8.

Kramis, R.C., Roberts, W.J., Gillette, R.G., "Non-nociceptive Aspects of Persistent Musculoskeletal Pain," *J Orthop Sports Phys Ther.* 1996 Oct;**24**(4), 255–67.

Kramis, R.C., Roberts, W.J., Gillette, R.G., "Post-sympathectomy Neuralgia: Hypotheses on Peripheral and Central Neuronal Mechanisms," *Pain*, 1996 Jan;**64**(1), 1–9.

Fine, P.G., Roberts, W.J., Gillette, R.G., Child, T.R., "Slowly Developing Placebo Responses Confound Tests of Intravenous Phentolamine to Determine Mechanisms Underlying Idiopathic Chronic Low Back Pain," *Pain*, 1994 Feb;**56**(2), 235–42.

Gillette, R.G., Kramis, R.C., Roberts, W.J., "Sympathetic Activation of Cat Spinal Neurons Responsive to Noxious Stimulation of Deep Tissues in the Low Back," *Pain*, 1994 Jan;**56**(1), 31–42.

ANDRAS GRUBER, M.D.

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RESEARCH INTERESTS

The role of contact activation in acute intraluminal thrombus propagation using synthetic vascular grafts in a primate model of thrombosis and hemostasis. If the functionality of the contact system enzyme complex (FXI/FXII/KK/HMWK) is relevant to the pathogenesis of thrombosis, a FXI inhibitor could become the first safe antithrombotic agent.

Characterization of the effects of endogenous protein C activation on acute arterial thrombogenesis and hemostasis using rationally engineered recombinant enzymes. A pharmacologically viable protein C activator could help utilize the body's own antithrombotic and antiinflammatory system similar to the way streptokinase and tPA became useful fibrinolysis activators.

REPRESENTATIVE PUBLICATIONS

Gruber A, Hanson S.R. "Factor XI-dependence of surface- and tissue factor-initiated thrombus propagation in primates," *Blood* **102**:953-5, 2003.

Gruber A, Hanson S.R. "Potential new targets for antithrombotic therapy," *Curr Pharm Des.* **9**:2367-74, 2003.

Gruber A, Cantwell A.M., Di Cera E., Hanson S.R. "The thrombin mutant W215A/E217A shows safe and potent anticoagulant and antithrombotic effects in vivo," *J Biol Chem.* **277**:27581-4, 2002.

Kim T, Murdande S, Gruber A, Kim S. "Sustained-release morphine for epidural analgesia in rats," *Anesthesiology* **85**:331-8, 1996.

TAMARA HAYES

Assistant Professor
Ph.D., Behavioral Neuroscience
University of Pittsburgh, 1994
tamara.hayes@bme.ogi.edu

RESEARCH INTERESTS

Algorithms and technologies for improving speech and language processing in patient and elderly populations (augmentative communication). Attentional processes in human language processing. Adaptive computer interfaces for improving human task performance (augmented cognition). Unobtrusive monitoring technologies for remote care of elderly populations (point-of-care engineering).

REPRESENTATIVE PUBLICATIONS

A.M. Adami, T. L. Hayes, and M. Pavel, "Unobtrusive Monitoring of Sleep Patterns," 25th Annual International Conference of the IEEE Engineering In Medicine And Biology Society, Cancun, September 2003.

T.L. Hayes, K. Li, and M. Pavel, "Augmenting Search Performance by Improving Attention Allocation," Bio-Bionics: DARPA Augmenting Cognition Workshop, Kona, Hawaii, January 2003.

T.L. Hayes, "Harness the Internet for Telemedicine Programs," invited workshop at Develop and Maintain Profitable Telemedicine Programs, Conference, Boston, MA, April 1996.

MONICA THACKER HINDS

Assistant Professor
Ph.D., Mechanical Engineering
Johns Hopkins University, 1998
hindsm@bme.ogi.edu

RESEARCH INTERESTS

Relationship between fluid dynamics and extracellular matrix production by cells, vascular tissue engineering, role of mechanical stimulation in tissue engineered constructs, elastin based biomaterials.

REPRESENTATIVE PUBLICATIONS

Hinds, M.T., Courtman D.W., Goodell, T., Kwong M., Brant-Zawadzki, H., Burke A., Fox B., and Gregory K.W., "Development of a xenogenic elastin-based biomaterial: calcification and inflammatory effects of aluminum chloride treatment," *Journal of Biomedical Materials Research*, April 2004, **69**A(1):55-64.

Kirkpatrick, S.J., Hinds, M.T., and Duncan, D.D., "Acousto-optical characterization of the viscoelastic nature of a nuchal elastin tissue scaffold," *Tiss. Eng.*, 2003 **9**(4): 645-56.

Hinds, M.T., and Kirkpatrick, S.J., "Material properties of engineered tissues evaluated with nondestructive methods," *Proceedings SPIE*, 2002. **4617**:275-283.

Kajitani, M., Wadia, Y., Hinds, M.T., Teach, J., Swartz, K.R. and Gregory, K.W., "Successful repair of esophageal injury using an elastin-based biomaterial patch," *Asaio J*, 2001. **47**(4), 342–5,

Hinds, M.T., Park, Y.J., Jones, S.A., Giddens, D.P., and Alevriadou, B.R., "Local hemodynamics affect monocytic cell adhesion to a three-dimensional flow model coated with E-selectin," *Journal of Biomechanical Engineering*, 2001, **34**(1): p. 95-103.

Kajitani, M., Wadia, Y., Xie, H., Hinds, M., Shalaby, S., Schwartz, K., and Gregory, K.W., "Use of new elastin patch and glue," *ASAIO J*, 2000. **46**(4), p. 409-414.

JOHN-PAUL HOSOM

Assistant Professor
Ph.D., Computer Science and Engineering,
Oregon Graduate Institute of Science & Technology, 2000
hosom@bme.ogi.edu

RESEARCH INTERESTS

Automatic speech recognition (ASR). Time alignment of phonemes. Acoustic-phonetic analysis of speech.
Assistive technology.

REPRESENTATIVE PUBLICATIONS

J. P. Hosom, "Automatic Speech Recognition," in *Encyclopedia of Information Systems*, H. Bidgoli (ed.)., vol. 4, pp. 155-169, Academic Press, San Francisco, 2003 (invited chapter).

J. P. Hosom, A. B. Kain, T. Mishra, J. P. H. van Santen, M. Fried-Oken and J. Staehely, "Intelligibility of Modifications to Dysarthric Speech," *The 2003 International Conference on Acoustics, Speech, and Signal Processing* (ICASSP 2003), Hong Kong, April 2003.

J. P. Hosom, "Automatic Phoneme Alignment Based on Acoustic-Phonetic Modeling." *The 2002 International Conference on Spoken Language Processing (ICSLP 2002)*, Boulder, Co., vol. I, pp. 357–360, September 2002.

J.P. Hosom and R.A. Cole, "Burst Detection Based on Measurements of Intensity Discrimination." *The 2000 International Conference on Spoken Language Processing (ICSLP 2000)*, Beijing, vol. IV, pp. 564-567, Oct. 2000.

J.P. Hosom, R.A. Cole and P. Cosi, "Improvements in Neural-Network Training and Search Techniques for Continuous Digit Recognition," *Australian Journal of Intelligent Information Processing Systems*, **5**(4), 277–284, Summer 1999.

J.P. Hosom and M.Yamaguchi, "Proposal and Evaluation of a Method for Accurate Analysis of Glottal Source Parameters," *The Institute of Electronics, Information and Communication Engineers (IEICE) Transactions on Information and Systems*, E77-D (10), pp. 1130-1141, October 1994.

STANLEY J. HUBER

Assistant Professor
M.D., School of Medicine
Oregon Health & Science University, 1965
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RESEARCH INTERESTS

Blood chemistry by ophthalmic spectroscopy; instrumentation; neuroengineering; point-of-care biomedical engineering

REPRESENTATIVE PUBLICATIONS

S.J. Huber, "Photic Pulse Stimulator for ERG Analysis," Sloan Foundation

S.J. Huber, "Battlefield Management of Ocular Injuries," ICMM, Interlochen, Switzerland

S.J. Huber, "Biological Effects of Space Radiation Fields," Classified Report, USAF MOL Project

S.J. Huber, "Triage and Management of Ocular Injuries," CIOMR, Brussels, Belgium

S.J. Huber, "Hazards of Military Lasers," CIOMR, Brussels, Belgium

S.J. Huber, "Radiation Induced Eye Injuries," CIOMR, Brussels, Belgium

S.J. Huber, "TacStar, A New Concept in Military Medical Training," CIOMR, Wurzburg, Germany

MARWAN JABRI

Gordon and Betty Moore Professor of Microelectronics
Ph.D., Electrical Engineering
University of Sydney, 1988
marwan@bme.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

O. J.-M. D. Coenen,.M.P. Arnold, T.J. Sejnowski and M.A. Jabri, "Parallel Fiber Coding in the Cerebellum for Lifelong Learning," *Autonomous Robots*, **11**(3), 291–7, Kluwer Academic Publishers, The Netherlands, 2001.

B. Zhang, R. Coggins, M.A. Jabri, D. D. Dersch, and B. Flower, "Multiresolution Forecasting for Futures Trading Using Wavelet Decompositions," *IEEE Transactions on Neural Networks*, **12**(4), 767–775, July 2001.

M.A. Jabri and R. Coggins, "Micro Power Adaptive Circuits for Implantable Devices," in *Low Power-Low Voltage Circuits and System*, E. Sanchez-Sinencio and Andreas Andreou, eds., IEEE Press, pp. 500-518, 1999.

R. Coggins and M.A. Jabri, "A Low Complexity Intracardiac Electrogram Compression Algorithm," *IEEE Transactions on Biomedical Engineering*, **46**(1), 82–91, January 1999.

J. Raymond, W. Wang and M.A. Jabri, "A Computational Model of the Auditory Pathway to the Superior Colliculus," in *Brain-like Computation and Intelligent Information Systems*, Shun-ichi Amari and Nikola Kasabov, eds., Springer Verlag, pp. 81-104, 1998.

X.Q. Li and M.A. Jabri, "Machine Learning-based VLSI Cells Shape Function Estimation," *IEEE Transactions on CAD for Integrated Circuits and Systems*, **17**(7), 613–623, 1998.

STEVEN L. JACQUES

Professor
Ph.D., Biophysics and Medical Physics
University of California, Berkeley, 1984
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RESEARCH INTERESTS

Biomedical optics and laser-tissue interactions. Development of diagnostic and therapeutic devices for medicine and biology using optical technologies.

REPRESENTATIVE PUBLICATIONS

Jessica C. Ramella-Roman, Ken Lee, Scott A. Prahl, Steven L. Jacques, "Design, testing and clinical studies of hand-held polarized light camera," *J. Biomed. Optics*, **9**(5), in press, 2004.

Daniel S. Gareau, Paulo R. Bargo, William A Horton, Steven L. Jacques, "Confocal fluorescence spectroscopy of subcutaneous cartilage expressing green fluorescent protein versus cutaneous collagen autofluorescence," *J. Biomed. Optics*, **9**(2), 254-258, 2004.

Paulo R. Bargo, Scott A. Prahl, and Steven L. Jacques, "Collection efficiency of a single optical fiber in turbid media," *Appl. Optics-OT.*, **42**, 3187-3197, 2003.

Jessica C. Ramella-Roman, Paulo R. Bargo, Scott A. Prahl, and Steven L. Jacques, "Evaluation of spherical particle sizes with an asymmetric illumination microscope," *IEEE J. Selected Topics in Quantum Electronics*, **9**, 301-306, 2003.

S.L. Jacques, J.C. Ramella-Roman and K. Lee, "Imaging skin pathology with polarized light," *J. Biomed. Opt.*, **7**, 329-340, 2002.

S.L. Jacques, N. Ramanujam, G. Vishnoi, R. Choe and B. Chance, "Modeling Photon Transport in Transabdominal Fetal Oximetry," *J. Biomed. Optics*, **5**, 277–282, 2000.

SEAN J. KIRKPATRICK

Associate Professor
Ph.D., Biomechanics
Unversity of Miami, 1992
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RESEARCH INTERESTS

Development and application of coherent light techniques to address issues in biomaterials science and tissue mechanics. Laser speckle techniques are of particular interest. Recent investigations have focused on the evaluation of the micromechanical behavior of vascular, dermatological and skeletal tissues using novel laser speckle strain measurement methods. Other interests include experimental investigations into the micromechanics of synthetic biomaterials used to replace or augment damaged or pathological tissue.

REPRESENTATIVE PUBLICATIONS

S.J. Kirkpatrick and D.D. Duncan, "Acousto-optical Assessment of Skin Viscoelasticity," *Proc. SPIE*, 2003 (in press).

S.J. Kirkpatrick, M.T. Hinds, and D.D. Duncan, "Acousto-optical Characterization of the Viscoelastic Nature of a Nuchal Elastin Tissue Scaffold," *Tissue Engineering* (accepted), 2002.

S.J. Kirkpatrick and D.D. Duncan, "Optical Assessment of Tissue Mechanics," in *Optical Biomedical Diagnostics*, V.V. Tuchin, ed., SPIE Press, Bellingham, WA, 2002.

S.J. Kirkpatrick, D.A. Baker and D.D. Duncan, "Speckle Tracking of Low-frequency Surface Acoustic Waves for Mechanical Characterization of Tissues," *Proceedings SPIE*, p. 461, 2002.

S.J. Kirkpatrick, M.T. Hinds and D.D. Duncan, "Laser Speckle Method for Measurement of Cell and Cell Sheet Mechanics," *Proceedings SPIE*, p. 4617, 2002.

M.T. Hinds and S.J. Kirkpatrick, "Material Properties of Engineered Tissues Evaluated with Nondestructive Methods," *Proceedings SPIE*, p. 4617, 2002.

JACK MCCARTHY

Assistant Professor
Ph.D., Materials Science and Engineering
Oregon Graduate Institute of Science & Technology, 1996
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RESEARCH INTERESTS

Ongoing research includes multibeam electron nanolithography, control of nano-scale hillocks in sputtered Au metallizations for use in GaAs devices and the fabrication and development of sensor array-chip hybrids for the detection of biological agents, pathogens, organic and inorganic gases in the environment. These research areas require fabrication and characterization on the micron, sub-micron and nano-scales. The primary fabrication tool in this research is the focused ion beam workstation (FIB), which permits seeing, machining and microforming on the micron, sub-micron and nano-scales. The characterization is provided by scanning and transmission electron microscopy (SEM, TEM) and atomic force microscopy (AFM). FIB fabrication techniques and SEM, AFM and TEM characterization and in-situ experimentation feedback are used to accelerate research on nanofabrication, biomimetic sensors, biomaterials and microelectronic thin films.

REPRESENTATIVE PUBLICATIONS

Jack M. McCarthy, Fabian Radulescu and Erich Stach, Transmission Electron Microscopy(TEM) In-situ Experiments Coupled with Differential Scanning Calorimetry(DSC) as Characterization Tools for Thin Film Reactions on the Nanoscale, presented NATAS conference 2003, *Thermocim. Acta*, accepted 2004.

S. Gosavi, J.M. McCarthy, J.L. House, B. Scholte van Mast, G. Janaway and C.N. Berglund, "Stability Improvement at High Emission Densities for Gold Thin Film Photocathodes Used in Advanced Electron Beam Lithographies," 45th International Conference on Electron, Ion and Photon Beam Technology and Nanofabrication, accepted for publication in *JVSTB*, Nov.-Dec. 2001.

MISHA PAVEL

Professor
Ph.D., Experimental Psychology
New York University, 1980
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RESEARCH INTERESTS

Analysis and modeling of complex behaviors of biological systems, including visual and auditory processing, pattern recognition, information fusion and decision-making. Development of engineering systems mimicking these abilities to support multimodal communication between humans and machines (speech and video), machine vision, visually guided vehicular control and virtual reality. Applications of these techniques to the development of future biomedical and healthcare systems, in particular point-of care biomedical engineering.

REPRESENTATIVE PUBLICATIONS

Adami, A., Yang, K., Song, X., and Pavel M., "Model-Base Image Processing and Analysis for Fracture Classification," Proceedings of the Second Joint Engineering in Medicine and Biology Conference, October 2002, Houston, TX, pp. 2525–2527.

McGee, D.R., Pavel, M. and Cohen, P.R. (2001) "Context Shifts: Extending the Meanings of Physical Objects with Language," *Human Computer Interaction*, 16, Context-aware computing.

J. Palmer, P. Verghese and M. Pavel, "The Psychophysics of Visual Search," *Vision Research*, **40**, 1227–1268, 2000.

T. Arai, M. Pavel, H. Hermansky and C. Avendano, "Syllable Intelligibility for Temporally Filtered LPC Cepstral Trajectories," *Journal of the Acoustical Society of America*, **105**, 2783–2791, 1999.

R.K. Sharma, T.K. Leen and M.Pavel, "Probabilistic Image Sensor Fusion," in *Advances in Neural Information Processing Systems 11*, M.S. Kearns, S.A. Solla and D.A. Cohn, eds., MIT Press, Cambridge, Mass., 1999.

TRAN THONG

Assistant Professor
Ph.D., Electrical Engineering
Princeton University, 1975
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RESEARCH INTERESTS

Cardiovascular engineering in the area of cardiac tachyarrhythmia prediction and prevention both in atria and ventricles, heart rate variability as an indicator of parasympathetic (vagal) tone during relaxed states such as meditation and sleep and as a long term indicator of health in mind-body exercise programs like yoga and tai-chi, effect of parasympathetic tone on tachyarrhythmia, in-vivo micro-recording of cardiac cell depolarization.

Biomedical signal processing using discrete time modeling and system design.

REPRESENTATIVE PUBLICATIONS

T. Thong and J. McNames, "Transforms for Continuous Time System Modeling," *Proceedings 45th IEEE Midwest Symposium on Circuits and Systems*, August 4–7, 2002, Tulsa, Oklahoma, pp. II-408–II-411.

T. Thong and J. McNames, "Nonlinear Representation of Over-sampled Coarsely Quantized Signals," *Proceedings 45th IEEE Midwest Symposium on Circuits and Systems*, August 4–7, 2002, Tulsa, Oklahoma, pp. II-416–II-417.

T. Thong, B. Goldstein, "Prediction of Tachyarrhythmia Episodes," *Proceedings of the Second Joint EMBS/BMES Conference*, Houston, TX, October 23–26, 2002, pp. 1445–1446.

T. Thong, B. Goldstein, "Prediction of Ventricular Tachyarrhythmia Episodes from Heart Rhythm Data by a Vagal Fatigue Index," Abstract 435, *Circulation*, **106**(19), II-86.

T. Thong, B. Goldstein, "Sustained Ventricular Tachyarrhythmia Prediction from Heart Rhythm Data," Abstract 333, *PACE*, Vol. 26, No. 4, Part II, p. 1012.

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Heart Research Center
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Language Understanding
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THE DEPARTMENT OF COMPUTER SCIENCE AND ELECTRICAL 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. Five degrees are offered through the Department of Computer Science and Electrical Engineering: Master of Science in Computer Science and Engineering, Master of Science in Electrical Engineering, Master of Software Engineering, Doctor of Philosophy in Computer Science and Engineering and Doctor of Philosophy in Electrical Engineering.

ADMISSION REQUIREMENTS

In addition to the general OGI admission requirements, the CSEE Department requires the general aptitude GRE scores, except in the case of advanced placement admission for M.S. students (see below).

Desirable scores for the Test of English as a Foreign Language (TOEFL) in the CSEE Department is 650 for the paper-base test or 280 for the computer-based test. An applicant whose score is between 580/237 and 650/280 may be admitted if special mitigating factors exist, e.g., excellent GRE scores.

Candidates for the CSE degree program typically hold a bachelor's degree in computer science, mathematics, engineering, one of the biological or physical sciences, or one of the quantitative social sciences. However, candidates from nontraditional backgrounds are encouraged to apply as well. All candidates are expected to 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 this prerequisite

To be considered for admission to the EE degree program, a candidate must hold a bachelor's degree in physics, applied physics, engineering physics, electrical engineering or equivalent. Candidates with undergraduate degrees in applied mathematics as well as other branches of engineering will also be considered.

ADVANCED PLACEMENT ADMISSIONS FOR M.S. STUDENTS

Students who have completed at least four OGI courses may be eligible to apply for admission under the Advanced Placement option. Under this option, applicants are exempt from the GRE and TOEFL requirements and are required to provide only two letters of recommendation. All other admissions requirements remain the same.

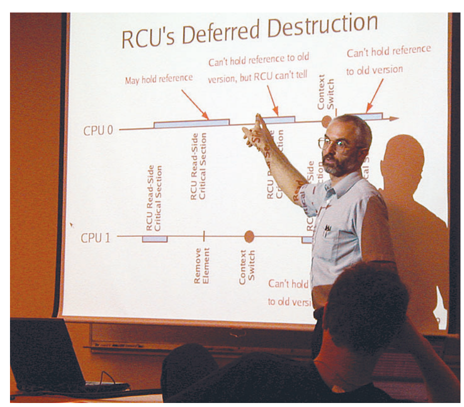
For students applying to the M.S. CSE degree program through Advanced Placement, the four courses must include at least two, preferably three, courses from the M.S. CSE Core (see page 24). The remaining credits must be CSE, EE or MATH courses.

For students applying to the M.S. EE program through Advanced Placement, it is recommended the four courses include at least two courses from the Computer Engineering and Design Concentration Core (see page 25) or the appropriate Signals and Systems track (see page 26). The remaining courses must be EE, CSE or MATH courses.

Students must earn an overall grade point average of 3.0 in their course work at OGI and a "B" or better in each M.S. core class to be eligible to apply through Advanced Placement.

DEGREE REQUIREMENTS

For M.S. students in CSE and for Ph.D. students in CSE and EE, a Student Program Committee (SPC) that provides academic



In 2004, Paul McKenny became the first OGI student to earn a Ph.D. in computer science and engineering as a part-time student. McKenny, who also works full-time at IBM's Linux Technology Center, is one of many OGI students who also work in the area's high-technology industry.

advising is assigned for each matriculated student. The SPC approves the application of courses toward the student's degree requirements. For master's students in EE, a single faculty member will serve as an advisor.

The program of study for each M.S. student may be tailored to meet individual needs by the SPC or advisor. Students are particularly encouraged to include special-topic courses relevant to their interests.

MASTER OF SCIENCE IN COMPUTER SCIENCE AND ENGINEERING

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

M.S. CSE CORE COURSES

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 516	Introduction to Software Engineering	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

M.S. CSE THESIS OPTION

Students choosing the thesis option must find a faculty member willing to serve as a thesis advisor. The department does not assign thesis advisors. The thesis option requires a minimum of 45 credits.

- M.S. CSE CORE (listed above)
- CSE 503 M.S. THESIS RESEARCH (minimum 12 credits)
- ELECTIVES (12 credits), as identified by the thesis advisor or SPC

Please note: Students may not receive credit for both CSE 519 and OMSE 533.

M.S. CSE NON-THESIS OPTION

Students choosing the non-thesis M.S. CSE option must complete a minimum of 15 courses and a minimum of 45 credits. Up to six credits of non-thesis research (CSE 501) may be included with the approval of the student's Student Program Committee (SPC). The first three credits of non-thesis research may be counted as one class, with an additional three credits counting as a second class toward the 15-class requirement.

M.S. CSE 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 three credits of a professional internship (CSE 504).

TRACKS

Students pursuing the non-thesis option must choose one of the nine tracks defined below or consult their SPC to define a custom program.

ADAPTIVE SYSTEMS TRACK

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

Required:

CSE 547	Statistical Pattern Recognition	3 credits
CSE 559	Machine Learning	3 credits

Choose two:

CSE 550	Spoken Language Systems	3 credits
CSE 558	Evolutionary Computation	3 credits
CSE 560	Artificial Intelligence	3 credits
CSE 562	Natural Language Processing	3 credits
CSE 564	Introduction to Human-Computer Interaction	3 credits
CSE 568	Empirical Research Methods	3 credits
EE 586	Adaptive and Statistical Signal Processing	3 credits
EE 587	Data & Signal Compression	3 credits

- SUGGESTED ELECTIVES (12 credits)

CSE 506	Appropriate special topics courses	
CSE 563	Multiagent Systems	3 credits
CSE 569	Scholarship Skills	3 credits
EE 580	Linear Systems	3 credits
EE 581	Intro to Signals, Systems & Transforms	3 credits
EE 582	Intro to Digital Signal Processing	3 credits
MATH 519	Optimization	3 credits

Any CSE class not already taken

Please note: Students may not receive credit for both CSE 519 and OMSE 533.

HUMAN-COMPUTER INTERACTION TRACK

- M.S. CSE CORE (listed above)
- HUMAN-COMPUTER INTERACTION CORE (15 credits)

Required:

CSE 560	Artificial Intelligence	3 credits
CSE 564	Introduction to Human-Computer Interactions	3 credits

Choose three:

CSE 506	Any special topics course in the human computer interaction area such as: 3D Graphics	3 credits
CSE 550	Spoken Language Systems	3 credits
CSE 559	Machine Learning	3 credits
CSE 561	Dialogue	3 credits
CSE 562	Natural Language Processing	3 credits
CSE 563	Multi-Agent Systems	3 credits
CSE 565	Advanced Topics in Human-Computer Interaction	3 credits
CSE 567	Developing User-Oriented Systems	3 credits
CSE 568	Empirical Research Methods	3 credits

- SUGGESTED ELECTIVES (9 credits)

CSE 515	Distributed Computing Systems	3 credits
CSE 547	Statistical Pattern Recognition	3 credits
CSE 551	Structure of Spoken Language	3 credits
CSE 552	Hidden Markov Models for Speech Recognition Architecture	3 credits
CSE 569	Scholarship Skills	3 credits

Any CSE class not already taken.

Please note: Students may not receive credit for both CSE 519 and OMSE 533.

SOFTWARE ENGINEERING TRACK

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

Required:

CSE 517	Software Engineering Processes	3 credits
CSE 519	Object-Oriented Analysis and Design	3 credits
CSE 520	Software Architecture	3 credits
CSE 529	Object-Oriented Programming	3 credits

One of:

CSE 564	Introduction to Human-Computer Interaction	3 credits
CSE 567	Developing User-Oriented Systems	3 credits

- SUGGESTED ELECTIVES (9 credits)

MST 512	Project Management	4 credits

Any course in software engineering, data-intensive systems, systems software, systems security or human-computer interfaces or any CSE course not already taken.

Please note: Students may not receive credit for both CSE 519 and OMSE 533.

SOFTWARE ENGINEERING FOR INDUSTRY PROFESSIONALS TRACK

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

One of:

CSE 564	Introduction to Human-Computer Interaction	3 credits
CSE 567	Developing User-Oriented Systems	3 credits

- SUGGESTED ELECTIVES (9 credits)

Any CSE class not already taken.

Please note: Students may not receive credit for both CSE 519 and OMSE 533.

SPOKEN LANGUAGE SYSTEMS TRACK

- M.S. CSE CORE (listed above)
- SPOKEN LANGUAGE SYSTEMS CORE (15 credits)

Any three:

CSE 550	Spoken Language Systems	3 credits
CSE 551	Structure of Spoken Language	3 credits
CSE 552	Hidden Markov Models for Speech Recognition	3 credits
CSE 562	Natural Language Processing	3 credits

Any two:

BME 568	Auditory & Visual Processing by Human & Machine	3 credits
CSE 547	Statistical Pattern Recognition	3 credits
CSE 553	Speech Synthesis	3 credits
CSE 559	Machine Learning	3 credits
CSE 560	Artificial Intelligence	3 credits
CSE 561	Dialogue	3 credits
CSE 564	Introduction to Human-Computer Interaction	3 credits

CSE 567	Developing User-Oriented Systems	3 credits
EE 581	Introduction to Signals, Systems and Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits

- SUGGESTED ELECTIVES (9 credits)

Courses in the Spoken Language Systems core not already taken

Any CSE class not already taken

Please note: Students may not receive credit for both CSE 519 and OMSE 533.

COOPERATIVE COMPUTER SCIENCE PROGRAMS

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

MASTER OF SCIENCE IN ELECTRIAL ENGINEERING

M.S. EE students may pursue either a Computer Engineering and Design Concentration or Signals and Systems Concentration.

M.S. EE COMPUTER ENGINEERING AND DESIGN (CE&D) CONCENTRATION CORE

All M.S. EE students pursuing the Computer Engineering and Design Concentration must complete the CE&D Concentration Core of 24 credits:

EE 570	Advanced Logic Design	4 credits
EE 571	System-on-Chip (SoC) Design with Programmable Logic	4 credits
EE 572	Advanced Digital Design-Timing Analysis and Test	4 credits
EE 573	Computer Organization and Design	4 credits
EE 574	CMOS Digital VLSI Design I	4 credits
EE 575	CMOS Digital VLSI Design II	4 credits

M.S. EE THESIS OPTION (COMPUTER ENGINEERING AND DESIGN)

Students choosing the thesis option must find a faculty member willing to serve as a thesis advisor. The department does not assign thesis advisors. The thesis option requires a minimum of 48 credits.

- M.S. EE CE&D CONCENTRATION CORE (listed above)
- EE 503 M.S. THESIS RESEARCH (minimum 12 credits)
- ELECTIVES (12 credits) from the CE&D Concentration electives listed in next column

M.S. EE NON-THESIS OPTION (COMPUTER ENGINEERING AND DESIGN)

All M.S. EE students in the Computer Engineering and Design Concentration must complete the concentration core of 24 credits (listed above), one of the following track cores, and remaining elective credits to total a miminum of 48 credits.

CIRCUIT DESIGN TRACK

- M.S. EE CE&D CORE (listed above)
- CIRCUIT DESIGN CORE (16 credits):

Required:

EE 560	Introduction to Electronics and Instrumentation	4 credits
EE 561	Analog Integrated Circuit Design	4 credits
EE 562	Digital Integrated Circuit Design	4 credits
EE 563	Analog CMOS Integrated Circuit Design	4 credits

- SUGGESTED CE&D ELECTIVES (8 credits - listed below)

COMPUTER ARCHITECTURE TRACK

- M.S. EE CE&D CORE (listed above)
- COMPUTER ARCHITECTURE CORE (6 credits)

Required:

CSE 521	Introduction to Computer Architecture	3 credits
CSE 522	Advanced Computer Architecture	3 credits

- SUGGESTED CE&D ELECTIVES (18 credits - listed below)

SIGNAL PROCESSING TRACK

- M.S. EE CE&D CORE (listed above)
- SIGNAL PROCESSING CORE (9 credits)

Required:

EE 581	Introduction to Signals, Systems, & Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 584	Introduction to Image Processing	3 credits

- SUGGESTED CE&D ELECTIVES (15 credits - listed below)

SUGGESTED ELECTIVES FOR COMPUTER ENGINEERING AND DESIGN CONCENTRATION

A minimum of 48 credits between the CE&D core, a track core and the following electives are required for a M.S. EE degree in the Computer Engineering and Design concentration.

BME 513	Biomedical Signal Processing I	3 credits
BME 566	Biomedical Signal Processing II	3 credits
EE 525	Introduction to Electromagnetics for Modern Applications	4 credits
EE 526	Electromagnetics for Modern Applications II	4 credits
EE 531	Introduction to Quantum Mechanics for Electrical & Computer Engineering	4 credits
EE 535	MOSFET Modeling for VLSI Circuit Design	4 credits
EE 560	Introduction to Electronics & Instrumentation	4 credits
EE 565	Introduction to Wireless Integrated Circuit Design	4 credits
EE 576	Algorithms for VLSI Design & Test	4 credits
EE 583	Digital Signal Processing II	3 credits
EE 590	Digital Communication I	3 credits
EE 591	Digital Communication II	3 credits
EE 592	Digital Communication Systems	3 credits
EE 593	Analytical Techniques in Statistical Signal Processing & Communications	3 credits

Any EE or CSE course not already taken

Additionally, students may consider the following courses from other universities:

ECE 527	VLSI System Design (Oregon State University)
ECE 570	High Performance Computer Architecture (Oregon State University)
ECE 675	Introduction to Integrated Circuit Test (Portland State University)
ECE 699	Digital Design Using Hardware Description Languages (Portland State University)

M.S. EE SIGNALS AND SYSTEMS (SAS) CONCENTRATION

Prerequisite knowledge for this concentration includes Mulitivariate Calculus, Differential Equations and Linear Algebra.

M.S. EE THESIS OPTION (SIGNALS AND SYSTEMS)

Students choosing the thesis option must find a faculty member willing to serve as a thesis advisor. The department does not assign thesis advisors. The thesis option requires a minimum of 45 credits.

- M.S. EE SAS CONCENTRATION CORE (18 credits, individually determined by advisor)
- EE 503 - M.S. Thesis Research (minimum 12 credits)
- ELECTIVES (15 credits) from the SAS Concentration electives listed below

M.S. EE NON-THESIS OPTION (SIGNALS AND SYSTEMS)

All M.S. EE students in the Signals and Systems Concentration must complete one of the following track cores and remaining elective credits to total a minimum of 45 credits.

SIGNAL AND IMAGE PROCESSING TRACK

- SIGNAL AND IMAGE PROCESSING CORE (30 credits)

Required:

BME 568	Auditory & Visual Processing by Human & Machine	3 credits
CSE 547	Statistical Pattern Recognition	3 credits
EE 580	Linear Systems	3 credits
EE 581	Introduction to Signals, Systems and Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 584	Introduction to Image Processing	3 credits
EE 585	Introduction to Digital Video Processing	3 credits
EE 586	Adaptive & Statistical Signal Processing	3 credits
MATH 517	Probability and Statistics	3 credits
MATH 519	Optimization	3 credits

- SUGGESTED SAS ELECTIVES (15 credits - listed on following page)

MACHINE LEARNING TRACK

- MACHINE LEARNING CORE (30 credits)

Required:

CSE 547	Statistical Pattern Recognition	3 credits
CSE 558	Evolutionary Computation	3 credits
CSE 559	Machine Learning	3 credits
CSE 560	Artificial Intelligence	3 credits
EE 580	Linear Systems	3 credits
EE 581	Introduction to Signals, Systems	3 credits
	and Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 586	Adaptive & Statistical Signal Processing	3 credits
MATH 517	Probability and Statistics	3 credits
MATH 519	Optimization	3 credits

- SUGGESTED SAS ELECTIVES (15 credits - listed below)

SPEECH PROCESSING TRACK (33 credits)

- SPEECH PROCESSING CORE (33 credits)

Required:

BME 572	Speech Synthesis	3 credits
CSE 547	Statistical Pattern Recognition	3 credits
CSE 550	Spoken Language Systems	3 credits
CSE 551	Structure of Spoken Language	3 credits
CSE 552	Hidden Markov Models for Speech Recognition	3 credits
EE 580	Linear Systems	3 credits
EE 581	Introduction to Signals, Systems and Transforms	3 credits
EE 582	Introduction to Digital Signal Processing	3 credits
EE 586	Adaptive & Statistical Signal Processing	3 credits
MATH 517	Probability and Statistics	3 credits
MATH 519	Optimization	3 credits

- SUGGESTED SAS ELECTIVES (12 credits - listed below)

SUGGESTED ELECTIVES FOR SIGNALS AND SYSTEMS CONCENTRATION

A minimum of 45 credits between the applicable track core required courses and the following electives are required for a M.S. EE degree in the Signals and Systems concentration.

BME 513	Biomedical Signal Processing	3 credits
BME 568	Auditory & Visual Processing by Human & Machine	3 credits
BME 571	Speech Systems	3 credits
CSE 532	Analysis and Design of Algorithms	3 credits
CSE 552	Hidden Markov Models for Speech Recognition	3 credits
CSE 558	Evolutionary Computation	3 credits
CSE 559	Machine Learning	3 credits
CSE 560	Artificial Intelligence	3 credits
CSE 562	Natural Language Processing	3 credits
EE 506	Special Topics in Signals and Systems such as:	
	Intelligent Signal Processing	3 credits
EE 584	Introduction to Image Processing	3 credits
EE 587	Data and Signal Compression	3 credits

Any EE or CSE course not already taken

MASTER OF SOFTWARE ENGINEERING

The OGI School of Science & Engineering and Portland State University offer a joint Oregon Master of Software Engineering (OMSE) degree to meet the needs of software professionals. The curriculum emphasizes the technical leadership, teamwork and communication skills, and the business aspects of developing industrial-strength software. For additional information visit www.omse.org.

Students wishing to apply for the OMSE master degree must minimally have a four-year bachelor's degree and two years of software development experience. The relevance of work experience can be pre-determined. This determination may require an oral interview.

OMSE students must complete a minimum of 48 credits: 39 credits from core courses and 9 credits from elective courses. Program pre-approval of elective courses is required. At least two years of software development experience is required to enroll in any OMSE course.

OMSE CORE COURSES

All OMSE students must complete the following OMSE core of 13 classes:

OMSE 500	Principles of Software Engineering	3 credits
OMSE 511	Managing Software Development	3 credits
OMSE 513	Professional Communication Skills for Software Engineering	3 credits
OMSE 521	Using Metrics and Models to Support Quantitative Decision Making	3 credits
OMSE 522	Modeling and Analysis of Software Systems	3 credits
OMSE 525	Software Quality Analysis	3 credits
OMSE 531	Software Requirements Engineering	3 credits
OMSE 532	Software Architecture and Domain Analysis	3 credits
OMSE 533	Software Design Techniques	3 credits
OMSE 535	Software Implementation and Testing	3 credits
OMSE 551	Strategic Software Engineering	3 credits
OMSE 555	Software Development Practicum I	3 credits
OMSE 556	Software Development Practicum II	3 credits

ELECTIVES

A total of 9 credits of elective classes are needed for the OMSE Master's degree. Any graduate-level course applicable to the student's chosen career may be considered as an elective. A student must receive pre-approval from the OMSE program for all elective courses.

GRADUATE CERTIFICATES

The OMSE program also offers three graduate-level certificates in Principles of Software Engineering, Software Analysis and Design, and Software Quality Engineering. Each certificate requires the completion of 9 credits. Courses taken for a certificate may also be applied towards an OMSE master's degree. At least two years of software development experience is required to enroll in any OMSE course.

CERTIFICATE IN PRINCIPLES OF SOFTWARE ENGINEERING

OMSE 500	Principles of Software Engineering	3 credits
OMSE 511	Managing Software Development	3 credits
OMSE 531	Software Requirements Engineering	3 credits

CERTIFICATE IN SOFTWARE ANALYSIS DESIGN

OMSE 522	Modeling and Analysis of Software Systems	3 credits
OMSE 532	Software Architecture and Domain Analysis	3 credits
OMSE 533	Software Design Techniques	3 credits

CERTIFICATE IN SOFTWARE QUALITY ENGINEERING

OMSE 521	Using Metrics and Models to Support Quantitative Decision Making	3 credits
OMSE 525	Software Quality Analysis	3 credits
OMSE 535	Software Implementation and Testing	3 credits

PH.D. PROGRAMS IN COMPUTER SCIENCE AND ENGINEERING AND ELECTRICAL ENGINEERING

Ph.D. programs with emphasis in Computer Science and Engineering and Electrical Engineering are offered through the Department of Computer Science and Electrical Engineering. 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.

In addition to the general OGI requirements for a Ph.D., students are required to pass a research-skills assessment. This includes satisfactory completion of CSE 669 Scholarship Skills, and a research proficiency examination (RPE). The RPE requires a written and oral presentation of a research paper and usually takes place in the spring quarter of the second year of residence.

Ph.D. students must obtain a grade of "B" or better in each required course. Ph.D. students must also complete a doctoral dissertation that documents a significant, original research contribution of publishable quality in both content and presentation.

The faculty strongly recommends that students prepare a formal thesis proposal that is presented publicly, with the dissertation committee in attendance, between 9 and 18 months before the Ph.D. defense. The proposal provides an opportunity for the student to receive feedback to ensure an acceptable level of intellectual vigor and maturity in the dissertation research.

Starting in the second year, the faculty strongly recommends that students deliver yearly research talks. The RPE, presentation at the student research symposium, the thesis proposal and talks at refereed conferences satisfy this requirement. Practice talks for conference papers should be open for commentary.

The program of study for each Ph.D. student is tailored to meet individual needs and interests. Each student's SPC provides academic advising and is in direct control of the student's program of study. The SPC will work with the student to set and review goals on a twice-yearly basis. Students must write a progress report for all SPC meetings, except the first one.

The entire faculty reviews each Ph.D. student's academic progress annually.

ADDITIONAL REQUIREMENTS FOR CSE PH.D. STUDENTS:

FOUNDATION REQUIREMENTS (18 credits)

Required:

CSE 613	Introduction to Operating Systems	3 credits
CSE 621	Introduction to Computer Architecture	3 credits
CSE 632	Analysis and Design of Algorithms	3 credits
CSE 633	Automata and Formal Languages	3 credits

Choose one programming language course:

CSE 629	Object-Oriented Programming	3 credits
CSE 631	Foundations of Semantics	3 credits
CSE 636	Functional Programming	3 credits

Choose one interactive and adaptive systems course:

CSE 659	Machine Learning	3 credits
CSE 660	Artificial Intelligence	3 credits
CSE 664	Introduction to Human-Computer Interaction	3 credits

RESEARCH SKILLS REQUIREMENT (3 credits)

CSE 669 Scholarship Skills . . . . 3 credits

AREA REQUIREMENTS (18 credits)

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

ADAPTIVE SYSTEMS AND APPLICATIONS

BME 668	Auditory and Visual Processing by Human and Machine	3 credits
CSE 606	Special topics in Cognitive Science	
CSE 647	Statistical Pattern Recognition	3 credits
CSE 658	Evolutionary Computation	3 credits
CSE 659	Machine Learning	3 credits
CSE 660	Artificial Intelligence	3 credits
EE 682	Introduction to Digital Signal Processing	3 credits
EE 686	Adaptive and Statistical Signal Processing	3 credits
EE 687	Data and Signal Compression	3 credits

HUMAN-COMPUTER INTERACTIVE SYSTEMS

BME 668	Auditory and Visual Processing by Human and Machine	3 credits
CSE 606	Special Topics such as:	
	Computer Graphics	3 credits
CSE 650	Spoken Language Systems	3 credits
CSE 651	Structure of Spoken Language	3 credits
CSE 652	Hidden Markov Models for Speech Recognition	3 credits
CSE 653	Speech Synthesis	3 credits
CSE 659	Machine Learning	3 credits
CSE 660	Artificial Intelligence	3 credits
CSE 661	Dialogue	3 credits
CSE 662	Natural Language Processing	3 credits
CSE 663	Multiagent Systems	3 credits
CSE 664	Introduction to Human-Computer Interaction	3 credits
CSE 665	Advanced Topics in Human-Computer Interaction	3 credits
CSE 667	Developing User-Oriented Systems	3 credits
CSE 668	Empirical Research Methods	3 credits

PROGRAMMING LANGUAGES AND SOFTWARE ENGINEERING

CSE 606	Special Topics such as:	
	High Assurance Software Engineering	3 credits
	Model Checking for Bug Discovery	3 credits
CSE 611	Principles of Compiler Design	3 credits
CSE 612	Compiling Functional Languages	3 credits
CSE 616	Introduction to Software Engineering	3 credits
CSE 617	Software Engineering Processes	3 credits
CSE 618	Software Design and Development	3 credits
CSE 619	Object-Oriented Analysis and Design	3 credits
CSE 620	Software Architecture	3 credits
CSE 629	Object-Oriented Programming	3 credits
CSE 630	Introduction to Mathematical Logic	3 credits
CSE 631	Foundations of Semantics	3 credits
CSE 634	Domain Specific Languages	3 credits
CSE 636	Functional Programming	3 credits

SYSTEMS SOFTWARE

CSE 606	Special Topics such as:	
	Building Secure Systems	3 credits
	Web Distribution Architecture	3 credits
CSE 614	Introduction to Database Systems	3 credits
CSE 615	Distributed Computing Systems	3 credits
CSE 622	Advanced Computer Architecture	3 credits
CSE 624	TCP/IP Internetworking Protocols	3 credits
CSE 625	Advanced Networking	3 credits
CSE 626	Advanced Topics in Operating Systems	3 credits
CSE 627	Principles and Practices of System Security	3 credits
CSE 628	Cryptography	3 credits
CSE 629	Object-Oriented Programming	3 credits
CSE 641	Database Implementation	3 credits
CSE 642	Object Data Management	3 credits
CSE 672	Security Protocols	3 credits

THEORY

CSE 628	Cryptography	3 credits
CSE 630	Introduction to Mathematical Logic	3 credits
CSE 631	Foundations of Semantics	3 credits
CSE 634	Computability and Intractability	3 credits
CSE 635	Categories in Computer Science	3 credits
CSE 643	Foundations of Database Systems	3 credits

ADDITIONAL REQUIREMENTS FOR EE PH.D. STUDENTS:

Admission to the Ph.D. program generally requires a prior M.S. in Electrical Engineering, Computer Engineering, or related field, whether from OGI of from another institution. Outstanding students who are admitted to the program with only a B.S. degree are required to complete the coursework for an M.S. EE degree. Completion of these credits can be spread out over multiple years to allow early involvement in research and independent studies.

Students should meet with their SPC committee to design an appropriate course of study. For all students, a minimum of 3 graded courses from OGI's EE program must be completed before taking the RPE exam. Electrical Engineering Ph.D. students must complete a minimum of 36 credits of Ph.D. disssertation research (EE 603).

RESEARCH PROGRAMS

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

Adaptive Systems

Our work on adaptive systems includes theoretical, algorithmic, scientific and practical aspects. Research on theory and algorithms for machine learning includes supervised, unsupervised and reinforcement learning; neural networks; genetic algorithms; generalization theory (model selection and pruning, invariant learning and theoretical characterization); stochastic optimization; local and mixture models; time series; control; and context-sensitive learning. Research on biological and cognitive modeling includes the effect of noise on learning in neural circuits, cognitive models of visual pattern recognition and analogy-making, and modeling of evolutionary systems. Practical applications of our research in these areas include speech and image processing, medical screening technology, environmental forecasting and observation systems, anomaly detection for aeronautics, aircraft control, sensor fusion and optimization, and automatic programming.
Hayes, Leen, Mitchell, Pavel, Song, Wan

Agent-Based Systems

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

Autonomous Unmanned Aerial Vehicles

This multidisciplinary project is exploring the design and implementation of nonlinear reconfigurable controllers that exploit the coupled dynamics between a model of a flight vehicle and adaptive models of the environment. New model-predictive techniques are developed to perform on-line optimization of vehicle control trajectories under dynamic and situational constraints.
This program includes both theoretical and algorithmic development of new control algorithms as well as experimental flight testing with small autonomous helicopters.
Wan

Estimation and Probabilistic Inference

Probabilistic Inference refers to the problem of optimally estimating the hidden variables (states or parameters) of a system given noisy or incomplete observations. Examples include estimating the states (e.g., position and attitude) of a vehicle from sensors, identifying parameters (e.g., mass, moments of inertia or weights of a neural network, target tracking with motion, robot localization, financial forecasting, etc. Our research focuses on fundamental algorithm development and testing of Recursive Bayesian Estimation techniques that exceed traditional Kalman filters. These algorithms, referred to as Sigma-Point-Kalman filters, include approximate Gaussian methods and hybrids with Sequential Monte-Carlo Methods (e.g., particle filters).
Wan

Image, Video Processing and Analysis

Both low-level processing and high-level analysis are studied. Special emphasis is on the interface of machine learning and computer vision, where insights from probability theory, stochastic systems and information theory are used to produce new algorithms that are robust, accurate and efficient. Current projects include information fusion, the incorporation of context for image recognition, model-based image segmentation, enhancement and 3-D reconstruction, and motion analysis for autonomous navigation.
Song, Pavel

Multimodal Systems

Multimodal interfaces enable more natural and efficient interaction between humans and machines by supporting multiple coordinated channels through which input and output can pass. The Center for Human-Computer Communication is engaged in empirical investigation of multimodal interaction. This informs our research and development of architectures for multimodal language processing, work which draws on a range of fields such as cognitive science, natural language processing, multimedia, user interface design, speech recognition, gesture recognition and visual parsing. The Quickset system developed at CHCC supports multimodal pen/voice interaction with complex visual/spatial displays, such as maps. The Rasa system allows users to engage multimodally with tangible tools, such as paper and Post-it notes. Finally, work is ongoing to develop techniques for 3-D multimodal interaction in augmented and virtual reality environments.
Cohen, Oviatt

MultiView

The MultiView project aims to produce foundational results and practical tools for representing and manipulating software from multiple viewpoints. Our ability to build complex software systems relies on composition techniques and programming language mechanisms that enable us to construct complete programs from smaller pieces. A particular decomposition imposes a structure that makes it possible to manage the complexity of a large system, provided that each component can be developed and maintained with some degree of independence, and that each feature can be localized in one or two components. Unfortunately, the same decomposition makes it harder to add or change features that cut across that structure.

We believe that the design, evolution, maintenance and comprehension of software can be better supported by tools that allow programmers to examine and work with multiple perspectives on a program instead of constraining them to a single decomposition. That is, programmers should be empowered to think of programs not as linear texts but as equivalence classes of concrete views, each of which is useful for certain tasks, but none of which is more definitive than any other.
Black, Jones

Natural Language Dialogue

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

Neurobiological Modeling

The brain handles a continuous temporal flow of sensory information. At the microscopic level of the synapses, the relevant signals are the small variable electrophysiological events called synaptic potentials. When learning occurs, there is a change in the relative weighted value of these synaptic potentials. At the macroscopic level of a functional region of the brain, the relevant variables are systems properties of the response to large numbers of cellular inputs. The system needs to optimize the trade-off between accuracy, which may take some time to establish, and adaptability, which often requires rapid adjustment to changes in the sensory environment. This collaborative project combines statistical adaptive system approaches with tools from computational biology and experimental neurophysiology. The present focus is on modeling adaptation in a sensory-motor system in weakly electric mormyrid fish. The modeling forms a bridge between microscopic dynamics and macroscopic system behavior. This project involves a novel aspect of modeling emphasizing statistical properties of then-synaptic adaptation in the presence of noise, and making testable predictions about how noise can affect the accuracy of the fish's stored signal memories.
Leen, Roberts

Programatica

"Programming as if properties mattered." We are developing a new kind of program development environment that actively supports and encourages its users in thinking about, stating and validating correctness properties of software as an integral part of the programming process. The Programatica framework allows programmers to assert precise properties of program elements as part of their source code. Assertions can then be annotated with one or more "certificates" that provide evidence of their validity. The certificate interface is generic; certificate servers can range from "pencil and paper" proofs, randomized test suites, all the way to formal proofs checked by a theorem prover. Changes to the original program are tracked by the framework, requiring only those certificates that depend on the changed code to be reverified. Property-oriented development environments such as Programatica are a key technology in helping developers build more robust and secure software systems.
Hook, Jones, Kieburtz, Matthews

Speech Enhancement

Speech Enhancement is concerned with the processing of corrupted or noisy speech in order to improve the quality or intelligibility of the signal. Applications range from front-ends for speech recognition systems, to enhancement of telecommunications for aviation, military, teleconferencing, and cellular environments. Our goal is to develop state-of-the art systems and conduct fundamental research based on nonlinear signal processing, machine learning, and perceptual techniques. This research is in collaboration with the Center for Spoken Language Understanding (CSLU).
Wan

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.

The goal for language and speaker recognition is to identify which language is being used in a conversation and who is talking by using signal processing, pattern recognition and computer science technology. The technology can be used to increase security and customer services. Our research in this area includes how to analyze, identify and capture these nuances and how to model these specific acoustics landmarks and phonotactic constraints contained in the targeted language and speakers.
Yan, Heeman

Spoken Language Engineering

Speech is the most natural and efficient means by which individuals may access a wide variety of information, and the need for speech-based interfaces is growing as computing gradually moves off of the desktop and into mobile devices. Spoken language engineering is an interdisciplinary field that draws elements from digital signal processing, computer science, linguistics, machine learning, and human perception. The Center for Spoken Language Understanding (CSLU) has unique breadth and depth of experience in all components of spoken language engineering, including text-to-speech synthesis, speech recognition, dialogue modeling, and signal processing. Research efforts at CSLU include assistive technology, speech as an information source for medical diagnosis, universal access to computers, small-footprint speech recognition and text-to-speech synthesis, and basic research on all aspects of spoken-language processing.
Heeman, Hosom, van Santen, Wan

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

RESEARCH CENTERS

CENTER FOR HUMAN-COMPUTER COMMUNICATION

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 of Science & Engineering. 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/. 39

PACIFIC SOFTWARE RESEARCH CENTER

The Pacific Software Research Center (PacSoft) is a team of faculty, students and professional research staff who focus on innovative uses of programming language technology and formal methods to improve the quality of software and to improve programmer productivity.

PacSoft's approach to software specification and development is grounded in the use of high level programming languages—including functional, object-oriented, and domain specific languages—and in mathematically based techniques for the specification, development and validation of complex computer software—including type theory, meta-programming, formal methods, and programming language semantics. 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. This allows non-programmers, who are domain experts, to create significant software artifacts that meet their own needs. Construction of domain specific languages requires experts in both the domain and language design. Domains in which our work has demonstrated particular success include: microarchitecture design for high performance microprocessors; construction of encryption algorithms; configuration of large software component systems; and implementation of real-time embedded systems.

PacSoft is organized as a collaborative effort between the Department of Computer Science at the OGI School of Science and Engineering and the Department of Computer Science at Portland State University. PacSoft faculty members at OGI include Dr. Mark Jones, Dr. John Matthews, Dr. John Launchbury, and Dr. Richard Kieburtz (emeritus). PacSoft faculty members at PSU include Dr. Andrew Black, Dr. James Hook, Dr. Tim Sheard (center director), and Dr. Andrew Tolmach. For further information, visit the PacSoft web site at HYPERLINK "http://www.cse.ogi.edu/PacSoft/" http://www.cse.ogi.edu/PacSoft/.

FACILITIES

The Department of Computer Science and Electrical 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 CSEE to be flexible and responsive in meeting the department's changing needs.

Support for central services such as email, 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 and Linux computers and a Network Appliance file server that make up the core support environment. The CSEE network is tied together through a Cisco 6513 core switch, which has a backplane rating of 720 Gbps.

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

The department also has facilities for research and teaching in computer hardware design and electrical engineering. Mentor Graphics IC Design Station is used for VLSI design. Chips are fabricated at the Mosis foundry and can be tested on our IMS XL60 chip tester. Mentor and Altera CAD tools are provided for FPGA programmable logic design. The computer design lab is equipped with PC workstations, Tektronix digital oscilloscopes, FPGA development boards and TI DSP boards. We have test equipment and facilities for analog and mixed signal design along with simulation support with Cadence PSpice. A digital television lab is available for video signal processing projects.

FACULTY

JAN P. H. VAN SANTEN

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University of Michigan, 1979
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

J. van Santen and B. Möbius, "A Model of Fundamental Frequency Contour Alignment," in *Intonation: Analysis, Modelling and Technology*, Cambridge University Press, Cambridge, United Kingdom, 2000.

J. van Santen and C. Shih, "Segmental and Suprasegmental Timing in American English and Manadarin Chinese," *Journal of the Acoustical Society of America*, 1012–1026, 2000.

J. van Santen and R. Sproat, "Highaccuracy Automatic Segmentation," *Proceedings of EUROSPEECH 99*, Budapest, Hungary, 1999.

J. van Santen, "Combinatorial Issues in Text-to-speech Synthesis," *Proceedings of EUROSPEECH 97*, Rhodes, Greece, 1997.

J. van Santen and A.L. Buchsbaum, "Methods for Optimal Text Selection," in *Proceedings Eurospeech 1997*, Rhodes, Greece, 1997.

J. van Santen, "Prosodic Modelling in Text-to-speech Synthesis," in *Proceedings Eurospeech, 1997*, Rhodes, Greece, 1997.

J. van Santen, "Segmental Duration and Speech Timing," in Y. Sagisaka, W.N. Campbell and N., Higuchi, eds., *Computing Prosody*, New York, Springer, 1996.

J. van Santen, R.W. Sproat, J. Olive and J. Hirschberg, eds., *Progress in Speech Synthesis*, New York, Springer-Verlag, 1996

RICHARD E. (DICK) FAIRLEY

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Associate Chair of
Computer Science
Ph.D., Computer Science
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

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

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

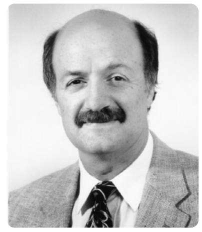
R. Fairley, "A Process-Oriented Approach to Software Product Improvement," PROFES'99 Conference Proceedings, Oulu, Finland, June 1999.

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

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

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

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



PHIL COHEN

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

S. Kumar, P. Cohen and H. Levesque, "The Adaptive Agent Architecture: Achieving Fault-Tolerance Using Persistent Broker Teams," in the Fourth International Conference on Multiagent Systems (ICMAS 2000), Boston, July 2000.

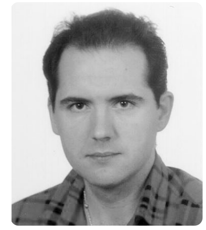
S. Kumar and P. Cohen, "Towards a Fault-Tolerant Multiagent System Architecture," in the Fourth International Conference on Autonomous Agents (Agents 2000), Barcelona, June 2000.

D. McGee, P. Cohen and L. Wu, "Something from Nothing: Augmenting a Paper-based Work Practice with Multimodal Interaction," Proceedings of the Designing Augmented Reality Environments Conference, ACM Press, 71-80, Copenhagen, April 2000.

S. Oviatt and P. Cohen, "Multimodal Interfaces That Process What Comes Naturally," *Communications of the ACM*, **43**(3), 45-53, March 2000.

L. Wu, S.L. Oviatt and P. Cohen, "Multimodal Integration — A Statistical View," *IEEE Transactions on Multimedia*, **1**(4), 334-341, December 1999.

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



MIGUEL Á CARREIRA-PERPIÑÁN

Assistant professor
Ph.D., Computer Science
University of Sheffield, UK, 2001

RESEARCH INTERESTS

Machine learning and pattern recognition, with applications to speech processing and computer vision. Computational neuroscience, in particular cortical map models.

REPRESENTATIVE PUBLICATIONS

M. Á. Carreira-Perpiñán and R. S. Zemel (2005): "Proximity graphs for clustering and manifold learning". Advances in Neural Information Processing Systems 17 (NIPS'2004).

M. Á. Carreira-Perpiñán and G. J. Goodhill (2004): "The influence of lateral connections on the structure of cortical maps". J. Neurophysiology 92(5):2947-2959.

X. He, R. S. Zemel, and M. Á. Carreira-Perpiñán (2004): "Multiscale conditional random fields for image labelling". IEEE Conference on Computer Vision and Pattern Recognition (CVPR 2004), pp. 695-702, Washington, DC, 27 June - 2 July 2004.

M. Á. Carreira-Perpiñán and G. J. Goodhill (2002): "Are visual cortex maps optimized for coverage?". Neural Computation 14(7):1545-1560.

M. Á. Carreira-Perpiñán (2000): "Mode-finding for mixtures of Gaussian distributions". IEEE Trans. on Pattern Analysis and Machine Intelligence 22(11):1318-1323.

M. Á. Carreira-Perpiñán (2000): "Reconstruction of sequential data with probabilistic models and continuity constraints". Advances in Neural Information Processing Systems 12 (NIPS'99), pp. 414-420.

M. Á. Carreira-Perpiñán and S. Renals (1999): "Practical identifiability of finite mixtures of multivariate Bernoulli distributions". Neural Computation 12(1):141-152.

M. Á. Carreira-Perpiñán and S. Renals (1998): "Dimensionality reduction of electropalatographic data using latent variable models". Speech Communication 26(4):259-282.

DENIZ ERDOGMUS

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Ph.D., Electrical and Computer Engineering
University of Florida, 2002
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RESEARCH INTERESTS

Adaptive, nonlinear, and statistical signal/image processing; information theory and its applications to signal processing, learning, and adaptation theories; applications of these principles to biomedical engineering, communications, and control systems.

REPRESENTATIVE PUBLICATIONS

D. Erdogmus, K.E. Hild II, Y.N. Rao, J.C. Principe, "Minimax Mutual Information Approach for Independent Components Analysis," Neural Computation, vol. 16, no. 6, pp. 1235-1252, 2004.

D. Erdogmus, K.E. Hild II, M. Lazaro, I. Santamaria, J.C. Principe, "Adaptive Blind Deconvolution of Linear Channels Using Renyi's Entropy with Parzen Estimation," IEEE Transactions on Signal Processing, vol. 52, no. 6, pp. 1489-1498, 2004.

D. Erdogmus, J.C. Principe, "Lower and Upper Bounds for Misclassification Probability Based on Renyi's Information," Journal of VLSI Signal Processing Systems, vol. 37, no. 2/3, pp. 305-317, 2004.

D. Erdogmus, J.C. Principe, K.E, Hild II, "On-Line Entropy Manipulation: Stochastic Information Gradient," IEEE Signal Processing Letters, vol. 10, no. 8, pp. 242-245, Aug 2003.

Y.N. Rao, D. Erdogmus, G.Y. Rao, J.C. Principe, "Stochastic Error Whitening Algorithm for Linear Filter Estimation with Noisy Data," Neural Networks, vol. 16, no. 5-6, pp. 873-880, Jun 2003.

D. Erdogmus, K.E. Hild II, J.C. Principe, "Blind Source Separation Using Renyi's a-Marginal Entropies," Neurocomputing, vol. 49, no. 1, pp. 25-38, Dec 2002.

D. Erdogmus, J.C. Principe, "An Error-Entropy Minimization Algorithm for Supervised Training of Nonlinear Adaptive Systems,: IEEE Transactions on Signal Processing, vol. 50, no. 7, pp. 1780-1786, Jul 2002.

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State University of New York at Stony Brook, 1997
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

Vassilis Christophides, Juliana Freire, Eds. Proceedings of the International Workshop on Web and Databases, 2003.

M. Benedikt, C-Y. Chan, W. Fan, J. Freire, and R. Rastogi. "Capturing both Types and Constraints in Data Integration," ACM SIGMOD International Conference on Management of Data, 2003.

P. Bohannon, J. Freire, J.R. Haritsa, M. Ramanath, P. Roy and J. Siméon, "Bridging the XML-Relational Divide with LegoDB: A Demonstration," IEEE International Conference on Data Engineering (ICDE), 2003.

J. Freire, J.R. Haritsa, M. Ramanath, P. Roy and J. Siméon, "StatiX: Making XML Count," ACM SIGMOD International Conference on Management of Data, pp. 181-192, 2002.

J. Freire and J. Simeon, "Adaptive XML Shredding: Architecture, Implementation, and Challenges," Efficiency and Effectiveness of XML Tools, and Techniques (EEXTT), pp. 104-116, 2002.

P. Bohannon, J. Freire, J.R. Haritsa, M. Ramanath, P. Roy and J. Siméon, "LegoDB: Customizing Relational Storage for XML Documents," Very Large Databases Conference (VLDB), pp. 1091-1094, 2002.

M. Benedikt, J. Freire and P. Godefroid, "VeriWeb: Automatically Testing Dynamic Web Sites," International World Wide Web Conference (WWW), 2002.

P. Bohannon, J. Freire, P. Roy and J. Siméon, "From XML Schema to Relations: A Cost-based Approach to XML Storage," IEEE International Conference on Data Engineering (ICDE), pp. 64-75, 2002.

PETER A. HEEMAN

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University of Rochester, 1997
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

S. Strayer, P. Heeman and F. Yang, "Reconciling Control and Discourse Structre," Current and new Directions in Discourse and Dialogue, in J. van Kuppevelt and R. Smith, eds., Kluwer Academic Publishers, 2003.

P. Heeman, F. Yang and S. Strayer, "DialogueView: An annotation tool for dialogue," Third SIGdial Workshop on Discourse and Dialogue, 2002.

P. Heeman and J. Allen, "Improving Robustness by Modeling Spontaneous Speech Events," in Robustness in Language and Speech Technology, J. Junqua and G. van Noord, eds., Kluwer Academic Publishers, 2000.

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

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

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

MARK P. JONES

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D.Phil., Computation
University of Oxford, 1992
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

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

M.P. Jones, "First-class Polymorphism with Type Inference," in Proceedings of the 24th Annual ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages, Paris, January 1997.

M.P. Jones, "Using Parameterized Signatures to Express Modular Structure," in Proceedings of the 23rd Annual ACM SIGPLAN-SIGACT Symposium on Principles of Programming Languages, St. Petersburg Beach, Fla., January 1996.

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

M.P. Jones, "A System of Constructor Classes: Overloading and Implicit Higher-order Polymorphism," *Journal of Functional Programming*, **5**(1), Cambridge University Press, January 1995.

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

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

RICHARD B. KIEBURTZ

Professor Emeritus
Ph.D., Electrical Engineering
University of Washington, 1961
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

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

R.B. Kieburtz, "A Logic for Rewriting Strategies," Strategies '01, June 2001.

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

R.B. Kieburtz, "Taming Effects with Monadic Typing," in Proc. 3rd International Conf. on Functional Programming, ACM Press, April 1998.

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

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

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

R.B. Kieburtz, "Programming with Algebras," in *Advanced Functional Programming*, E. Meijer and J.Jeuring, eds., Springer-Verlag, Series LNCS, Vol. 925, 1995.

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

JOHN LAUNCHBURY

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Ph.D., Computing Science
University of Glasgow, 1990
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

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

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

J. Launchbury, J. Lewis and B. Cook. "On Embedding a Microarchitecture Design Language within Haskell," International Conference on Functional Programming, ACM, 1999.

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

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

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

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

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

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

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

TODD K. LEEN

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

Machine learning, local and mixture models, invariance, stochastic learning, with applications to anomaly detection, environmental systems monitoring, and data coding. Modeling neurobiological systems.

REPRESENTATIVE PUBLICATIONS

R. Sharma, T.K. Leen and M. Pavel, "Bayesian Image Sensor Fusion Using Local Linear Generative Models," *Optical Engineering*, **40**, 1364, 2001.

C. Archer and T.K. Leen, "The Coding Optimal Transform," in Proceedings of the Data Compression Conference 2001, IEEE Computer Press, 2001.

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

W. Wei, T.K. Leen and E. Barnard, "A Fast Histogram-Based Postprocessor that Improves Posterior Probability Estimates," *Neural Computation*, **11**, 1235, 1999.

T.K. Leen, B. Schottky and D. Saad, "Optimal Symptotic Learning: Macroscopic Versus Microscopic Dynamics," *Physical Review E*, **59**, 985, 1999.

T.K. Leen and J.E. Moody, "Stochastic Manhattan Learning: Time-Evolution Operator for the Ensemble Dynamics," *Physical Review E*, **56**, 1262, 1997.

N. Kambhatla and T.K. Leen, "Dimension Reduction by Local Principal Component Analysis," *Neural Computation*, **9**, 1493, 1997.

T.K. Leen, "From Data Distribution to Regularization in Invariant Learning," *Neural Computation*, **7,** 974, 1995.

T.K. Leen, "A Coordinate-Independent Center Manifold Reduction," *Physics Letters, A* **174**, 89, 1993.

JOHN MATTHEWS

Assistant Professor
Ph.D., Computer Science
Oregon Graduate Institute, 2000
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RESEARCH INTERESTS

Formal verification; theorem proving; model checking; specification languages; functional and constraint logic programming languages.

REPRESENTATIVE PUBLICATIONS

L. Lamport, J. Matthews, M. Tuttle and Y. Yu, "Specifying and Verifying Systems With TLA+," Tenth ACM SIGOPS European Workshop: Can we really depend on an OS?, Saint-Emilion, France, September 2002 (to appear).

S. Krstic and J. Matthews, "Verifying BDD Algorithms through Monadic Interpretation," Proceedings of the Third International Workshop on Verification, Model Checking and Abstract Interpretation, Venice, Italy, January 2002.

J. Matthews, "Recursive Function Definition over Coinductive Types," Proceedings of the 12th International Conference on Theorem Proving in Higher Order Logics, Nice, France, LNCS Vol. 1690, September 1999.

J. Matthews and J. Launchbury, "Elementary Microarchitecture Algebra," Proceedings of the 11th International Conference on Computer Aided Verification, Trento, Italy, LNCS Vol. 1633, July, 1999.

B. Cook, J. Launchbury and J. Matthews, "Specifying Superscalar Microprocessors in Hawk," Workshop on Formal Techniques for Hardware and Hardware-like Systems, Marstrand, Sweden, June 1998.

J. Matthews, J. Launchbury and B. Cook, "Microprocessor Specification in Hawk," Proceedings of the IEEE International Conference on Computer Languages 1998, Chicago, May 1998.

SHARON L. OVIATT

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Co-Director for Center for
Human Computer Communication
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RESEARCH INTERESTS

Multimodal and spoken language interfaces; conversational interfaces; ubiquitous and perceptive interfaces; modality effects in communication and communication models; tele-communication and technology-mediated communication; mobile and interactive interfaces; human-computer interaction; empirically based design and evaluation of human-computer interfaces; cognitive science and research methodology.

REPRESENTATIVE PUBLICATIONS

S.L. Oviatt, "Breaking the Robustness Barrier: Recent Progress on the Design of Robust Multimodal Systems," Advances in Computers (ed. by M. Zelkowitz) Academic Press, 2002, vol. 56, pp. 305-341.

S.L. Oviatt, "Multimodal Interfaces," in J. Jacko and A. Sears, eds., *Handbook of Human-Computer Interaction*, Lawrence Erlbaum Assoc., Mahwah, N.J., 2002, ch. 14, pp. 286-304.

S.L. Oviatt, P.R. Cohen, L. Wu, J. Vergo, L. Duncan, B. Suhm, J. Bers, T. Holzman, T. Winograd, J. Landay, J. Larson and D. Ferro. "Designing the User Interface for Multimodal Speech and Gesture Applications: State-of-theart Systems and Research Directions," *Human Computer Interaction*, **15** (4), 263-322, 2000. Reprinted in J. Carroll, ed., *Human-Computer Interaction in the New Millennium*, Addison-Wesley Press, 2001.

S.L. Oviatt, "Multimodal System Processing in Mobile Environments," Proceedings of the 13th Annual ACM Symposium on User Interface Software Technology UIST'2000, pp. 21-30, 2000.

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

BRIAN E. ROARK

Assistant Professor
Ph.D., Linguistics
Brown University, 2001
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RESEARCH INTERESTS

Parsing of text and speech; language modeling for automatic speech recognition; supervised and unsupervised learning of language and parsing models; weighted finite-state approaches to language processing,

REPRESENTATIVE PUBLICATIONS

B. Roark, M. Saraclar, and M. Collins. "Corrective language modeling for large vocabulary ASR with the perceptron algorithm," In Proceedings of ICASSP, Montreal, 2004.

B. Roark. "Robust garden path parsing," Natural Language Engineering, 10(1), 1-24, 2004.

M. Riley, B. Roark, and R. Sproat. "Good-Turing estimation from word lattices for unsupervised language model adaptation," In Proceedings of the IEEE ASRU workshop, St. Thomas, 2003.

C. Allauzen, M. Mohri, and B. Roark. "Generalized algorithms for constructing language models," In Proceedings of the 41st Annual Meeting of the ACL, Sapporo, Japan, 2003.

B. Roark and M. Bacchiani. "Supervised and unsupervised PCFG adaptation to novel domains," In Proceedings of HLT-NAACL, Edmonton, Canada, 2003

M. Bacchiani and B. Roark. "Unsupervised language model adaptation," In Proceedings of ICASSP, Hong Kong, 2003.

B. Roark. "Markov parsing: lattice rescoring with a statistical parser," In Proceedings of the 40th Annual Meeting of the ACL, Philadelphia, 2002.

B. Roark. "Probabilistic top-down parsing and language modeling," Computational Linguistics, 27(2), 249-276, 2001.

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RESEARCH INTERESTS

Computer graphics; scientific visualization; applied computational geometry; high performance computing.

REPRESENTATIVE PUBLICATIONS

R. Cook, N. Max, C. Silva, and P. Williams, "Image-Space Visibility Ordering for Cell Projection Volume Rendering of Unstructured Data", *IEEE Transactions on Visualization and Computer Graphics* (to appear).

S. Fleishman, M. Alexa, D. Cohen-Or and C. Silva, "Progressive Point Set Surfaces," *ACM Transactions on Graphics* (to appear).

W. Corrêa, J. Klosowski and C. Silva, "Out-Of-Core Sort-First Parallel Rendering for Cluster-Based Tiled Displays," *Parallel Computing*, **29**, 325-338, 2003.

M. Alexa, J. Behr, D. Cohen-Or, S. Fleishman, C. Silva and D. Levin, "Computing and Rendering Point Set Surfaces," *IEEE Transactions on Visualization and Computer Graphics*, **9**(1), 3-15, 2003.

R. Farias and C. Silva, "Out-Of-Core Rendering of Large Unstructured Grids," *IEEE Computer Graphics and Applications*, **21**(4), 42-50, 2001.

P. Lindstrom and C. Silva, "A Memory Insensitive Technique for Large Model Simplification," IEEE Visualization 2001, pp. 121-126.

J. El-Sana, N. Sokolovsky and C. Silva, "Integrating Occlusion Culling with View-Dependent Rendering," IEEE Visualization 2001, pp. 371-378.

J. Klosowski and C. Silva, "The Prioritized-Layered Projection Algorithm for Visible Set Estimation," *IEEE Transactions on Visualization and Computer Graphics*, **6**(2), 108-123, 2000.

B. Wei, C. Silva, E. Koutsofios, S. Krishnan and S. North. "Visualization Research with Large Displays," *IEEE Computer Graphics and Applications*, **20**(4), 50-54, 2000.

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

G. Wang, M. Pavel, X. Song, "Robust Recognition Based on Combination of Weak Classifiers," International Joint Conference of Neural Networks, July 2003.

X. Song, Y.S. Abu-Mostafa, J. Sill, H.L. Kasdan and M. Pavel, "Image Recognition by Fusion of Contextual Information," *Information Fusion Journal* **3**, 277-287, 2002.

A. Adami, K. Yang, X. Song, M. Pavel and D. Dirschl, "Model-based Image Processing and Analysis for Fracture Classification," The Second Joint Meeting of the IEEE Engineering in Medicine and Biology Society (EMBS) and the Biomedical Engineering Society (BMES), 2002.

X. Song, Y. Abu-Mostafa, J. Sill and H. Kasdan, "Image Recognition in Context: Application to Microscopic Urinalysis," in Advances in Neural Information Processing Systems, S.A. Solla, T.K. Leen, and K.R. Muller (eds.), MIT Press, pp. 963-969, 2000.

X. Song, Y. Abu-Mostafa, J. Sill and H. Kasdan, "Incorporating Contextual Information into White Blood Cell Image Recognition," in Advances in Neural Information Processing Systems, M.I. Jordan, M.J. Kearns, and S.A. Solla (eds.), MIT Press, pp. 950-956, 1998.

Y. Abu-Mostafa, and X. Song, "Bin Model for Neural Networks," in Proceedings of the International Conference on Neural Information Processing, S. Amari, L. Xu, L. Chan, I. King, and K. Leung (eds.), Springer, pp. 169-173, 1996.

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RESEARCH INTERESTS

Learning algorithms and architectures for neural networks and adaptive signal processing; applications to time-series prediction, speech enhancement, adaptive control and telecommunications.

REPRESENTATIVE PUBLICATIONS

E.A. Wan, A.A. Bogdanov, R. Kieburtz, A. Baptista, M. Carlsson, Y. Zhang and M. Zulauf, "Model Predictive Neural Control for Aggressive Helicopter Maneuvers," IEEE volume on Software-Enabled Control, T. Samad and G. Balas (eds.), 2003.

E.A. Wan and R. van der Merwe, "The Unscented Kalman Filter," in *Kalman Filtering and Neural Networks*, S. Haykin (ed.), John Wiley & Sons, 2001.

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E. Wan and F. Beaufays, "Diagrammatic Methods for Deriving and Relating Temporal Neural Networks Algorithms," in Adaptive Processing of Sequences and Data Structures," Lecture Notes in Artificial Intelligence, M. Gori, and C.L. Giles (eds.), Springer Verlag, 1998.

E. Wan, and A. Nelson, "Neural Dual Extended Kalman Filtering: Applications in Speech Enhancement and Monaural Blind Signal Separation," IEEE Workshop on Neural Networks and Signal Processing, 1997.

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E. Wan, "Discrete Time Neural Networks," *Journal of Applied Intelligence*, 3(1), 91-105, 1993.

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The mission of the **DEPARTMENT OF ENVIRONMENTAL AND BIOMOLECULAR SYSTEMS** is to study physical, chemical and biological processes that occur naturally or result from the interaction of humans with the environment, emphasizing approaches that are possible through novel advances in biomolecular, genetic, computational and information sciences and technology.

Three over-arching goals characterize our research and education programs:

- Fundamental understanding of processes at molecular, cellular and particle levels
- Integrative, process-based understanding of ecosystems and other complex environmental and biological systems
- Effective integration of science in society's approaches to ecosystem health, human health, and economic development

Prospective students are asked to carefully examine faculty research interests and departmental research programs to determine whether their specific professional goals can be fulfilled at OGI in the Department of Environmental and Biomolecular Systems. Communication with individual faculty members is encouraged before applying or enrolling.

DEGREES OFFERED

The EBS department offers four degrees:

Master of Science in Environmental Science and Engineering
Environmental Information Technology Track

Doctor of Philosophy in Environmental Science and Engineering
Environmental Information Technology Track

Master of Science in Biochemistry and Molecular Biology

Doctor of Philosophy in Biochemistry and Molecular Biology

M.S. degrees are available in the thesis or non-thesis options. The thesis option generally requires up to eight academic quarters, and the non-thesis option can be completed in four academic quarters.

ENVIRONMENTAL SCIENCE AND ENGINEERING (ESE)

The ESE program balances practical applications with fundamental investigations of the physical, chemical and biological processes underlying environmental phenomena. The M.S. in Environmental Science and Engineering prepares students for careers in environmental management, practice, or research. The curriculum is highly interdisciplinary and is built on a solid foundation of fundamental science and engineering.

- **Environmental Information Technology Track – EIT (M.S. and Ph.D.)**

  The EIT track combines the expertise and coursework found in the EBS Department and in the Department of Computer Science and Electrical Engineering (CSEE). The goal of the EIT track is to combine a deep understanding of environmental processes with mastery of sensing, modeling and information technology. The EIT curriculum includes fundamental courses, science courses, technology courses, electives and capstone integrative courses.

BIOCHEMISTRY AND MOLECULAR BIOLOGY (BMB)

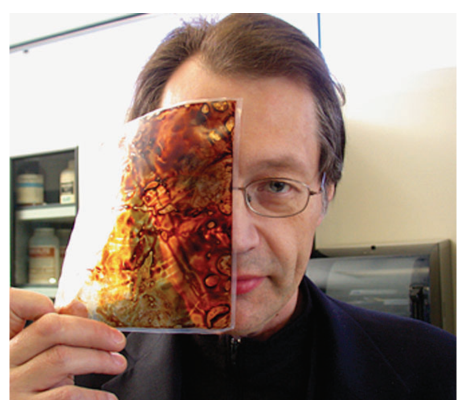
The BMB program offers students immediate participation in research upon entering. This early exposure to research allows each student to become familiar with the variety of activities represented in the EBS Department and aids the student in thesis research selection.

ADMISSION REQUIREMENTS

In addition to the general OGI admissions requirements, the EBS Department requires the following:

ENVIRONMENTAL SCIENCE AND ENGINEERING (M.S. AND PH.D.)

GRE general scores are required. GRE subject scores are not required. TOEFL minimum score is 600 for the paper-based test or 250 for the computer-based test.



Prof. James Pankow's news-making nicotine research is an example of how the EBS Department focuses on the connections between human health and the environment. His "smoke in a bag" demonstration shows how the smoke residue from one pack of cigarettes can affect the lungs.

BIOCHEMISTRY AND MOLECULAR BIOLOGY (M.S.)

GRE scores are not required. TOEFL minimum score is 550 for the paper-based test or 213 for the computer-based test.

BIOCHEMISTRY AND MOLECULAR BIOLOGY (PH.D.)

GRE general scores and GRE subject scores for one of the following tests: (a) biology, (b) chemistry or (c) biochemistry, cell and molecular biology are required. TOEFL minimum score is 550 for the paper-based test or 213 for the computer-based test.

APPLICATION DEADLINES

Applications for fall quarter received by March 1 receive priority review for admission and financial support. M.S. applications are accepted year-round and applicants are encouraged to complete the application process by July 31 for fall quarter admission. Ph.D. applications for admission in quarters other than fall are considered on the basis of available space and financial assistance.

CREDITS FROM OTHER OHSU DEPARTMENTS

Up to eight credits from courses taken in other OHSU departments may be applied to the BMB or ESE programs. The student's program committee (SPC) must first approve the appropriateness of credits from other OHSU departments.

DEPOSIT

Upon acceptance to the EBS Department, students in the M.S. programs are required to pay a nonrefundable deposit of $100, which will be applied to the tuition payment for the first academic quarter.

DEGREE REQUIREMENTS

ENVIRONMENTAL SCIENCE AND ENGINEERING

Students may pursue the Ph.D. program or M.S. program (non-thesis or thesis) in ESE or EIT, an educational track within the ESE program. Students who complete the EIT tracks receive their degree in Environmental Science and Engineering and complete different course distribution requirements.

M.S. IN ENVIRONMENTAL SCIENCE AND ENGINEERING

M.S. NON-THESIS OPTION

Students pursuing the M.S. non-thesis option must complete at least 45 credit hours. These credits include a distribution requirement (listed below) and additional courses selected with the approval of the SPC. A maximum of eight credit hours may be granted for approved participation in non-thesis research and/or a professional internship. Comprehensive examinations are not required.

M.S. THESIS OPTION

Students pursuing the M.S. thesis option must complete at least 45 credits. These credits include a distribution requirement (listed below), additional courses selected with the approval of the SPC, and research credits. M.S. thesis research (EBS 503) is usually no more than nine credits. A written M.S. dissertation with an oral defense is required. Comprehensive examinations are not required.

PH.D. IN ENVIRONMENTAL SCIENCE AND ENGINEERING

Ph.D. students must complete at least 52 credit hours of coursework. These credits include a distribution requirement (listed below) and additional courses selected with the approval of the SPC. Ph.D. candidates must pass a two-part comprehensive examination. 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 required.

ESE DISTRIBUTION REQUIREMENTS

To achieve the necessary breadth in training, M.S. and Ph.D. students take courses that cover a range of scientific disciplines and environmental media. Five courses must be taken to satisfy the following distribution requirements. No course can satisfy more than one requirement.

At least 1 course must be taken from 3 of the following 4 discipline groups:

APPLIED MATHEMATICS

EBS 547/547	Uncertainty Analysis
EBS 550/650	Environmental Systems Analysis
EBS 555/655	Computational Fluid Dynamics
EBS 561/661	Introduction to Spatial Sciences
MATH 511/611	Introduction to Discrete Numerical Methods

CHEMISTRY

EBS 510/610	Aquatic Chemistry
EBS 511/611	Advanced Aquatic Chemistry
EBS 535/635	Distribution and Fate of Organic Pollutants
EBS 537/637	Chemical Degradation and remediation

FLUID DYNAMICS

EBS 560/660	Introduction to Environmental Observation and Forecasting Systems
EBS 574/674	Introduction to Environmental Forecasting Systems
EBS 575/675	Transport Processes
EBS 578/678	Methods in Estuarine Oceanography: Field Observation

BIOLOGY

EBS 590/690	Environmental Microbiology
EBS 593/693	Biodegradation and Bioremediation

At least 1 course must be taken from 2 of the following 3 environmental media groups:

SURFACE WATERS

EBS 560/660	Introduction to Environmental Observation and Forecasting Systems
EBS 575/675	Transport Processes
EBS 578/678	Methods in Estuarine Oceanography: Field Observation
EBS 581/681	Ecosystem Management and Restoration

GROUNDWATER

EBS 570/670	Groundwater and Watershed Hydrology
EBS 571/671	Groundwater Modeling
EBS 572/672	Contaminant Hydrology
EBS 573/673	Modeling in Contaminant Hydrogeology

AIR

EBS538/638	Air Pollution: Origins, Chemistry and Control

Students in the EIT track have customized distribution requirements defined by their SPC.

M.S. and Ph.D. students in the ESE program are required to take the EBS Department Seminar (EBS 507A/607A) each academic quarter, except summer. This course does not count toward degree credit requirements.

BIOCHEMISTRY AND MOLECULAR BIOLOGY

Students may pursue the Ph.D. program or M.S. program (non-thesis or thesis options) in BMB.

M.S. IN BIOCHEMISTRY AND MOLECULAR BIOLOGY

M.S. NON-THESIS OPTION

Students pursuing the M.S. non-thesis option must satisfactorily complete at least 44 credits; 28 in graded courses and 16 derived from an experimental research project (EBS 501), as well as a written report on the research.

The 28 credits in graded courses must include (12 credits):

EBS 512	Biochemistry I: Proteins and Enzymes
EBS 513	Biochemistry II: Introduction to Molecular Biology
EBS 514	Biochemistry III: Metabolism and Bioenergentics

Plus 16 or more credits in
Advanced courses (EBS 525 - 598),
Student Seminars (EBS 507B or 507C),
and Special Topics (EBS 506).

Research for the M.S. non-thesis option is typically a specific contribution to a larger project, providing the student with extensive hands-on experience in biochemical and molecular biological techniques.

M.S. THESIS OPTION

The M.S. thesis option is a research degree that requires satisfactory completion of at least 44 credits; 20 of which are in graded courses (12 credits in EBS 512, 513 and 514, plus 8 or more credits in advanced courses), and a written thesis based on independent research (EBS 503).

M.S. students in the BMB program are encouraged to take the EBS Department Seminar (EBS 507A). This course does not count toward degree credit requirements.

PH.D. IN BIOCHEMISTRY AND MOLECULAR BIOLOGY

Ph.D. students are required to take:

EBS 612	Biochemistry I: Proteins and Enzymes
EBS 613	Biochemistry II: Introduction to Molecular Biology
EBS 614	Biochemistry III: Metabolism and Bioenergentics

Plus three of the following core courses:

EBS 625	Bioenergetics and Membrane Transport
EBS 628	Enzyme Structure, Function and Mechanisms
EBS 640	Instrumental Methods in Biophysics I
EBS 685	Advanced Molecular Biology
EBS 687	Molecular Cell Biology

Courses in other departments and schools within OHSU may be substituted for the core course requirements with permission of the SPC. The SPC may also require additional courses based upon the particular research interests and needs of the student.

Ph.D. Students must register for 12 credits per academic quarter. These credits typically include:
Student Seminars (EBS 607B or 607C),
Department Seminar (EBS 607A; required each quarter, except summer),
and Research (EBS 601 or 603).

The qualifying examination for the Ph.D. is a comprehensive examination in Biochemistry. It must be completed within 2 years of entering the school. An oral defense of the Ph.D. dissertation is required.

RESEARCH PROGRAMS

(alphabetically by faculty name)

CORIE: A Multipurpose Coastal Observatory

Operating since 1996, CORIE is a multipurpose coastal observatory for the Columbia River (http://www.ccalmr.ogi.edu/ CORIE). The motivation of this research program 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 environmental information technology and our coastal observation and prediction research.
Baptista, Chawla, Zhang, Zulauf

Ocean Survival of Salmonids Relative to Migrational Timing, Fish Health and Oceanographic Conditions.

Interannual variation in ocean recruitment of salmon is high and thought to be associated with variation in nearshore ocean conditions. The nearshore ocean environment, particularly that associated with the Columbia River plume, is a critical habitat to outmigrating juvenile salmon. Several investigators have suggested that survival during the first year of ocean life is a key to establishing year-class strength. In the case of salmonids originating in the Columbia River Basin, survival success hinges on the complex interaction of smolt quality and the abiotic and biotic ocean conditions at the time of entry and during their first year of ocean existence. This research hypothesizes that variation in the physical and biological conditions of the nearshore environment, particularly that associated with the Columbia River plume, affects overall survival of Columbia River stocks. Further, the research hypothesizes that primary factors driving the variation in the nearshore environment include (a) food availability and habits, (b) time of entry, smolt quality and growth and bioenergetic status at the time of entry and during the first growing season in the ocean and (c) predation (a companion study on predation on juvenile salmon is ongoing). This project, will characterize, over a 10-year period, the physical and biological features of the nearshore ocean environment with real-time and modeling projections of the Columbia River plume as it interacts with the coastal circulation regime, and will relate these features, both spatially and temporally, to variation in salmon health, condition and survival.
Baptista, Jay, and multi-institutional collaborators (PI: E. Casillas, NOAA Fisheries)

Estuarine Habitat and Juvenile Salmon — Current and Historic Linkages in the Lower Columbia River and Estuary

Estuaries are considered important to rearing of juvenile salmon and represent an integral component of the continuum of habitats that salmon occupy for significant periods of time. There is, however, a general lack of science-based information concerning attributes of these tidal freshwater and oligohaline transition zones needed to support juvenile salmon, particularly in the Columbia River estuary. Further, recent evidence supports the concern that flow in the Columbia River significantly affects the availability of estuarine habitats, that flow is much reduced compared to historic levels, and that seasonal flow patterns are much different now than a century ago. The long history of wetland loss in the Columbia River estuary coupled with change in flow patterns suggests that restoration of the habitats may benefit recovery of depressed salmon stocks. The need to develop effective restoration strategies led us to propose empirically identifying the benefit of these habitats to juvenile salmon by evaluating habitat-salmon linkages in the lower Columbia River and estuary. We are conducting a monitoring approach to identify associations between salmon and habitat in the lower Columbia River and estuary.
Baptista, Jay, and multi-institutional collaborators (PI: D. Bottom, NOAA Fisheries)

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 neurotransmitter biosynthesis and metabolism (including important neuroactive amines such as nor-adrenaline and amphetamine); enzymes protecting against oxidative cellular damage

caused by reactive 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. In our laboratory we overexpress wild-type and mutant proteins in mammalian cell culture using large-scale hollow fiber bioreactors, purified them to homogeneity and study them using a variety of physical and kinetic methods which include high pressure liquid chromatography (HPLC), mass spectrometry (MS), electron paramagnetic resonance (EPR), Fourier transform-infrared (FT-IR) and X-ray absorption spectroscopy (XAS). The XAS technique is performed at the Stanford Synchrotron Radiation Laboratory http://www-ssrl.slac.stanford.edu/, which is a national user facility. Funded by grant R01 NS27583 (Chemistry and Spectroscopy of Copper Monooxygenases) from the National Institutes of Neurological Disorders and Stroke http://crisp.cit.nih.gov/
Blackburn

Cellular Transport and Regulation of Metal Ions

Metal ions such as iron and copper play an essential role in many cellular processes including energy production, biosynthesis and antioxidation. The key to their usefulness as enzyme cofactors lies in their ability to catalyze redox reactions, but this very chemistry introduces the need to tightly regulate the speciation, concentration and transport of cellular metal ions, since the free ions are themselves cytotoxic. Our lab is involved in deducing the molecular mechanism of metal ion transport. Copper enters the cell through the transporter CTR1 and is then partitioned between a number of small molecule metallochaperone molecules (CCS, COX17, SCO1, HAH1) which selectively metallate target copper enzymes (e.g., SOD1, cytochrome c oxidase), or P-type ATPases (MNK, WND) which provide further transport machinery for metallation of secreted proteins. Through application of advanced spectroscopic techniques such as X-ray absorption and mass spectrometry we are studying the mode of copper binding and transport within a number of these chaperone-target systems. Part of this research involves developing semisynthetic methods for incorporation of Se as selenocysteine into the metallochaperones which will provide us with a unique probe of metal coordination via Se- and Cu-K absorption edge spectroscopy. These studies will lead to a better understanding of the molecular mechanisms of metal-ion homeostasis and will aid in combating diseases (Menkes, Wilson, ALS) believed to be associated with aberrant metal ion regulation. Funded by a Program Project grant from the National Institute of General Medical Studies (Mechanisms of Metal Ion Regulation in Human Cells), P01GM067166% www.crisp.cit.nih.gov/)
Blackburn

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 coast.
C*hawla, Baptista, external collaborators*

Collaborative Research: Productivity, Biogeochemical Transformations and Cross-Margin Transport in an Eastern Boundary Buoyant Plume Region (A.K.A. RISE-River Influences on Shelf Ecosystems)

River plumes significantly alter nutrient supply, plankton growth rates and standing stocks as well as enhance material export from productive coastal areas across the continental margin. Because the typical (upwelling-favorable) wind stress and ambient currents act to move plumes away from the coast during high production periods, cross margin export is extremely effective on eastern boundaries. In this proposal we focus on a highly productive Eastern Boundary river plume, the Columbia — a plume sufficiently large to be of regional importance, yet small enough to allow determination of dominant processes affecting river plumes, and to facilitate rate comparisons with regions outside the plume. Available data suggest that the Columbia affects regional productivity from phytoplankton up the food chain to juvenile fish (e.g., salmon). Prior measurements provide a framework for a new collaborative study that uses the Columbia to examine plume effects on a productive eastern margin. This study will integrate results from a nearby wind-driven CoOP study as well as salmon-related regional studies to provide definitive new information on alteration of rates of biogeochemical processes by the unique stratification, turbidity, mixing environment and nutrients of a river plume. Because the Columbia River provides no significant terrigenous nitrate to the plume in the growing season, our study allows plume-endemic processes to be isolated and hence process results can be directly applied to other plumes. Results can also be contrasted with contrasted with more eutrophic, buoyancy influenced coasts.

Our study is designed to address the following three hypotheses:

- During upwelling the growth rate of phytoplankton within the plume exceeds that in nearby areas outside the plume being fueled by the same upwelling macronutrients.
- The plume enhances cross-margin transport of plankton and nutrients.
- Plume-specific nutrients (iron and silicate) alter and enhance productivity on nearby shelves.

Jay, Baptista, and multi-institutional collaborators (PI: B. Hickey, University of Washington)

Remediation of Explosives in Groundwater Using Passive In Situ Permeable Reactive Barriers

Groundwater contamination associated with the use of explosives (e.g., TNT) is widespread at many Department of Defense sites. Research in our laboratories has shown that explosives can be rapidly destroyed in situ using zero-valent iron (ZVI). When ZVI is placed in the subsurface as part of a permeable reactive barrier, it can prevent the migration of explosives in groundwater for decades in a manner that is completely passive.
Johnson and Tratnyek

Simulation of Subsurface Processes Using Very Large Scale Experimental Aquifers

Many important chemical, physical and biological processes are difficult to study in the laboratory because of problems of scaling. Many of these processes are also difficult to characterize in the field, because of the complex and uncontrolled nature of environmental systems. For these reasons, OGI has established the Large Experimental Aquifer Program (OGI/LEAP). At present, the facility consists of five large aquifers used to examine the movements of organic solvents and petroleum compounds in the unsaturated and saturated porous media. Future LEAP aquifers will examine inorganic geochemistry and the interactions between chemical, biological and physical processes in contaminated aquifers.
Johnson and other faculty

Gas-Phase Transport in Unsaturated Porous Media

Gas-phase transport is important in controlling many subsurface processes, including respiration, pesticide behavior and contaminant volatilization and movement. Laboratory experiments have been conducted to determine diffusion rates of a variety of organic compounds in porous media and the kinetics of adsorption and desorption for a variety of soil types and a range of water contents.
Johnson

Multiphase Monitoring of Gasoline Movement Using a Very Large Physical Model (OGI/LEAP)

Leaks from underground storage tanks (UST) represent a major ongoing source of groundwater contamination. The rapid detection of leaks is, therefore, a major goal of UST legislation. The OGI/LEAP facility is used to study the movement of gasoline components in the vapor, aqueous and pure-product phases. This work will help establish which of a variety of leak-detection technologies is best suited to detect leaks under a range of environmental conditions.
Johnson

Statistical Pattern Recognition in Environmental Observation and Forecasting Systems

Environmental observation and forecasting systems (EOFS) are emerging new technologies with unparalleled potential to impact sustainable development. EOFS are expected to foster and support new paradigms for generation, transfer and social application of knowledge in domains that range from the global earth to its regional and local subsystems. At the core of EOFS is the timely and customized acquisition, generation, processing and delivery of reliable, relevant information to many and very diverse audiences. Multiple challenges need to be met to implement this concept. A critical challenge is the development of automated procedures to verify the quality of the huge amounts of observational and simulation data that are generated by EOFS both in real time and off-line. Processing based strategies for quality control of scientific data, while effective for moderate-sized archival data, are too labor-intensive to map well into EOFS-scale data sets. Strategies based on pattern recognition and machine learning hold significant promise as an alternative or complement. Under the proposed project, we are developing approaches based on statistical pattern recognition and signal processing, on-line adaptive systems, data mining and advanced search to address critical quality control issues including: 1) Detecting sensor corruption in non-stationary, spatial-temporal systems, 2) Estimating true signals from corrupted sensor data, and 3) Detecting and characterizing regimes where model anomalies are likely. These quality control techniques will be developed and exercised on CORIE, a pilot coastal observatory for the Columbia River estuary and adjacent coastal waters (www.ccalmr.ogi.edu/CORIE/).
Leen and Baptista

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 rR) and EPR spectroscopy to characterize metal-ion active sites. Our laboratory has a sensitive, state-of-the-art Raman instrument: a fast spectrograph with a liquid N_2-cooled CCD detector. We also use a combined FT-IR/FT-Raman instrument for protein and model compound studies. Our research focuses on heme (iron porphyrin), nonheme-iron and copper enzymes and the roles of their metal ions in enzymatic catalysis. Of particular interest is the biochemistry of O_2. Metalloproteins are involved in O_2 binding (e.g., hemoglobin or hemocyanin) and in oxidative chemistry whereby O_2 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 O_2-binding affinity of its heme substrate in the cellular degradation of heme to open-chain biliverdin. These studies are carried out with Paul R. Ortiz de Montellano's group at U.C. San Francisco. The resting heme-heme oxygenase enzyme substrate complex is much like myoglobin: The heme is linked to the enzyme by an ironhistidine bond and the iron exists mainly in a six-coordinate, high-spin state with an additional water ligand. The Fe-NHis 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 Moënne-Loccoz

Oxygen Activation by Iron Proteins

Several diiron enzymes react with molecular oxygen to form powerful oxidizing agents important in biology. Examples include (i) ribonucleotide reductase protein R2, which oxidizes tyrosine 122 to its catalytically important neutral radical form; (ii) methane monooxygenase, whose hydroxylase component oxidizes hydrocarbons to alcohols; (iii) plant desaturases, which oxidize fatty acids to olefins, e.g., stearoyl to oleoyl; and (iv) ferroxidase reactions, in which Fe^{2+} is oxidized to Fe^{3+}. A common feature of these enzymes appears to be the formation of an initial peroxo intermediate upon exposure of the reduced enzyme to O_2. In the respiratory protein, hemerythrin, O_2 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 Moënne-Loccoz

Anaerobiosis of Bacillus subtilis

A gram-positive soil bacterium, *B. subtilis*, is highly amenable to genetic analysis and has been used as a model system to study fundamental microbiological research. In addition, *B. subtilis* is medically and industrially important since it produces a variety of antibiotics and extracellular enzymes. Although the organism has been widely used, it has been mistakenly referred to as a strict aerobe until recently. Our studies, together with others, have shown that *B. subtilis* is able to grow under anaerobic conditions by utilizing nitrate or nitrite as an alternative electron acceptor. In the absence of terminal electron acceptors, it undergoes fermentative growth. Our research aims include elucidation of the regulatory mechanisms through which the cells adapt to oxygen limitation. Molecular genetic and biochemical approaches are applied.
Nakano

ResD-ResE Two-Component Signal Transduction System

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

Flavohemoglobin (Hmp)

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

Distribution of Organic Compounds Between the Gas and Urban Aerosol Particulate Phases

The behavior of organic compounds in the atmosphere depends in large part on the extent to which they partition from the gas phase to aerosol particulate matter. Processes that are affected by this partitioning process include precipitation scavenging of gases and particles as well as dry deposition of gases and particles. Fundamental gas/solid sorption theory is being used to investigate important aspects of atmosphericgas/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

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 www.cgr.ese.ogi.edu/mtbe/.
Pankow, Tratnyek, Johnson

Mechanisms of Mammalian Chemical Communication and Vomeronasal Olfaction

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

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

Gases such as CCl_3F (F-11), $CC_{12}F2$ (F-12) $CHClF_2$ (F-22), CF_4 (F-14), $C_2Cl_3F_3$ (F-113), CH_3CCl_3, CH_3Cl and N_2O are being added to the atmosphere by various industrial processes and the public's use of high-technology products. Such chlorine-containing compounds are believed to threaten the Earth's natural ozone layer high in the atmosphere (stratosphere). This research will systematically obtain a long-time series of concentration measurements by a flask sampling system. The results are then interpreted with global mass balance models and sophisticated statistical techniques to quantify the sources and lifetimes of these gases in the environment. Such data are now obtained from sites all over the world extending from the Arctic Circle to the South Pole.
R. Rasmussen

Studies of Past Atmospheres

Atmospheric gases such as N_2O, CO_2, CO, CH_3Cl, carbonyl sulfide (OCS) and CH_4 are primarily produced by natural processes, but over the past century human activities have been adding growing amounts to their natural abundance. This process can upset the cycles of these gases and lead to possibly adverse environmental effects such as the warming of the Earth's surface (N_2O, CO_2, CH_4). When both natural and anthropogenic processes contribute to the current atmospheric abundance of a trace gas, it is of interest to determine the amount which existed before human activities had any effect. Perhaps the only realistic method to determine the composition of the ancient atmosphere is to analyze the air in bubbles buried deep in polar ice. The depth of the ice indicates the age of the air in the bubbles. By going far enough back in time, the relationship between past atmospheric composition and climate might be found. The novel and simple method of studying the old atmosphere of the earth is beset by many problems that complicate the relationship between the gases in the bubbles and the composition of the old atmosphere. Theoretical and experimental research for resolving these problems as well as the measurement of trace gases are the major goals of this project.
R. Rasmussen

Ocean-Air Exchange of Gases

Some atmospheric gases are greatly influenced by the Earth's oceans. For instance, a large amount of the atmospheric methyl chloride (CH_3Cl) and methyl iodide (CH_3I) are produced in the oceans, possibly by biogenic processes. It has also been shown recently that carbonyl sulfide (OCS) is produced in the oceans and subsequently emitted to the atmosphere. On the other hand, manmade gases such as CCl_3F (F-11) can dissolve in the oceans and thus be removed from the atmosphere. This research project is devoted to determining the solubility of such gases in water and to modeling the flux of gases into or out of the oceans. The results obtained are essential ingredients in determining the sources and fates of atmospheric trace gases and in estimating the effects of human activities on the future warming of the Earth or depletion of the ozone layer.
R. Rasmussen

Studies of Atmospheric Methane

Considerable evidence has been accumulated showing that methane (CH_4) is increasing in the atmosphere, most likely as an indirect result of growing human population. In the future, such an increase of CH_4 can lead to a global warming by enhancing the Earth's natural greenhouse effect and create more ozone and carbon monoxide in the atmosphere. However, it might also prevent some of the destruction of the stratospheric ozone layer by the manmade fluorocarbons 11 and 12. In this project, experimental and theoretical research is focused on statistical trend analyses for the global increase of CH_4, its seasonal variation, sources and sinks, models of its effect on the CO, O_3, and OH cycles and its role in the future of the environment.
R. Rasmussen

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 C_2-C_{12} nonmethane hydrocarbons at tens of parts-per-trillion levels. Techniques for collecting and storing air and water samples also are being developed.
R. Rasmussen

Biogenic Sources of Atmospheric Gases

Living organisms produce and consume a variety of gases and may therefore form an integral part of the global cycle of a trace gas. Selected plants and animals, living in the sea or on land, are being studied to determine their role in the cycles of CH_4, N_2O, CH_3CI, CH_3I, isoprene and other hydrocarbons.
R. Rasmussen

The Global Cycle of Carbon Monoxide (CO)

Based on 15 years of global sampling and the application of modern trend analysis techniques, our data have shown that CO increased in the atmosphere until around 1987 and has since declined. These changes in CO have major implications for atmospheric chemistry and the role of biomass burning in causing global increases of trace gases. Present research includes modeling of the global budgets, seasonal cycles and potential environmental effects.
R. Rasmussen

Methane Emissions from Rice Fields

Methane concentrations have nearly tripled compared to the natural atmosphere of 300 years ago (based on ice core analyses). The increase of rice agriculture to sustain an increasing population may be a major contributor to the increase of methane during the last century. This research program is designed to determine the role of rice agriculture in the global methane cycle. Field experiments are being conducted in China, Indonesia and the United States. 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.
R. Rasmussen

Translational Control in Fungal Amino Acid Biosynthesis

A greater understanding of many human health issues relies on increased knowledge of how cells express genetic information. Gene expression can be controlled by regulating the synthesis and stability of functional RNA and protein. The goal of our research is to obtain a greater understanding of how these mechanisms work using the *Neurospora crassa arg-2* and *Saccharomyces cerevisiae CPA1* genes as models. These homologous genes encode the first enzyme in arginine biosynthesis and they are negatively regulated at 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

Genome Organization in Fungi

The *N. crassa* genome and the genomes of other filamentous fungi are being sequenced, enabling comparisons of how these fungi differ from each other and from the yeasts. We are focusing on the characterization of the sub-telomeric regions of *N. crassa*, since genes in sub-telomeric regions are implicated in environmental sensing and in interactions with host species.
Sachs

Human-Health Implications of Chemical Contaminants in Water Resources

A collaborative effort is underway with the U.S. Geological Survey (USGS) to communicate the significance of the water-quality findings of its National Water-Quality Assessment (NAWQA) Program in a human-health context. Historically, the USGS has assessed water-quality conditions by comparing water concentration data against established drinking-water standards and guidelines. However, because drinking-water standards and guidelines do not exist for many of the contaminants analyzed by the NAWQA Program and other USGS studies, this approach has proven to be insufficient for placing USGS data in a human-health context.
Toccalino

Development of Health-Based Screening Level (HBSL) Values

To help meet the U.S. Geological Survey's (USGS) need to communicate its water-quality findings in a human-health context, Health-Based Screening Level (HBSL) values are being determined for unregulated compounds (that is, those for which Federal or State drinking-water standards have not been established), using a consensus approach that was developed collaboratively by the USGS, U.S. Environmental Protection Agency (USEPA), New Jersey Department of Environmental Protection, and OHSU. An interagency pilot effort is underway in New Jersey to develop and test the HBSL approach to improve the communication of water-quality findings.
Toccalino

Prioritization of Nationally Important Compounds for Future Monitoring

The chemical industry produces thousands of organic compounds that are in widespread use across the Nation. It is critically important that organic compounds not presently monitored in the U.S. Geological Survey's National Water-Quality Assessment Program be systematically evaluated so that future monitoring programs can consider the compounds that are of greatest concern because of the magnitude of their use/releases, environmental behaviors, and potential toxicities. The primary objective of this work is to develop a science-based strategy to anticipate those organic compounds that are likely to emerge as major, national water-quality issues.
Toccalino and Pankow

Remediation of Halocarbon-Contaminated Groundwater

There is enormous demand for improved ways to clean up aquifers that have been contaminated with halogenated hydrocarbon solvents like carbon tetrachloride and TCE. Recent field-scale tests have shown that technologies based on dechlorination with granular iron may have substantial value. The goal of our research in this area is to provide a sound scientific basis for designing and operating such technologies by determining the mechanisms of dechlorination by iron and the geochemical and microbiological processes that affect the performance of this technique in the field. For more information on this work, see www.cgr.ese.ogi.edu/iron.
Tratnyek

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 www.cgr.ese.ogi.edu/iron/.
Tratnyek and Johnson

Reduction Reactions of Organic Pollutants in Anaerobic Environments

Some organic pollutants undergo rapid reduction in anaerobic sediments, soils and groundwaters. Despite the potential importance of this process, little is known about the natural reducing agents that are responsible for these reactions. In this project, assays are being developed to identify and quantify environmental reducing agents in situ. These assays will be used in kinetic studies of important pollutant reduction reactions.
Tratnyek

Oxidation Reactions of Organic Pollutants

Some organic pollutants undergo rapid oxidation in natural waters, when catalyzed by sunlight, and in technological systems, when chemical oxidants are added to effect remediation. These reactions are usually mediated by "activated oxygen species" such as hydroxyl radical. We are studying the kinetics, mechanisms and products of these reactions with a wide variety of contaminants. The aim of this work is to 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*

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 cysteinyl side chain (a 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.
Whittaker

Manganese Metalloenzymes

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

Electronic Spectroscopy of Biological Metal Complexes

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

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

The rate-limiting step in ß-oxidation is the conversion of long-chain acyl-CoA to acylcarnitine, a reaction catalyzed by the outer mitochondrial membrane enzyme carnitine palmitoyltransferase I (CPTI) and inhibited by malonyl-CoA. The acylcarnitine is then translocated across the inner mitochondrial membrane by the carnitine/acylcarnitine translocase and converted back to acyl-CoA by CPTII. This reaction in intact mitochondria is inhibited by malonyl-CoA, the first intermediate in fatty acid synthesis, suggesting coordinated regulation of fatty acid oxidation and synthesis.

Structure-Function Studies with the Mitochondrial CPT System. We have separately expressed the genes for human heart muscle M-CPTI and rat liver LCPTI and CPTII in Pichia pastoris, a yeast with no endogenous CPT activity. We have constructed a series of deletion and substitution mutations to the N-terminus of L-CPTI, and demonstrated that Glu-3 and His-5 are necessary for malonyl-CoA inhibition and binding of L-CPTI, but not catalytic activity. Similar mutagenesis studies with the human heart M-CPTI revealed that Glu-3, Val-19, Leu-23, and Ser-24 are necessary for malonyl CoA inhibition and binding, in accordance with the differences in malonyl-CoA sensitivity observed with the two isoforms of the enzyme. We have also expressed pig L-CPTI in yeast and shown that Pig L-CPTI is much more sensitive to malonyl CoA inhibition than rat L-CPTI, a kinetic characteristic similar to that of human or rat M-CPTI enzymes. Hence, pig L-CPTI behaves like a natural chimera of the L- and M-CPTI isotypes, which makes it a useful model to study the structure-function relationships of CPTI.

Our site-directed mutagenesis studies of conserved basic and aromatic residues in the C-terminal region of L-CPTI suggest that conserved arginine and tryptophan residues contribute to the stabilization of the enzyme substrate complex by charge neutralization and hydrophobic interactions. The predicted secondary structure of the 100-amino acid region of L-CPTI, spanning arginines 388 and tryptophans 452, consists of four ±-helices similar to that of the acyl CoA binding protein with a known 3D structure, and may constitute the putative palmitoyl CoA-binding site in L-CPTI. Furthermore, our mutagenesis studies of the conserved acidic and basic residues in the C-terminal region of L-CPTI showed that residues E590, E603, R601 and R606 are important for both substrate and inhibitor binding. We predict that the region of L-CPTI spanning the conserved residues R601 and R606 may be the putative low-affinity acyl-CoA/malonyl-CoA binding site. With M-CPTI, deletion of L764 or substitution with arginine was found to inactivate the enzyme, suggesting that L764 may be important for native folding and optimal activity of M-CPTI. For CPTII, our site-direscted mutagenesis studies demonstrated that Glu487 is essential for catalysis. We will purify milligram quantities of the His-tagged yeast-expressed M-CPTI, L-CPTI, CPTII and engineered fragments for structural studies.
Woldegiorgis

Transgenic and Knockout Mice Models for CPTI

We will determine the molecular basis for tissue-specific and hormonal/dietary regulation of human heart M-CPTI gene expression in a transgenic mouse model in vivo carrying a 1.1 kb of the 5Ñ flanking region of the human heart M-CPTI gene promoter fused to a CAT reporter gene. We will employ homologous recombination in embryonic stem cells to produce mice lacking the M-CPTI gene (knockout mice) using our cloned mouse genomic M-CPTI DNA. We will also generate a transgenic mouse model overexpressing human heart M-CPTI in vivo carrying the murine ±-myosin heavy-chain gene promoter fused to human heart muscle M-CPTI cDNA (reporter gene). Transgenic and knockout mice models would provide valuable information about the role of M-CPTI in fatty acid metabolism in the normal and diseased heart. Because the enzyme is essential for heart function, loss of M-CPTI may be incompatible with life.
Woldegiorgis

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 coregulated 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

RESEARCH CENTERS

CENTER FOR COASTAL AND LAND-MARGIN RESEARCH (CCALMR)

www.ccalmr.ogi.edu

The Center for Coastal and Land-Margin Research (CCALMR) is an interdisciplinary research center affiliated with the Department of Environmental and Biomolecular Systems. 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:

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CENTER FACULTY AND RESEARCH SCIENTISTS

António M. Baptista, Professor and Director

Arun Chawla, Associate Research Scientist

Juliana Freire, Assistant Professor (Computer Science and Electrical Engineering)

Todd Leen, Professor (Computer Science and Electrical Engineering)

David Maier, Professor (Computer Science, Portland State University)

Claudio Silva, Associate Professor (Computer Science and Electrical Engineering)

Yinglong (Joseph) Zhang, Associate Research Scientist

Mike Zulauf, Assistant Research Scientist

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 EBS.

REAL-TIME DATA ACQUISITION NETWORK

The coastal observatory CORIE includes a real-time data acquisition network with close to 20 multisensor oceanographic stations in the Columbia River estuary and plume. 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 a training and research vessel, the 50-foot M/V Forerunner. CCALMR operates a 21-foot research vessel, the R/V CORIE.

OCEANOGRAPHIC EQUIPMENT

- 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 (Downing Associates)
- Wind gauges (Coastal Leasing)
- High-density thermistor chains (CCALMR)
- Differential GPS (Trimble)
- Spread spectrum radio data modems (FreeWave)

COMPUTATIONAL ENGINES AND ON-LINE STORAGE

- 16 parallel Intel dual CPU compute nodes (2.4 GHz, 4 Gb)
- 6 single CPU Alpha compute nodes
- 10 TB primary storage

CENTER FOR GROUNDWATER RESEARCH

www.cgr.ese.ogi.edu.

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 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; 3) improved groundwater remediation methods and 4) physical and numerical models of groundwater- and watershed-scale processes.

The Center operates the Large Experimental Aquifer Program (LEAP), which contains the experimental facilities outlined below. The LEAP facility provides staff with the capability to conduct both bench-scale experiments and essentially full-scale pilot demonstrations. Students involved in LEAP receive a rare combination of experiences, including full-scale remediation engineering and process-level understanding of contaminant hydrology and chemistry.

For additional information about CGR, contact:

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CENTER FACULTY

Richard Johnson, Associate Professor and Director
James F. Pankow, Professor
Patricia L. Toccalino, Assistant Professor
Paul Tratnyek, Associate Professor

LEAP EQUIPMENT

- Five tanks: one 10 m x 10 m x 3 m; two 10 m x 10 m x 5 m; one 10 m x 2.5 m x 0.5 m; and one 8 m x 2.5 m x 0.5 m
- In-situ instrumentation, including automated temperature, pressure and water-level monitoring; multilevel samplers; down-hole video camera; and automated vapor and product-sensing equipment
- Remediation equipment, including soil vapor extraction and air sparging capabilities
- Automated on-site analytical equipment, including capillary GC-MS

RESEARCH FACILITIES

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

- Gas chromatograph/mass spectrometer with computer data system
- High-resolution mass spectrometer
- UV/Visible spectrometer
- Capillary column gas chromatographs with flame ionization detectors
- Fourier transfor-infrared spectrometers
- Fourier transfor-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/Visible spectrophotometer
- Laser Raman spectrophotometer
- Raman spectrograph with CCD detector
- Ar, Kr, HeCd, HeNe 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

See additional research equipment listings in the Research Centers section.

FACULTY

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Director, Center for Coastal and Land-Margin Research
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RESEARCH INTERESTS

Integrated understanding and prediction of hydrodynamic and environmental processes in estuaries and coasts. Development of associated concepts and technologies: coastal observatories, environmental information technology, numerical methods and modeling systems, error and uncertainty analysis, and physically based ecological indicators.

REPRESENTATIVE PUBLICATIONS

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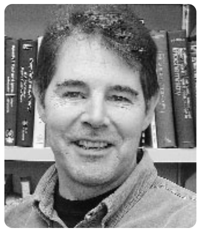
E.P. Myers and A.M. Baptista, "Analysis of Factors Influencing Simulations of the 1993 Hokkaido Nansei-Oki and 1964 Alaska Tsunamis," *Natural Hazards*, **23** (1), 1-28, 2001.

D.C. Steere, A.M. Baptista, D. McNamee, C. Pu and J. Walpole, "Research Challenges in Environmental Observation and Forecasting Systems," in *Proceedings of the 6th Annual International Conference on Mobile Computing and Networking (Mobicom 2000)*, Boston, 292-299, 2000.

A. Oliveira, A.B. Fortunato and A.M. Baptista "Mass Balance in Eulerian-Lagrangian Transport Simulations in Estuaries," *ASCE Journal of Hydraulic Engineering*, **126** (8), 605-614, 2000.



NINIAN J. BLACKBURN

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

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

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

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

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

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

WILLIAM H. GLAZE

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Ph.D., Physical Chemistry
University of Wisconsin, Madison, 1961
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RESEARCH INTERESTS

Integration of ecological sciences with human health sciences including the integration of functional genomics. Sustainable technologies applied to urban design and to the energy and transportation sectors.

REPRESENTATIVE PUBLICATIONS

W.H. Glaze, D.S. Maddox and P. Bose, "Degradation of RDX by Various Advanced Oxidation Processes: I. Reaction Rates," *Water Research*, 997-1004, 1998.

P. Bose, W.H. Glaze and D.S. Maddox, "Degredation of RDX by Various Advanced Oxidation Processes: II. Organic By-Products," *Water Research*, 1005-1018, 1998.

David R. Pesiri, David K. Morita, William Tumas and William Glaze, "Selective Epoxidation in Dense-Phase Carbon Dioxide," *Chem. Commun.* (Cambridge), Issue 9, 1015-1016, 1998.

John L. Ferry and William H. Glaze, "Photocatalytic Reduction of Nitro Organics over Illuminated Titanium Dioxide: Electron Transfer Between Excited-State TiO2 and Nitroaromatics," *J. Phys. Chem. B* **102**(12), 2239-2244, 1998.

John L. Ferry and William H. Glaze, "Photocatalytic Reduction of Nitro Organics over Illuminated Titanium Dioxide: Role of the TiO2 Surface," Langmuir, **14**(13), 3551-3555, 1998.

H.S. Weinberg and W.H. Glaze, "A Unified Approach to the Analysis of Polar Organic By-Products of Oxidation in Aqueous Matrices," *Water Research*, 1555-1572, 1997.

DAVID A. JAY

Associate Professor
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University of Washington, 1987
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RESEARCH INTERESTS

River basin, estuarine and continental shelf processes, turbulent mixing, tides and tidal analysis. A unifying theme is the influence of hydrodynamic processes on ecosystems.

REPRESENTATIVE PUBLICATIONS

Naik, P.K., and D.A. Jay, 2004, "Virgin flow estimation of the Columbia River" (1879-1928), accepted, Hydrologic Processes.

Jay, D. A., and T. Kukulka, 2003, "Revising the paradigm of tidal analysis — the uses of non-stationary data," Ocean Dynamics 53: 110-123. Kukulka, T., and D. A. Jay, 2003, Impacts of Columbia River discharge on salmonid habitat I. a non-stationary fluvial tide model, *J. Geophys. Res.* 108, 3293 doi 10.1029/2002JC001382.

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Kay, D. J. and D. A. Jay, 2003, "Interfacial Mixing in a Highly Stratified Estuary. 2. A 'Method of Constrained Differences' Approach for the Determination of the Momentum and Mass Balances and the Energy of Mixing," *J. Geophys. Res* 108, 3072 doi 10.1029/2002 JC000252.

RICHARD L. JOHNSON

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RESEARCH INTERESTS

Physical and chemical behavior of organic contaminants in the air, soil and water; environmental analytical organic chemistry; transport and fate of contaminants at the watershed scale; modeling of contaminant transport.

REPRESENTATIVE PUBLICATIONS

Amerson, I.L. and R.L. Johnson," A Natural Gradient Tracer Test to Evaluate Natural Attenuation of MTBE Under Anaerobic Conditions," *Groundwater Monitoring and Remediation*, **23**(1), 54-61, 2003.

R.L. Johnson, P.C. Johnson, T.L. Johnson and A. Leeson, "Helium Tracer Tests for Assessing Contaminant Vapor Recovery and Air Distribution During In-Situ Air Sparging," *Bioremediation Journal*, **5**(4), 321-336, 2001.

R.L. Johnson, P.C. Johnson, T.L. Johnson, Neil R. Thomson and A. Leeson, "Diagnosis of In-Situ Air Sparging Performance Using Transient Groundwater Pressure Changes During Startup and Shutdown," *Bioremediation Journal*, **5**(4), 299-320, 2001.

R.L. Johnson, P.C. Johnson, I.L. Amerson, T.L. Johnson, C.L. Bruce, A. Leeson and C.M. Vogel, "Diagnostic Tools for Integrated In-Situ Air Sparging Pilot Tests," *Bioremediation Journal*, **5**(4), 283-298, 2001.

N.R. Thomson and R.L. Johnson, "Air Distribution During In-Situ Air Sparging: An Overview of Mathematical Modeling," *J. Hazardous Materials* **72** (2-3), 265-282, 2000.

R.L. Johnson, J.F. Pankow, D. Bender, C. Price and J. Zogorski, "To What Extent Will Past MTBE Releases Contaminate Community Water Supply Wells?" *Environ. Science and Technol.*, **34**, 2A-7A, 2000.

L. Slater, A.M. Binley, W. Daily and R.L. Johnson, "Cross-hole Electrical Imaging of a Controlled Saline Tracer Injection," *J. Applied Geophysics*, **44**, 85-102, 2000.

PIERRE MOËNNE-LOCCOZ

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

E. Kim, M. E. Helton, I. M. Wasser, K. D. Karlin, S. Lu, H.-w. Huang, P. Moënne-Loccoz, C. D. Incarvito, A. L. Rheingold, S. Kaderli, M. Honecker, A. D. Zuberb¸hler Superoxo, (-peroxo and (-oxo complexes derived from heme/O2 and heme-copper/O2 reactivity studies: Copper-ligand influences in synthetic model reactivity studies of the cytochrome c oxidase binuclear active site. Proc. *Natl. Acad. Sci. U.S.A.*, **100,** 3623-3628, 2003.

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I. M. Wasser, S. de Vries, P. Moënne-Loccoz, I. Schrˆder, K. D. Karlin Nitric oxide in biological denitrification: Fe/Cu metalloenzyme and metal complex NOx redox chemistry. *Chem. Rev.*, **102,** 1201-1234, 2002.

J. Baldwin, W.C. Voegtli, N. Khidekel, P. Moënne-Loccoz, C. Krebs, A.S. Pereira, B.A. Ley, B.H. Huynh, T.M. Loehr, P. Riggs-Gelasco, A.C. Rosenzweig, J. M. Bollinger, Jr. "Rational reprogramming of the R2 subunit of Escherichia coli ribonucleotide reductase into a self-hydroxylating monooxygenase." *J. Am. Chem. Soc.*, **123**, 7017-7030, 2001.

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

MICHIKO M. NAKANO

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

H. Geng, S. Nakano, and M. M. Nakano, "Transcriptional Activation by *Bacillus subtilis* ResD: Tandem Binding to Target Elements and Phosphorylation-dependent and -independent Transcriptional Activation." *J. Bacteriol.*, **186**, 2028-2037, 2004.

A. Baruah, B. Lindsey, Y. Zhu, and M. M. Nakano, "Mutational Analysis of the Signal-sensing Domain of ResE Histidine Kinase from *Bacillus subtilis*." *J. Bacteriol.*, **186**, 1694-1704, 2004.

S. Nakano, M. M. Nakano, Y. Zhang, M. Leelakriangsak and P. Zuber, "A Regulatory Protein that Interferes with Activator-Stimulated Transcription in Bacteria," *Proc. Natl. Acad. Sci. USA*, **100**, 4233-4238, 2003.

M.M. Nakano and P. Zuber, "Anaerobiosis," in *Bacillus subtilis and Its Closest Relatives*, A.L. Sonenshein, J.A. Hoch and R. Losick, eds., American Society for Microbiology, Washington, D.C., pp. 393-404, 2002.

M.M. Nakano, "Induction of ResDE-dependent Gene Expression in *Bacillus subtilis* in Response to Nitric Oxide and Nitrosative Stress," *J. Bacteriol.*, **184**, 1783-1787, 2002.

JAMES F. PANKOW

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RESEARCH INTERESTS

Physical and analytical chemistry of organic and inorganic species in natural waters, the atmosphere, and smoke aerosols; the formation and chemistry of atmospheric aerosols; the chemistry of the delivery of nicotine and carcinogens by tobacco smoke.

REPRESENTATIVE PUBLICATIONS

Pankow, J.F., Tavakoli, A.D., Luo, W., Isabelle, L.M. (2003) "Percent Free-Base Nicotine in the Tobacco Smoke Particulate Matter of Selected Commercial and Reference Cigarettes". Chemical Research in Toxicology, 16, 1014-1018.

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J.H. Seinfeld, W.E. Asher, G.B. Erdakos and J. F. Pankow, "Modeling the Formation of Secondary Organic Aerosols. 2. The Predicted Effects of Relative Humidity on Aerosol Formation in the (-Pinene-, (-Pinene-, Sabinene-, (3-Carene, and Cyclohexene- Ozone Systems," *Environ. Sci. Technol.*, **35**, 1806-1817, 2001.

R.L. Johnson, J. Pankow, D. Bender, C. Price and J. Zogorski, "MTBE, To What Extent Will Past Releases Contaminate Community Water Supply Wells?" *Environ. Sci. Technol.*, 210A-217A, 2000.

J.F. Pankow, B.T. Mader, L.M. Isabelle, W. Luo, A. Pavlick and C. Liang, "Conversion of Nicotine in Tobacco Smoke to Its Volatile and Available Free-Base Form through the Action of Gaseous Ammonia," *Environ. Sci. Technol.*, **31**, 2428-2433, 1997.

L. E. L. (BETS) RASMUSSEN

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Washington University
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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

L.E.L. Rasmussen, H.S. Riddle and V. Krishnamurthy, "Mellifluous Matures to Malodorous in Musth," *Nature*, **415**, 975-976, 2002.

L.E.L. Rasmussen and G. Wittemyer, "Chemosignaling of Musth by Individual Wild African Elephants (*Loxodonta africana*): Implications for Conservation and Management," *Proc. Royal Soc. London*, **269**, 853-860, 2002.

L.E.L. Rasmussen, J. Lazar, D.R. Greenwood and G.D. Prestwich, "Albumin - An Ideal Pheromone Carrier," *Chem. Senses*, **26**, 1102, 2001.

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

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

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

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

REINHOLD A. RASMUSSEN

Professor
Ph.D., Botany/Plant Physiology
Washington University,
(St. Louis), 1964
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RESEARCH INTERESTS

Atmospheric chemistry of trace gases; biogenic and anthropogenic emissions of trace gases and their roles in stratospheric ozone destruction and tropospheric ozone formation; measurements of trace gases at parts per trillion to parts per quadrillion levels; sources and sinks of isoprene and other hydrocarbons.

REPRESENTATIVE PUBLICATIONS

C. Geron, R.A. Rasmussen, R.R. Arnts and A. Guenther, "A Review and Synthesis of Monoterpene Speciation from Forests in the United States," *Atmos. Environ*, **34** (11), 1761-1781, 2000.

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E. Grosjean, R.A. Rasmussen and D. Grosjean, "Toxic Air Contaminants in Porto Alegre, Brazil," *Environ. Sci. Technol.*, 33 (12), 1970-1978, 1999.

R.A. Rasmussen, M.A.K. Khalil and F. Moraes, "Permafrost Methane Content: 1. Experimental Data from Sites in Northern Alaska," *Chemosphere*, **26**, 591, 1993.

M.A.K. Khalil, R.A. Rasmussen, J.R. French and J. Holt, "The Influence of Termites on Atmospheric Trace Gases: CH4, CO2, CHCl3, N2O, CO, H2 and Light Hydrocarbons," *J. Geophys. Res.*, **95**, 3619, 1990.

D.A. Hegg, L.F. Radke, P.V. Hobbs, R.A. Rasmussen and P.J. Riggan, "Emissions of Some Trace Gases from Biomass Fires," *J. Geophys. Res.*, **95**, 5669, 1990.

MATTHEW S. SACHS

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

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

REPRESENTATIVE PUBLICATIONS

Sachs, M. S., and Geballe, A. P., "Biochemistry. Sense and Sensitivity - Controlling the Ribosome," *Science* **297**, 1820-1821, 2002.

Sachs, M. S., Wang, Z., Gaba, A., Fang, P., Belk, J., Ganesan, R., Amrani, N., and Jacobson, A., "Toeprint Analysis of the Positioning of Translational Apparatus Components at Initiation and Termination Codons of Fungal mRNAs," *Methods* **26**, 105-114, 2002.

Fang, P., Wu, C., and Sachs, M. S., "*Neurospora crassa* Supersuppressor Mutants are Amber Codon-specific," *Fungal. Genet. Biol.*, **36**, 167-175, 2002.

Gaba, A., Wang, Z., Krishnamoorthy, T., Hinnebusch, A. G., and Sachs, M. S. "Physical Evidence for Distinct Mechanisms of Translational Control by Upstream Open Reading Frames," *EMBO J.* **20**, 6453-6463, 2001.

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

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

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Ph.D., Bacteriology
University of Wisconsin-Madison,
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RESEARCH INTERESTS

Microbial interactions, ecology and genomics; ecophysiology of mesophilic crenarchaeota.

REPRESENTATIVE PUBLICATIONS

Simon, H. M. and R. M. Goodman. Archaea in soil habitats. 2002. In The Encyclopedia of Environmental Microbiology (G. Bitton, ed.), John Wiley & Sons, New York. pp. 293-305.

Simon, H. M., Smith, K. P., Dodsworth, J. A., Guenthner, B., Handelsman, J., and R. M. Goodman. 2001. Influence of tomato genotype on growth of inoculated and indigenous bacteria in the spermosphere. Appl. Environ. Microbiol. 67: 514-520.

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Simon, H. M., Gosink, M. M., and G. P. Roberts. 1999. Importance of cis determinants and nitrogenase activity in regulated stability of the Klebsiella pneumoniae nitrogenase structural gene mRNA. J. Bacteriol. 181: 3751-3760.

Goodman, R. M., Bintrim, S. B., Handelsman, J., Rosas, J. C., Quirino, B. F., Simon, H. M., and K. P. Smith. A Dirty Look: Soil Microflora and Rhizosphere Microbiology. 1998. In Radical Biology; Advances and Perspectives on the Function of Plant Roots (H.E. Flores, J.P. Lynch, and J. Shannon, Eds.), American Society of Plant Physiologists, Rockville, MD, pp. 219-234.

Simon, H. M., Homer, M. J., and G. P. Roberts. 1996. Perturbation of nifT expression in Klebsiella pneumoniae has limited effect on nitrogen fixation. J. Bacteriol. 178: 2975-2977.

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Ph.D., Environmental Science and Engineering
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RESEARCH INTERESTS

Interfaces between environmental chemistry, toxicology, risk assessment, and the fate and transport of contaminants in the environment.

REPRESENTATIVE PUBLICATIONS

P. Toccalino, L. Nowell, W. Wilber, J. Zogorski, J. Donohue, C.Eiden, S. Krietzman, and G. Post. 2003. Development of health-based screening levels for use in state- or local-scale water-quality assessments. U. S. Geological Survey Water Resources Investigations Report WRIR 03-4054.

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P.L. Toccalino, "Evaluation of the Contained Burn of Two M88 NIKE Rocket Motors for Environmental Safety & Health Implications," Nevada Test Site X-Tunnel Facility (U25X), Las Vegas, 1997.

P.L. Toccalino, R. L. Johnson and D. R. Boone, "Nitrogen Limitation and Nitrogen Fixation During Alkane Biodegradation in a Sandy Soil," Appl. Environ. Microbiol., 59, 2977-2983, 1993.

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RESEARCH INTERESTS

Mechanistic and kinetic aspects of the fate of organic pollutants in the environment; degradation reactions involving pesticides, phenols, munitions, dyestuffs and chlorinated hydrocarbon solvents; chemical and microbiological processes in sediments, soils and groundwaters as well as photochemical processes in surface waters; natural and engineered remediation systems.

REPRESENTATIVE PUBLICATIONS

Tratnyek, P. G., E. J. Weber and R. P. Schwarzenbach, "Quantitative Structure-Activity Relationships (QSARs) for Chemical Reductions of Organic Contaminants," *Environ. Toxicol. Chem.* **22**(8), 1733-1742.

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Nurmi, J. T., and P. G. Tratnyek, "Electrochemical Properties of Natural Organic Matter (NOM), Fractions of NOM, and Model Biogeochemical Electron Shuttles," *Environ. Sci. Technol.* **36**(4), 617-624, 2002.

Tratnyek, P. G., M. M. Scherer, B. Deng and S. Hu, "Effects of Natural Organic Matter, Anthropogenic Surfactants, and Model Quinones on the Reduction of Contaminants by Zero-valent Iron," *Water Research*, **35**(18), 4435-4443, 2001.

KAREN WATANABE

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Ph.D., Mechanical Engineering
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RESEARCH INTERESTS

Computational methods in biology including chemical bioaccumulation in organisms and food webs, and pharmacokinetics. Applications of models in health and ecological risk assessment.

REPRESENTATIVE PUBLICATIONS

Lin, H., Berzins, D. W., Myers, L., George, W. J., Abdelghani, A. and Watanabe, K. H. (in press). A Bayesian approach to parameter estimation for a crayfish (Procambarus Spp.) bioaccumulation model. Environmental Toxicology and Chemistry 23(9).

Watanabe, K.H., Desimone, F.W., Thiyagarajah, A., Hartley, W.R. and Hindrichs, A.E. (2003). Fish tissue quality in the lower Mississippi River and health risks from fish consumption. *The Science of the Total Environment* **302**(1-3): 109-126.

Watanabe, K.H. (2002). Fundamentals of physiologically-based toxicokinetic models. In: *Endocrine Disrupters and Carcinogenic Risk Assessment.* L. Chyczewski, J. Niklinski and E. Pluygers, Eds. Amsterdam, Netherlands, IOS Press: 271-280.

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Luebeck, E. G., Travis, C. and Watanabe, K. (1999). Informative case studies. In: Perspectives on Biologically Based Cancer Risk Assessment. V. J. Cogliano, E. G. Luebeck and G. A. Zapponi. New York, Kluwer Academic/Plenum Publishers: 275-308.

Luebeck, E. G., Watanabe, K. and Travis, C. (1999). Biologically based models of carcinogenesis. In: Perspectives on Biologically Based Cancer Risk Assessment. V. J. Cogliano, E. G. Luebeck and G. A. Zapponi. New York, Kluwer Academic/Plenum Publishers: 205-241.

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

M.M. Whittaker and J.W. Whittaker, "Characterization of Recombinant Barley Oxalate Oxidase Expressed by *Pichia pastoris," J. Biol. Inorg. Chem.*, **7**, 136-145, 2002.

V.V. Barynin, M.M. Whittaker, S.V. Antonyuk, V.S. Lamzin, P.M. Harrison, P.J. Artymiuk and J.W. Whittaker, "Crystal Structure of Manganese Catalase from *Lactobacillus plantarum," Structure*, **9**, 725-738, 2001.

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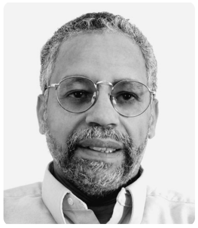
R.A. Edwards, M.M. Whittaker, J.W. Whittaker, E.N. Baker and G.B. Jameson, "Outer Sphere Mutations Perturb Metal Reactivity in Manganese Superoxide Dismutase," *Biochemistry*, **40**, 15-27, 2001.

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

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



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RESEARCH INTERESTS

Structure-function studies with the mitochondrial carnitine palmitoyltransferases I and II (CPTI and CPTII); regulation of CPTI gene expression, fatty acid transport, and oxidation in mammalian cells; investigations into the role of CPTI in diabetes, obesity, heart disease, and the molecular basis of human CPT deficiency diseases using animal models; regulation of cell metabolism and signaling by llong-chain acyl-CoA esters; mitochondrial ion transport and bioenergetics.

REPRESENTATIVE PUBLICATIONS

Huang H, Starodub O, McIntosh A, Atshaves BP, Woldegiorgis G, Kier AB, Schroeder F. Liver Fatty Acid-Binding Protein Colocalizes with Peroxisome Proliferator Activated Receptor alpha and Enhances Ligand Distribution to Nuclei of Living Cells. *Biochemistry,* **43,** 2484-2500, 2004.

L. Napal, J. Dai, M. Treber, D. Haro, P.F. Marrero, and G .Woldegiorgis, "A Single Amino Acid Change (Substitution of the Conserved Glu-590 with Alanine) in the C-terminal Domain of Rat Liver Carnitine Palmitoyltransferase I Increases its Malonyl-CoA Sensitivity Close to that Observed with the Muscle Isoform of the Enzyme." *J. Biol. Chem.,* **278**, 34084-34089, 2003.

M. Treber, J. Dai, and G. Woldegiorgis, "Identification by Mutagenesis of Conserved Arginine and Glutamate Residues in the C-Terminal Domain of Rat Liver Carnitine Palmitoyltransferase I That Are Important for Catalytic Activity and Malonyl CoA Sensitivity," *J. Biol. Chem.*, **278**, 11145-11149, 2003.

H. Zhu, J. Shi, M. Treber, J. Dai, J., D.N. Arvidson and G. Woldegiorgis, "Substitution of Glutamate-3, Valine-19, Leucine-23, and Serine-24 with Alanine in the N-Terminal Region of Human Muscle Carnitine Palmitoyltransferase I Abolishes Malonyl CoA Inhibition and Binding," *Arch. Biochem. Biophys.*, **413**, 67-74, 2003.

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS

Kawulka, K. E, T. Sprules, C. M. Diaper, R. M. Whittal, R. T. McKay, P. Mercier, P. Zuber, J. C. Vederas. 2004. Structure of subtilosin A, a cyclic antimicrobial peptide from *Bacillus subtilis* with unusual sulfur to ±-carbon crosslinks: formation and reduction of ±-thio-±-amino acid derivatives. Biochemistry (In Press).

Kawulka, K., T. Sprules, R. T. McKay, P. Mercier, C. M. Diaper, P. Zuber and J. C. Vederas, "Structure of Subtilosin A, An Antimicrobial Peptide from *Bacillus subtilis* with Unusual Post-translational Modifications Linking Cysteine Sulfurs to ∂-carbons of Phenylalanine and Threonine," *J. Am. Chem. Soc.* **125**, 4726-4727, 2003.

Nakano, M. M., S. Nakano and P. Zuber, "Spx (YjbD), a Negative Effector of Competence in *Bacillus subtilis*, Enhances ClpC-MecA-ComK Interaction," *Mol. Microbiol.* **44**, 1341-1350, 2002.

Nakano, S., G. Zheng, M. M. Nakano and P. Zuber, "Multiple Pathways of Spx (YjbD) Proteolysis in *Bacillus subtilis*," *J. Bacteriol.* **184**, 3664-3670, 2002.

Zuber P., "Control of Gene Expression in Gram-positive Bacteria: Extensions of and Departures from Enteric Paradigms," *Front. Biosci.* 2002 Aug 1;7:D1857-66, 2002.

Nakano, S., M. M. Nakano, Y. Zhang, M. Leelakriangsak and P. Zuber, "A Regulatory Protein that Interferes with Activator-stimulated Transcription in Bacteria," *Proc. Natl. Acad. Sci.* (Mar 17, e-pub ahead of print), 2003.

Nakano, M. M., F. Hajarizadeh, Y. Zhu and P. Zuber, "Loss-of-Function Mutations in *yjbD Result in clpX- and clpP*-independent Competence Development of *Bacillus subtilis,"* *Mol. Microbiol.*, **42**, 383-394, 2001.

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THE DEPARTMENT OF MANAGEMENT IN SCIENCE AND TECHNOLOGY focuses on educating leaders and managers in a technology-intensive world. All M.S. in Management courses have a strong technology focus, meeting the educational needs of students working in high-technology industries and/or technology-intensive professions. Our curriculum also emphasizes leadership and the communication and teamwork skills needed to work effectively with people.

WHAT SETS MANAGEMENT IN SCIENCE AND TECHNOLOGY APART?

The M.S. in Management is:

Technology-focused. Our graduate management program is designed with a very specific intent: to prepare students to effectively lead and manage in a technology-intensive organization. Compared to a traditional MBA, the learning from the M.S. in Management is much more relevant to the student's professional situation. Go to http://www.ogi.edu/MST/deg_comp.shtml for a more detailed comparison of the M.S. in Managment with traditional M.B.A. and M.S. in Engineering Management degrees.

Relevant. Management in Science and Technology courses are taught by faculty with outstanding professional and academic credentials. Faculty have developed their expertise through years of professional work in the private sector as well as in distinguished research careers. Each class is designed to deliver cutting-edge knowledge about best practices. Managers and executives from the region's high-technology companies visit classes to share their experience with the students. Students and managers alike tell us that the "M.S. in Management classes offer knowledge you can apply Monday morning."

Flexible. We designed the program for working people, making it possible for students to attend intensive weekend or weeknight classes and continue to fulfill their commitments at work and home. Students may begin taking classes in any quarter, and may take individual courses for professional development prior to enrolling in the degree program. Our online presence makes our degree program available to students around the world, as well as to those students from our region for whom online courses are more convenient.

Collaborative. Management in Science and Technology equips students with the functional expertise and the people skills to manage cross-boundary partnerships effectively. The curriculum and faculty emphasize the development of leadership and communications skills that are critical to collaboration between people from different functions, companies, and countries. Team projects, group exercises and oral presentations are emphasized throughout the curriculum. In addition, small class sizes make interactions and discussions between faculty and students an enriching learning experience.

Entrepreneurial. The M.S. in Management program emphasizes entrepreneurship through the integrative Capstone experience, culminating in the Jim Hurd New Venture Competition. Students form management teams and develop business plans requesting investment from a panel of distinguished venture capitalists who evaluate their oral and written presentations.

INDIVIDUAL COURSES FOR CAREER DEVELOPMENT

Each Management in Science and Technology course has been designed as a valuable professional development experience for working professionals. Project Management (MST 512), Becoming an Effective Manager (MST 520) and Leadership and Communication Skills (MST 541), for example, may be taken as stand-alone courses. We encourage non-matriculated students to join our courses for their own career development in specific areas.

ONLINE COURSES AND REMOTE CLASSROOM SITES

Management in Science and Technology delivers challenging and engaging versions

Department of Management in Science and Technology

www.ogi.edu/MST/

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The MST department's 2004 graduating class, pictured here, included the first cohort of students to complete OGI's new certificate program in Health Care Management.

of its courses over the Internet. *U.S. News & World Report* chose MST-Online as one of the "Best of the Online Grad Programs" in 2001. This is an excellent option for students facing time pressures or working in locations where travel to campus is not feasible. Courses offered online will have a "D" designation as the section number following the course number. For further information, visit the Management in Science and Techonology Web site at www.ogi.edu/MST/.

The M.S. in Management program also offers on-site courses at our remote classroom location at the Wilsonville Training Center, 29353 Town Center Loop East, Wilsonville, OR 97070. Currently, one or two MST courses per term are offered at the Wilsonville Training Center. Please refer to the department's Web site at www.ogi.edu/MST/ for updated course schedule information. Courses offered at Wilsonville will have a "W" designation as the section number following the course number.

FOR-CREDIT CERTIFICATE PROGRAMS

ADMISSION REQUIREMENTS

Our for-credit certificate programs require the following for admission:

- A completed application with $25 nonrefundable application fee
- At least two years of relevant professional experience
- For non-native speakers of English, a score of 625 or better on the TOEFL examination

Individual courses are open to interested persons without the need to matriculate into the degree or certificate programs. Enrollment is available to any qualified student.

MANAGEMENT IN SCIENCE AND TECHNOLOGY CERTIFICATE

The Management in Science and Technology department offers a six-course certificate in Management in Science and Technology. The following five courses, plus an additional management elective course chosen in consultation with a faculty advisor, for a total of at least 22 credits are required:

CORE COURSES

MST 510 (D)	Principles and Trends in Technology Management	3 credits
MST 512 (D)	Project Management	4 credits
MST 520 (D)	Becoming an Effective Manager	4 credits
MST 571 (D)	Managerial and Financial Accounting for Science and Technology	4 credits
MST 573 (D)	Technology Marketing: Planning for Market	4 credits
• ELECTIVES:	One elective to be chosen after consultation with faculty advisor	

HEALTH CARE MANAGEMENT CERTIFICATE

The certificate in Health Care Management is designed for working professionals in administration, reimbursement or management roles in health care organizations. The program provides an overview of the financial, policy, organizational and operational environments of health care-related enterprises. Students gain focused skills for designing and managing organizations engaged in the delivery of health care.

The Health Care Management Certificate blends the unique management and planning expertise within the M.S. in Management faculty with those of recognized professionals in the health care community at OHSU and elsewhere.

The program consists of six courses, including four core (required) courses and two elective choices, for a total of at least 20 credits, as listed below.

CORE COURSES

MST 560	The Organization, Financing, and History of Health Care Delivery in the United States	4 credits
MST 561	Managerial and Financial Accounting for Health Care Professionals	4 credits
MST 562	Health Care Program Management	4 credits
MST 563	The Regulation and Legislation of Health Care Delivery	4 credits
• ELECTIVES:	Two of the following courses are required	
MST 564	Business Planning and Strategy in the Health Care Industry	4 credits
MST 565	Human Resources in Health Care	4 credits
MST 566	Health Care Information Systems Management	4 credits
MST 567	Health Care Technology – New Medical Advances	4 credits
MST 568	New Trends in Health Care Delivery	2-4 credits
MST 507HC	Seminar for Health Care Management	2 credits

The following courses from MST and other OHSU departments may also be used as electives, as may other Oregon University System courses, by petition to the department.

MST 512 (D)	Project Management	4 credits
MST 520 (D)	Becoming an Effective Manager	4 credits
MST 522 (D)	Influencing Change in Organizations	3 credits
MST 541	Leadership and Communication Skills	3 credits
MST 542	Business Ethics and Corporate Social Responsibility	3 credits
MINF 510	Introduction to Medical Informatics	
MINF 517	Organizational Behavior and Management in Informatics	
MINF 518	Project Management in Informatics	
NURS 531	Ethical Decisions in Health Care Management Marketing	

NON-CREDIT CERTIFICATE PROGRAMS

ESSENTIALS OF GENERAL MANAGEMENT FOR EMERGING HIGH TECHNOLOGY LEADERS: A Partnership between OGI, PSU and AeA

The Essentials of General Management program is an excellent foundation for those bound for senior management. It brings together the region's rising stars of high-technology, offering a high-quality, local, affordable foundation for entry into senior-level management.

This unique executive development workshop series is ideal for functional managers and high-potential employees who are on their way up. It lays the groundwork for the next level of leadership training, making future investments in more extensive management programs even more valuable and meaningful. In addition, the program provides an excellent environment for networking.

The format includes intensive one-day workshops taught by senior executives and academics who are highly respected in the technology industry, an interactive online forum, immediate application and feedback and a graduate ceremony. For more information, contact Jack Raiton at raitonj@ohsu.edu or 503 748-3075.

M.S. DEGREE PROGRAM

ADMISSION REQUIREMENTS FOR THE M.S. DEGREE PROGRAM

The general admission requirements for the institution apply to the M.S. in Management in Science and Technology program with the following additions or exceptions:

- 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.
- Recommended TOEFL score of 625 (paper-based test) / 263 (computer-based test) if English is not the applicant's first language.
- GMAT or GRE scores are not required.

Part-time students may apply for admission to the M.S. in Management program during any quarter. Full-time students are strongly encouraged to apply in the winter or summer quarter and begin in the spring or fall quarter.

DEGREE REQUIREMENTS

OGI offers a non-thesis M.S. in Management in Science and Technology. Students elect one of three tracks within the degree program: Managing the Technology Company, Managing in the Software Industries or Managing Information Systems. Students must complete a minimum of 52 credits with an average GPA of 3.0 or better.

MANAGEMENT IN SCIENCE AND TECHNOLOGY CORE SEQUENCE

All M.S. students must take the 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 degree.

MST 510 (D)	Principles and Trends in Technology Management	3 credits
MST 512 (D)	Project Management	4 credits
MST 513 (D)	Operations Management and Practices	3 credits
MST 520 (D)	Becoming an Effective Manager	4 credits
MST 530 (D)	Strategic Management and Planning	4 credits
MST 550 (D)	Capstone Project: Business Plan	4 credits
MST 571 (D)	Managerial and Financial Accounting for Science and Technology	4 credits
MST 572 (D)	Financial Management for Science and Technology	4 credits
MST 573 (D)	Technology Marketing: Planning for Market	4 credits
MST 590 (D)	Effective Business Writing for Management	1 credit
– OR –		
MST 591 (D)	Effective Business Writing for Non-native Speakers	1 credit

Based on experience, certain courses are more beneficial when taken earlier or later in a student's program of study. Students are encouraged to meet with an advisor to help plan a program of study.

It is strongly recommended that students take MST 512 – Project Management; MST 520 – Becoming an Effective Manager; and MST 590 – Effective Business Writing for Management or MST 591 – Effective Business Writing for Non-native Speakers, as early as possible in their studies.

For the best possible Capstone experience, students form teams at least six months in advance of the quarter in which they plan to take MST 550 – Capstone Project: Business Plan. Past Capstone students strongly recommend taking MST 573 – Technology Marketing: Planning for Market, late in their studies and forming a Capstone team prior to completing MST 573 assignments. Elective MST 574 – Going to Market: Delivering Value to Customers and Shareholders, is also highly recommended as a follow-on to MST 573 and to be taken together with one's Capstone team. MST 530 – Strategic Management and Planning, and MST 550 – Capstone Project: Business Plan should both be taken as close to the end of a student's studies as possible.

TRACKS

Students must choose one of the three tracks defined below. The following tracks require the completion of the 35-credit M.S. core sequence listed above. For each track, a minimum of 52 credits is required. A course number followed by (D) indicates that course is available online as well as on-campus.

MANAGING THE TECHNOLOGY COMPANY TRACK

As new technological advances profoundly alter our working world, there is an urgent need for managers who understand general business practices and how technological change is affecting them. The central learning objective of the Managing the Technology Company track is to provide graduates with the necessary fundamental and applied knowledge and skills to function as successful managers in technology-intensive industries.

M.S. in Management students following the Managing the Technology Company track may complete the degree entirely online. However, the department recommends that students take at least two on-campus courses if possible. A proctored comprehensive exam may be required at or near the completion of the M.S. in Management degree when completed solely online.

- M.S. Management Core Sequence (listed above)
- Track Core: Three of the following six courses are required

MST 511 (D)	Quality Management	3 credits
MST 514 (D)	Issues in R&D Management	3 credits
MST 522 (D)	Influencing Change in Organizations	3 credits
MST 540 (D)	International Management in Science and Technology	3 credits
MST 541	Leadership and Communication Skills	3 credits
MST 574	Going to Market: Delivering Value to Customers and Shareholders	4 credits

- ELECTIVES: Any course in the above list not already taken and/or any of the following

EBS 547	Uncertainty Analysis	4 credits
EBS 583	Environmental Law and Regulation	3 credits
CSE 517	Software Engineering Processes	3 credits
CSE 568	Empirical Research Methods	3 credits
MST 506	Special Topics (special electives offered on a one-time only basis)	variable credits
MST 509	Commercialization Practicum	3 credits
MST 515	Supply Chain Management	3 credits
MST 516	Global Logistics and Financial Management	3 credits
MST 517	Supply Chain Management Advanced Modeling	3 credits
MST 521 (D)	Managing Human Resources	3 credits
MST 523	New Product Development	4 credits
MST 524	eBusiness: Strategy and Roadmap	4 credits
MST 531	Software Commercialization	3 credits
MST 542	Business Ethics and Corporate Social Responsibility	3 credits
MST 544 (D)	Strategic Alliances	3 credits
MST 549D	Applied Business Forecasting	4 credits
MST 577	Principles for Process Development and Introduction to Manufacturing	4 credits

Students may petition the department for elective credit for other OGI academic courses relevant to the theory or practice of management.

MANAGING IN THE SOFTWARE INDUSTRIES TRACK

The software industries are demonstrating a great demand for well-informed, effective managers and executives. In the Software Industries track you can prepare for these roles by taking a core of management courses in the Management in Science and Technology department, plus a special course in Software Commercialization and a flexible set of courses in OGI's Computer Science and Electrical Engineering department.

- M.S. Management Core Sequence (listed above)
- Track Core: The following two courses are required

CSE 516	Introduction to Software Engineering	3 credits
MST 531	Software Commercialization	3 credits

- ELECTIVES: Any of the following courses

CSE 514	Introduction to Database Systems	3 credits
CSE 517	Software Engineering Processes	3 credits
CSE 518	Software Design and Development	3 credits
CSE 519	Object-Oriented Analysis and Design	3 credits
CSE 560	Artificial Intelligence	3 credits
CSE 564	Introduction to Human Computer Interaction	3 credits
CSE 567	Developing User-Oriented Systems	3 credits
MST 511 (D)	Quality Management	3 credits
MST 514 (D)	Issues in R&D Management	3 credits
MST 522 (D)	Influencing Change in Organizations	3 credits
MST 540 (D)	International Management in Science and Technology	3 credits
MST 541	Leadership and Communication Skills	3 credits
MST 574	Going to Market: Delivering Value to Customers and Shareholders	4 credits

Students may petition the department for elective credits for other OGI academic courses relevant to the theory or practice of management.

MANAGING INFORMATION SYSTEMS TRACK

The objective of the Managing Information Systems track is to give IS professionals the ability to manage complex enterprise information systems from an operational excellence perspective, and equally to maximize the strategic leverage of such systems on a company's operations. Key issues that are addressed are the design, planning and implementation of such systems, with particular attention to communication from and service of stakeholders throughout the organization. Emphasis will be placed on driving a company's business objectives through optimal information system design, leadership, and communication.

- M.S. Management Core Sequence (listed above) — with the following modifications:

MST 532	Issues & Trends in Managing Information Systems *(instead of MST 510)*	3 credits
MST 533	Project and Program Management for MIS (*instead of MST 512)*	4 credits
MST 534	Linking MIS and Corporate Strategy (*instead of MST 530)*	4 credits

- Track Core: Two of the following three courses are required

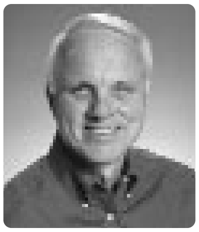
MST 535	Business Process Mapping	4 credits
MST 536	Managing Information Systems Security and Operations	4 credits
MST 537	Leading Innovation in Managing Information Systems	3 credits

- ELECTIVES: Any course in the above list not already taken and/or any of the following:

CSE 516	Introduction to Software Engineering	3 credits
MST 515	Supply Chain Management	3 credits
MST 521 (D)	Managing Human Resources	3 credits
MST 522 (D)	Influencing Change in Organizations	3 credits
MST 524	eBusiness: Strategy and Roadmap	4 credits
MST 531	Software Commercialization	3 credits
MST 538	Database Systems in a Business Context	4 credits
MST 541	Leadership and Communication Skills	3 credits
MST 542	Business Ethics and Corporate Social Responsibility	3 credits
MST 544 (D)	Strategic Alliances	3 credits
MST 566	Health Care Information Systems Management	4 credits
MST 574	Going to Market: Delivering Value to Customers and Shareholders	4 credits

Students may petition the MST Department to count OMSE (Oregon Master of Software Engineering), OHSU MINF (Medical Informatics), or Portland State University EMGT (Engineering & Technology Management) courses for elective credit toward the MIS track.

FACULTY



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REPRESENTATIVE PUBLICATIONS:

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RESEARCH INTERESTS

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

REPRESENTATIVE PUBLICATIONS:

D.B. Drake, N.A. Steckler, and M.J. Koch, "Information Sharing in and across Government Agencies: The Role and Influence of Scientist, Politician, and Bureaucrat Subcultures," *Social Science Computer Review*, **22**, No. 1, Spring, 2004.

M. Koch and D Moshavi, "The Adoption of Family-Friendly Policies in Family-Owned Firms: Paragon or Paradox," Proceedings of the 2001 Southern Management Association Annual Meeting, New Orleans, LA, 2001.

M. Koch and G. Hundley, "The Effects of Unionism on Recruitment and Selection Practices," *Industrial Relations*, **36**(3), 349–370, 1997.

M. Koch and R. McGrath, "Improving Labor Productivity: Human Resource Management Policies Do Matter," 1996, *Strategic Management Journal*, **17**, 335–354, 1996. (Awarded an Anbar Electronic Intelligence Citation of Excellence Award for 1997).

M. Koch, L. Long, 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. "Hiring Practices and Labor Productivity," Garland Publishing, New York, 1995.

JACK RAITON

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Having previously served as chief financial officer of Planar Systems and as corporate controller of Tektronix, Jack brings a wealth of high-level management experience in local industry to the MST department. He is active in the leadership of the American Electronics Association and Financial Executives International, and serves on the Advisory Boards of Compli, Inc, StoriedLearnings, and two high tech start-ups. Jack earned his BS in Mathematics from Oregon State University in 1966 and his MBA in Finance and Statistics from the University of Washington in 1967. He attended Harvard University's Advanced Management Program, and passed the CPA exam in 1979.

AREAS OF EXPERTISE

Performance measurement, capital structure, stock options and incentive plans, forensic accounting.

NICOLE A. STECKLER

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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

D.B. Drake, N.A. Steckler, and M.J. Koch, "Information Sharing in and across Government Agencies: The Role and Influence of Scientist, Politician, and Bureaucrat Subcultures," *Social Science Computer Review*, **22**, No. 1, Spring, 2004.

D.B. Drake, M.J. Koch, and N.A. Steckler, "Scientist, Politician, and Bureaucrat Subcultures as Barriers to Information-Sharing in Government Agencies," Proceedings of the 2003 National Conference on Digital Government Research, May 18-21, 2003, Boston, MA.

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N.A. Steckler and R. Rosenthal, "Sex Differences in Nonverbal and Verbal Communication with Bosses, Peers, and Subordinates," *Journal of Applied Psychology*, **70**, 157–163, 1985.

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ADJUNCT FACULTY

JEAN-CLAUDE BALLAND
JCB Associates

LARRY BUNYARD
Tektronix, Inc.

GREG CHARLES
Independent Consultant

SUSAN COOMBES
Legacy Health Systems

LESLIE COPLAND
Leslie Smid & Associates

LINDA CRAFTS
Cumulus Resources LLC

JERRY DAVIES
EPIC Aviation, LLC

GEORGE DOCHAT
ESI

TOM FLORA
OHSU

RICHARD FOURNIER
Business Computer Institute

KATE GAWF
Independent Consultant

DAVID GARTEN
Intel

ROBERT HARMON
Portland State University

JOHN HENGEVELD
Portland State University

JILL KELLY, PH.D.
Women's Journal

RITA LAXTON-BENZAN, PH.D.
PacifiCorp

DON LEWIS
Lewis and Lewis Consulting

KATHY LONG HOLLAND
LongSherpa/Eco-D

ROY MAGNUSSON
OHSU

SUZANNE MALEK
Independent Consultant

KATHY MANGEL DAVIS
Professionally Speaking

MICHAEL MCLEAN
AC Transit

DEIRDRE MENDEZ, PH.D.
Foreign Business
Management Consultants

MARGARET (MELODY) MONTGOMERY
OHSU

MICHAEL NEAL
Independent Consultant

PAUL NEWMAN, PH.D.
Cooper Mountain Research, Inc.

LYLE OCHS
Technology & Innovation
Management, Inc.

JEFF OLTMANN
Synergy Professional Services

MARK PALMER
Merant, Inc.

JODI PETTIT, PH.D.
Providence Hospital

JESSE REEDER
Leadership Dynamics

ADRIAN ROBERTS, PH.D.
Independent Consultant

DOUG SHAFER
Unicru

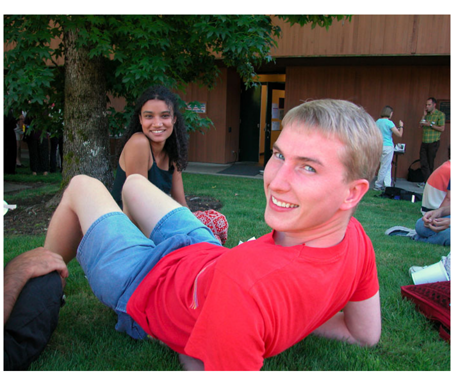
THOI TRUONG
CNF

JOHN WALLNER
Tektronix, Inc.

ARTHUR WARD, PH.D.
IBM

CROSS-INSTITUTIONAL PROGRAMS AND COURSES

Most courses at the OGI School of Science & Engineering are applicable to a specific program of study. However, the following programs and subjects are not identified with any one department or program. These programs and courses are relevant for students in various departments and academic programs, and are accessible from more than one department.



Taniya Mishra, Ph.D. student, and Nathan Linger, Ph.D. student, enjoy some sun and relaxation at an OGI barbeque for students, faculty and staff.

PROGRAMS OF STUDY IN SPOKEN LANGUAGE UNDERSTANDING

The research program of the **Center for Spoken Language Understanding** 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, dialog modeling, natural language processing, multimodal systems, linguistics and human-computer interaction.

This program focuses on specific problem areas such as: multimodal, interactive reading tutors for children with reading or hearing problems; 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.

The Center for Spoken Language Understanding participates in the master's and Ph.D. programs of study in the Departments of Biomedical Engineering and Computer Science and Electrical Engineering. Students who are interested in earning a master's or Ph.D. degree in biomedical engineering, computer science and engineering, or electrical engineering, with specialization in spoken language understanding, should consult the catalog information for those departments and contact an advisor in the Center for Spoken Language Understanding, the Department of Biomedical Engineering or the Department of Computer Science and Electrical Engineering.

APPLIED COMPUTING COURSES

Applied computing (APC) courses provide the skills needed to accomplish specific goals and provide prerequisite knowledge for more advanced courses. Students should check with their advisors to determine whether these courses should be taken and check with their academic programs to determine whether applied computing credit hours can be used to satisfy degree requirements in their programs of study.

APPLIED MATHEMATICS COURSES

Applied math (MATH) courses provide prerequisite knowledge for more advanced courses. Students should check with their advisors to determine which, if any, of these courses are needed for their programs of study and check with their ademic programs to determine whether applied mathematics credit hours can be used to satisfy degree requirements in their programs of study.

GENERAL EDUCATION COURSES

General education (GEN) courses are provided as a service to the academic community. They are intended to improve the general academic skills of participants. Credit hours earned from general education courses do not usually apply toward degree requirements. Students should check with their advisors concerning the desirability of taking general education courses.

COURSE DESCRIPTIONS

Effective Fall quarter 2003, the OGI School has renumbered many of its courses to better align course numbers with the Oregon Health & Science University standard numbering scheme. To assist in relating the new course numbers to courses offered in the past, a course number crosswalk is available online at www.ogi.edu/graduate_edu/schedule/crosswalk.cfm.

5xx Graduate courses offered primarily in support of master's programs. May be used towards a doctoral program as appropriate.

6xx Graduate courses offered primarily in support of doctoral programs. May be used towards a master's program as appropriate.

Master's and certificate students should register for the 5xx class and doctoral students should register for the 6xx class when available.

APPLIED COMPUTING

APC 514/614 Applications Programming in C++
(Formerly APC 505a and APC 505b)
This course provides an introduction to programming in C++, which is widely used for developing engineering and business applications. This course introduces students to the C++ language, and covers fundamental concepts such as classes, composition and inheritance, polymorphism, virtual functions, overloading and overriding, abstract classes, pure virtual functions, streams, operator overloading, brief introduction to some STL containers, and time permitting, exceptions and templates. The course is suitable for students in engineering, science and finance who wish to gain an understanding of the language. On completion, students will be in a position to contribute to the design and development of systems using the main features in C++. Assignments include writing programs and a programming project. Prerequisites: Knowledge of a programming language. 3 credits

APC 515/615 Data Structures and Discrete Mathematics
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 514 or equivalent knowledge of C or C++. 3 credits

BIOMEDICAL ENGINEERING

BME 501 M.S. Non-Thesis Research
Supervised project research for Master's students who are not pursuing a thesis.
Variable and repetitive credit

BME 502/602 Independent Study
Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval from the faculty member and the student's academic department.
Variable and repetitive credit

BME 503 M.S. Thesis Research
Supervised original research towards a thesis for the Master's degree. Variable and repetitive credit

BME 504/604 Professional Internship
Professional internship credits provide students 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 following graduation. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students and Scholars before enrolling. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit

BME 505/605 Readings in Biomedical Engineering
This course is designed to teach critical evaluation of information in the field of Biomedical Engineering. Students will read articles and papers on timely topics related to the student's area of interest. Students will be required to present a summary of the readings to the class. 1 credit/term, repetitive

BME 506/606 Special Topics
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently. Variable and repetitive credit

BME 507/607 Biomedical Engineering Seminar
This seminar course will feature presentations and discussions on topics in biomedical engineering that exemplify the wide range of applications of biomedical engineering to science and medicine. The goals are to provide the students with an overview of the diverse opportunities for research and application, to foster development of critical analysis and thinking, and to stimulate creative problem solving and research planning. Both faculty and students will present topics and lead discussions. Students will be required to write a short paper that introduces a topic and proposes an original project.
1 credit/term, repetitive

BME 511/611 Biochemistry for Biomedical Engineering
The course will introduce the basics of biochemistry, emphasizing the chemical structure and physio-chemical behavior of biochemicals such as sugars proteins, nucleic acids, water, various polymers and other common components of cells and tissues. An overview of the basic metabolic pathways of cells and the integrated chemistry of different organs in the whole body will be presented. A biochemical perspective on processing of biomaterials will be presented, drawing examples from tissue engineering and cooking. The goal is to give an introduction to biochemistry that enables the biomedical engineer to better communicate with medical researchers and clinicians, while also offering a unique engineering perspective on the biochemical nature of biomaterials. 3 credits

BME 513/613 Biomedical Signal Processing I
This series covers the analysis of biomedical signals. The first course introduces the basic tools for continuous- and discrete-time signal analysis and modeling: Laplace and continuous-time Fourier transform, z-transform and discrete time Fourier transform, Fourier series, discrete Fourier transform, continuous time filter design, FIR and IIR filter design, wavelet transform. Applications areas covered are ECG, IEGM, blood pressure measurement, cardiac impedance measurement, and heart rate variability. Tool: MATLAB with Simulink. Prerequisites: undergraduate signal and system course covering Laplace and Fourier transform.
3 credits

BME 514/614 Biomedical Instrumentation — Signals and Sensors
This course covers the concept and application of instrumentation techniques to biomedical subjects. Areas studied will include biopotentials, sensors, stimulators, amplifiers, filters, displays, safety, and instrument design. This course includes a laboratory and a design project. Prerequisites: Calculus through differential equations. 3 credits

BME 517/617 Systems Physiology
Systems Physiology provides an introduction to several major physiological systems with which biomedical engineers are involved in research directed toward both an understanding of normal physiological functions and the successful development of devices, drug delivery systems, and processes to compensate for abnormal functions. Emphasis will be places on understanding these systems from an engineering perspective. Coverage will include the following systems: circulatory, nervous, pulmonary, and urogenital. 3 credits

BME 522/622 Biomedical Optics I: Tissue Optics
Light propagation in tissue: This course treats light transport in scattering and absorbing media such as biological tissue. Light transport is modeled using a variety of theories and computational techniques, including Monte Carlo simulations and approximate solutions of the radiative transport equation. Steady- state and time-dependent problems are treated. Spectroscopy and fluorescence measurements are introduced. Optical imaging techniques are presented. Students learn the basics required for design of optical devices for therapy and diagnostics. 3 credits

BME 523/623 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. Prerequisite: BME 522/622 Biomedical Optics I, or permission of instructor. 3 credits

BME 524/624 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. Roles are rotated amongst the students for each business plan. Feasibility studies are conducted in a laboratory exercise designed by the students. The team formally presents a business plan every two weeks. Prerequisite: BME 523/623 Biomedical Optics II, or permission of instructor. 3 credits

BME 525/625 Biomedical Photomechanics
This course is aimed at introducing the field of optical NDE to engineering students. The course focuses primarily on coherent light techniques such as interferometry, holography, and laser speckle methods. Moiré, photo-elastic, and structured light methods are also discussed. Specific applications to biomedical engineering, semiconductor, and electronic materials will be presented. 3 credits

BME 526/626 Computational Approaches to Laser Interactions with Biological Tissues
Lasers and light from alternative conventional sources interact with biological tissues or other complex media through photochemical, photothermal and photomechanical mechanisms. This course will employ computational methods to simulate interaction of lasers with tissues. Compartmental modeling will model photochemical interactions. Green's function and finite difference techniques will model thermal and water diffusion, surface evaporation, and explosive vaporization. Arrhenius rate process calculations will model thermal damage, thermoelastic expansion and velocity potential models will simulate pressure wave generation and propagation, spallation/cavitation models will model initiation and growth of laser-induced material defects leading to fragmentation. These methods provide a tool kit for handling a wide variety of laser effects in biological tissues. 3 credits

BME 527/627 Computational Approaches to Light Transport in Biological Tissues
Understanding the movement of light through complex biological tissues or other complex media is the first step in design of optical devices or clinical protocols in medical applications of lasers and light. This course will use various computational methods to simulate such light propagation: (1) wave theory to discuss the early loss of coherence and polarization as light initially enters tissue; (2) small angle scattering to discuss the transition of ballistic photons into scattering photons; (3) Monte Carlo simulations to discuss a variety of issues in energy propagation, including irregular boundary conditions; (4) diffusion theory to predict light fields distant from sources; (5) perturbation theory to approximate optical heterogeneities with absorption and scattering properties that vary from the background medium properties. These methods provide a tool kit for handling a wide variety of optical problems encountered in design of optical systems involving tissues. 3 credits

BME 528/628 Physical and Geometrical Optics
First-order Gaussian optics and thin-lens system layout. Photometric theory applied to optical systems. Topics include: the eye, magnifiers, microscopes, matrix optics, Seidel aberrations, scalar diffraction theory; Fresnel and Fraunhofer diffraction, and interferometry. 3 credits

BME 541/641 Mechanical Properties of Tissues I
This course introduces the application of continuum mechanics to biological tissues. A rigorous derivation of stress and strain tensors, the theory of elasticity and the theory of viscoelasticity are presented. The bulk of the course focuses on the development of pseudo-strain energy density functions to describe the hyperelastic behavior of biological tissues. Suggested Prerequisites: Mathematics through differential equations, some familiarity with linear algebra and matrix manipulations, MATLAB programming skills. 3 credits

BME 542/642 Mechanical Properties of Tissues II
This course is a direct continuation of BME 541/BME 641. The mechanical behavior of specific biological tissue types, including hard and soft tissues, is discussed in detail. A rigorous introduction to experimental and computational fluid dynamics is presented, along with discussions regarding the influence of fluid flows on the mechanical behavior and remodeling of biological and engineered tissues. 3 credits

BME 543/643 Advanced Tissue Engineering Techniques
This course is designed to teach the techniques necessary to perform advanced research in Tissue Engineering. Techniques include the latest in imaging, stem cell isolation, growth factor treatments and mechanical stimulation of engineered tissues. Prerequisites: BME 511/611 Molecular and Cellular Biology for Biomedical Engineering, BME 541/641 Mechanical Properties of Tissues I, and BME 542/642 Mechanical Properties of Tissues II. 3 credits

BME 544/644 Advanced Biomaterials
This course is a seminar-style course in which students critically evaluate key papers in the biomaterials literature. Specifics topics will change with developments in the field as well as with the students' interests. Students may take this course more than once. Prerequisites: BME 541/641 Mechanical Properties of Tissues I and BME 542/642 Mechanical Properties of Tissues II. 3 credits

BME 545/645 Biocompatibility: Host-Implant Interactions
This course provides the student with a firm understanding of how the body reacts to implanted biomaterials at the cell, tissue, organ, and systemic levels. In addition, specific characteristics that hinder or improve the biocompatibility of materials will be addressed. Prerequisites: BME 511/611 Molecular and Cellular Biology for Biomedical Engineering and BME 542/642 Mechanical Properties of Tissues II. 3 credits

BME 561/661 Neuronal Control Systems
This course explores various neuronal control systems from an engineering perspective. Topics include: control system theory; neuronal plasticity and state dependence; sympathetic nervous system control of cardiovascular functions, temperature, and respiration; and vestibulooculomotor control. 3 credits

BME 562/662 Motor Control
This course is intended to introduce the student to simple and complex mechanical, electronic, and digital control systems using human and animal skeletomuscular systems and robotics as model systems. The course will consist of three parts: first, the physiology and neural control of the neuromuscular system; second, control problems faced in designing robots with complex mechanical systems and the relation to problems faced by the mammalian motor control system; third, background and design of clinical devices and procedures for motor disorders, including stroke, spinal cord injury, balance disorders, and neuroprostheses. 3 credits

BME 563/663 Mathematic and Computational Modeling of Biological Systems
This course introduces mathematical and computational techniques for modeling the dynamics of biological systems. Topics will include analytical, numerical, and agent-based simulations using ordinary and partial differential equations, stochastic dynamics, and discrete methods. Applications will be drawn from topics including neural dynamics at the cellular and circuit level, circulation, respiration, and immune system response, molecular evolution, enzyme kinetics, and development. Discussion will include techniques for validating models and for incorporating experimental data, and the roles of simulation and theory in the effort to understand biological systems. 3 credits

BME 564/664 Methods in Neuromedicine
This course includes topics on methods related to the diagnosis, treatment and intraoperative assessment of the nervous system in humans. Topics include: electrical stimulation (neuronal excitability, diagnostic testing of nerves and brain structures, surgical monitoring, neuronal rehabilitation, and functional electrical stimulation); safety (coupling to biological tissues, excitotoxicity, neuronal vulnerabilities, and special considerations with disease states); drug targeting; blood brain barrier; and basic neuro-imaging. 3 credits

BME 565/665 Introduction to Computational Neurophysiology
This course uses a hands-on approach to develop and explain concepts from computational neurophysiology. In this course students will explore how neurons communicate through electrical signals, how information transmission between neurons occurs, and how connectivity between neurons determines activity patterns and results in specialized behavior. The course has two goals: to help students understand how computational models can be used to analyze, explain and predict the physiological behavior of neurons and assemblies of neurons; and to provide students with an opportunity to use current research tools to investigate the concepts underlying these computational models. The course will include a short review of basic cellular neurophysiology, including action and membrane potentials, channels and channel blockers, and ion pumps, and of mathematical concepts needed to understand the material. Topics to be covered include Hodgkin-Huxley models of simple and complex morphologies; central pattern generators; models of simple invertebrate circuits; integrate-and-fire and spike-response neuron models for use in network models; models of neural development, ocular dominance and orientation columns; and rate versus spike-timing dependent plasticity. A solid math background is needed; some programming (in MATLAB) will be required. 3 credits

BME 566/666 Biomedical Signal Processing II
The course covers advanced techniques of digital signal processing for solving biomedical signal problems. Time and frequency domain filtering techniques, adaptive and optimal systems, detection of biomedical waveforms, spectral estimation and system modeling are covered. Applications to problems in ECG and EEG are featured. Prerequisites: BME 513/613 Biomedical Signal Processing and I and EE 582/682 Introduction to Digital Signal Processing. 3 credits

BME 567/667 Visual Sensory Systems
In this course, the anatomy, physiology and function of visual systems are examined with emphasis on the dynamic processing of visual inputs and on technological approaches to functional analysis and on methods for diagnosis of eye diseases. Topics to be covered include optics, anatomy of the eye, retinal physiology, signal processing, plasticity, perception, functional assessment with complex visual stimuli and evoked potentials, and new developments in visual prosthetic systems. 3 credits

BME 568/668 Auditory and Visual Processing by Human and Machine
Interaction between humans and machines could be greatly enhanced by machines that could communicate using human sensory signals such as speech and gestures. Knowledge of human information processing including audition, vision, and their combination is, therefore, critical in the design of effective human-machine interfaces. The course introduces selected phenomena in auditory and visual perception, and motor control. Students learn how to interpret empirical data, how to incorporate these data in models, and how to apply these models to engineering problems. The anthropomorphic (human-like) signal processing approach is illustrated on engineering models of perceptual phenomena. 3 credits

BME 571/671 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 of speech signal used for speech coding and synthesis, enhancement of degraded speech, speech recognition, speaker recognition, and language identification. 3 credits

BME 581/681 Fourier Analysis
Fourier analysis is used in nearly every field of engineering, including biomedical engineering. It provides a unifying mathematical approach to the study of networks, electrical and mechanical systems, linear systems, image and signal processing, as well as many other systems. This course will provide a solid introduction to application of Fourier theory in biomedical engineering. Topics include: convolution and correlation; Fourier theorems; Numerical transforms; Sampling and series; Discrete Fourier transform and the FFT; Related transforms. Prerequisites: one year of calculus. 3 credits

BME 601 Prequalifying Ph.D. Research
Supervised Ph.D. research prior to passing the programs qualifying exam. Variable and repetitive credit

BME 603 Ph.D. Dissertation Research
Research toward the dissertation for the Ph.D. degree occurring after passing the qualifying exam. Variable and repetitive credit

COMPUTER SCIENCE & ENGINEERING

CSE 501 M.S. Non-thesis Research
(Formerly CSE 610)
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 501 may count as one class to fulfill the M.S. non-thesis graduation requirements. Variable and repetitive credit

CSE 502/602 Independent Study
Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval from the faculty member and the student's academic department. Variable and repetitive credit

CSE 503 M.S. Thesis Research
(Formerly CSE 700)
Research toward the thesis for the M.S. degree. Variable and repetitive credit

CSE 504/604 Professional Internship
(Formerly CSE 620)
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 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 506/606 Special Topics
(Formerly CSE 58X)
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. Some recent offerings include: Advanced Functional Programming; Building Secure Systems; Formal Verification of Software; High Assurance Software Engineering; Information Integration; Information Retrieval on the Internet; Internet Technology; Networking Practicum; Principles of Database Systems; 3D Graphics; Real-time Rendering Using Modern Graphic Architecture; Scientific Visualization; Security Protocols; and Web Data Management. 3 credits

CSE 511/611 Principles of Compiler Design
This course introduces the basics of building a compiler using a multiphase translation process. It covers lexical analysis, parsing and translation to abstract syntax using modern parser generator technology. It discusses binding of identifiers and symbol table organization, and a variety of intermediate representations that are suitable for back-end analysis. It investigates back-end transformations and optimizations for a number of languages. Other topics include type checking, static analysis and basic run time support. Compiling is essentially a process of symbolically manipulating program representations represented by tree and graph-like data structures. Because of this, we will use tools that facilitate symbolic manipulation and definition of such structures as parser and lexical generators, and tools for generating code from pattern-based descriptions. Prerequisite: CSE 533. 3 credits

CSE 512/612 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 513/613 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 514/614 Introduction to Database Systems
A survey of database management systems (DBMS) capabilities. The course covers topics on how to use a DBMS, including: database design, data dependencies and normalization, and SQL (including embedded SQL). The course also introduces topics on how DBMS systems are implemented, including: secondary storage structures, relational algebra, query processing, query optimization, transactions, and recovery. The course focuses on relational database systems and the SQL query language. Students participate in a small project to design, populate and query a database. Prerequisites: Data structures, discrete mathematics and mathematical logic or equivalent understanding of these topics.
3 credits

CSE 515/615 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 as well as a basic understanding of computer communications problems and protocols.
3 credits

CSE 516/616 Introduction to Software Engineering
(Formerly CSE 500)
Software engineering is concerned with the ways in which people conduct their work activities and apply technology to produce and maintain software products and software-intensive systems. Issues of concern include specification, design, implementation, verification, validation and evolution of software artifacts. Related topics include software metrics, project management, configuration management, quality assurance, peer reviews, risk management and process improvement. This course presents an integrated view of these topics and related issues. It is an essential course for anyone working in development, maintenance, management or related areas in a software organization.
3 credits

CSE 517/617 Software Engineering Processes
(Formerly CSE 503)
This course is concerned with examining and improving the software development processes, including the technical, managerial and cultural processes, used by organizations to develop and maintain high-quality software systems in a timely and economical manner. Various process models, including the SEI Capability Maturity Models, the ISO SPICE model, the Team Software Process, and the Personal Software Process are studied and contrasted. Tailoring of process models to fit local situations and various approaches to software process improvement are presented. Students select and complete term projects that address topics in software process improvement. 3 credits

CSE 518/618 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 refactoring, automated unit testing, pair programming, participatory design and managing short product development cycles. These principles and techniques will be illustrated in a term-length project that provides design and implementation experience.
3 credits

CSE 519/619 Object-Oriented Analysis and Design
(Formerly CSE 504)
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 529/629 Object-Oriented Programming is intended as a follow-on course for CSE 519/619. 3 credits

CSE 520/620 Software Architecture
In this course, we will learn a core vocabulary of published architectural patterns and develop skill in recognizing and applying these patterns. In addition, we will examine case studies of large systems architecture development and evolution. Lectures will provide structure and points of view missing from the textbook. The course will encourage recognition and discussion of controversial ideas from the literature on software architecture. Students will learn heuristics for design and evaluation of software architectures. Coursework will emphasize frequent small tests and a hands-on project to gain skill in collaborating and reasoning about architectures.
3 credits

CSE 521/621 Introduction to Computer Architecture
This course provides a broad introduction to computer architecture. It covers a large amount of material in moderate depth, providing a good understanding of the basic issues in computer system design. Specifically, the course covers instruction set design, pipelining, the memory hierarchy, I/O systems, networking issues and multiprocessors. Example systems include the Intel x86, MIPS and DEC Alpha processors. Prerequisites: Experience writing software, preferably with some C or assembler programming. NOTE: Computer architecture has become a quantitative science, so there will be considerable algebraic manipulation involved in the performance analysis component of the course.
3 credits

CSE 522/622 Advanced Computer Architecture
This course is a follow-up to CSE 521/621. 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 521/621. 3 credits

CSE 523/623 Multimedia Networking
This class is an advanced course focused on multimedia networking. In particular, it focuses on the networking and compression support necessary to make such systems more scalable and adaptive to load. The course will consist of three main components. In the first third, we will review some of the basic background material necessary for the rest of the course including basic compression technologies (LZW), image compression (PNG, GIF, JPEG), audio compression (u-law, A-law, MPEG-audio), and video compression technologies (H.263, MPEG-1, and MPEG2). The second part of the course will focus on systems support, architecture, and compression technologies necessary to support the efficient transmission of multimedia. In the third part of the course, we will focus on efficient networking technologies and architectures to support streaming media. 3 credits

CSE 524/624 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 socket programming experience with the client/server model. Provides experience reading Internet RFC's and/or drafts. Prerequisites: Familiarity with the functions of a modern multi-user operating system such as is covered in CSE 513/613 or PSU's CS 533; familiarity with C programming on modern UNIX computers. 3 credits

CSE 525/625 Advanced Networking

This course is a seminar-style course targeted at learning about advanced Internet technology and Internet research. In particular, we will choose from a range of contemporary papers and topics dealing with gigabit switching and routing, web switching, firewalls, traffic engineering, MPLS, lambda switching, issues in wide-area networking, internet routing, packet classification, fast IP routing lookups, content-addressable networks, peer-to-peer networking, wireless networking, Internet mapping and measurement, content distribution networks, overlay networks, sensor networks, ad hoc networks, power-aware networking, intrusion detection systems, distributed denial of service attacks and prevention, web and application server technology, browser technology, and web cashing. Prerequisites: CSE524 TCP/IP Internetworking Protocols. 3 credits

CSE 526/626 Advanced Topics in Operating Systems

This course includes an in-depth study of modern operating system design. The course is based on reading recent research papers, and includes an emphasis on evaluating the papers in addition to understanding the systems they describe. Topics vary from year to year but typically include micro-kernel operating systems, lightweight inter-process communication, extensible operating systems, file systems, mobile computing, ubiquitous computing, workstation clusters, adaptive resource management, and OS support for multimedia applications. Prerequisites: CSE 513 and CSE 521. 3 credits

CSE 527/627 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 528/628 Cryptography

This course covers the major modern cryptographic techniques — the core technology for the area of information security. We start with an overview of classical cryptography and information theory. Then we examine in-depth the most widely used cryptosystems: symmetric systems such as DES (Data Encryption Standard) and AES (Rijndael, the new standard), and public-key systems, notably RSA. Discrete log systems and standard digital signature schemes are also covered, including elliptic curve cryptography. The course should be accessible to anyone who is willing to encounter some number theory. 3 credits.

CSE 529/629 Object-Oriented Programming

(Formerly CSE 509)

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 519/619, 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 519/619 or equivalent. 3 credits

CSE 530/630 Introduction to Mathematical Logic

Provides a foundation to mathematical logic, with an emphasis on its applications in computer science. Topics covered include: propositional and first-order predicate calculi; soundness and completeness; computational tree logic and model checking; foundations of automated theorem proving and logic programming; modal logic and knowledge engineering; program verification; computability, decidability, and incompleteness. 3 credits

CSE 531/631 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 532/632 Analysis and Design of Algorithms

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

CSE 533/633 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 to stack and tape (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 534/634 Domain Specific Languages

This course introduces students to the techniques used to design sound and usable DSLs. It teaches the abstraction techniques used to make such designs easy to modify and evolve, and the implementation techniques used to embed such designs into an underlying system. Recent events have added a wealth of written material that the class will draw from for inspiration and guidance. Papers will be selected from the January 1997 DSL workshop held in conjunction with POPL, the October 1997 Usenix Conference on Domain Specific Languages, and the Usenix Domain Specific Language Conference held on Oct. 3-5 in Austin, Texas. The class is structured around student-led discussions of the literature and lectures by the instructor. There are reading and programming assignments and a project. 3 credits

CSE 535/635 Categories in Computer Science

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

CSE 536/636 Functional Programming

(Formerly CSE 502)

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

CSE 541/641 Database Implementation

This course explores the internals of relational database management systems. This course will give students a strong grounding in the design tradeoffs and implementation issues that are addressed by large relational database systems. The course will also help DBA's understand how the tuning parameters of commercial databases can affect performance, and will help database application programmers to create applications better tuned to take advantage of the database internals. Typical topics discussed include file and index implementation, buffer management, query processing, cost-based query optimization, concurrency control, transaction processing, and logging and recovery implementations. The class includes hands-on programming assignments. Prerequisite: CSE 514; UNIX and C/C++ programming experience is recommended. 3 credits

CSE 542/642 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 current product. Prerequisite: CSE 514 or other introductory database course.
3 credits

CSE 543/643 Foundations of Database Systems

This class is designed to build an understanding of database formalisms that appear in research papers and other sources, evaluate and understand the benefits of particular formalisms, and develop formalisms. This course covers the mathematical foundations of database data models and query languages. Topics, covered at varying levels of depth, include query formalisms and their equivalence, query transformation, semi-structured data models, dependencies and normal forms, logic and deductive databases, data language complexity, treatment of incomplete information, complex-value models, semantic models and classification, and temporal databases. Students will have regular homework assignments, a midterm exam, and a presentation on an assigned topic or a final exam. Prerequisites: CSE514/614. 3 credits

CSE 544/644 XML Data Management

XML has been adopted as the prime standard for both exchanging and integrating data from diverse data sources. Unlike traditional databases XML is a flexible format that can represent many classes of data. As a result, it is increasingly being adopted as the central component of many applications with a wide range of requirements, from e-commerce and scientific applications to document management systems. The ability to handle these widely different scenarios adds significant complexity to the various data management tasks. Not surprisingly, XML data management (XDM) has become an active area of research. This course will discuss the new data management problems that arise with XML. It will cover techniques and systems that address these problems, offering insights into the advantages and drawbacks of various solutions. Students will have a choice of various kinds of projects to work on, including new research problems and improvements on published results. Prerequisite: CSE514/614 Introduction to Database Systems. 3 credits

CSE 547/647 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 550/650 Spoken Language Systems

Spoken language systems will revolutionize how people interact with machines, replacing the keyboard and mouse with natural conversations. These systems will act like helpful human assistants and teachers for information access, commercial transactions, and learning. You'll review the state of the art in building spoken language systems. You will gain hands-on experience using toolkits for building such systems, as well as learn the technologies needed for next-generation systems, such as robust parsing, semantic processing, dialogue management, and agent architectures. Class projects will be done using the CSLU toolkit, Tcl/Tk, and VoiceXML. 3 credits

CSE 551/651 Structure of Spoken Language

Speech is considered a key component in the future of human-computer communication. However, the success of speech recognition and text-to-speech synthesis systems depends on development of the technology as well as further research advances. Research and development of spoken-language technology is facilitated by an understanding of the acoustic and symbolic structure of language, as well as the capabilities and limitations of current systems. This course will present some of what is known about speech in terms of phonetics, acoustic-phonetic patterns, and models of speech perception and production. The goals are for the student to understand how speech is structured, understand and identify acoustic cues (especially in different phonetic contexts), and understand how this information may be relevant to automatic speech recognition or generation systems. 3 credits

CSE 552/652 Hidden Markov Models for Speech Recognition

(Formerly ECE 580-HMM)

Hidden Markov Model-based technology is widely used in today's speech recognition systems. This course is an introduction to speech recognition using HMM technology. Topics include dynamic time warping, Markov Models and Hidden Markov Models (discrete, semi-continuous, and continuous), vector quantization, Gaussian Mixture Models, the Viterbi search algorithm, the Forward-Backward training algorithm, language modeling, and speech-specific adaptations of HMMs. The course is focused on understanding these fundamental technologies and developing the main components of speech recognition systems. Prerequisite: C programming experience. 3 credits

CSE 553/653 Speech Synthesis

(Formerly BME 572/672)

This course will introduce students to the problem of synthesizing speech from text input. Speech synthesis is a challenging area that draws on expertise from a diverse set of scientific fields, including signal processing, linguistics, psychology, statistics, and artificial intelligence. Fundamental advances in each of these areas will be needed to achieve truly "human-like" synthesis quality and advances in other realms of speech technology (like speech recognition, speech coding, speech enhancement). In this course, we will consider current approaches to sub-problems such as text analysis, pronunciation, linguistic analysis of prosody, and generation of the speech waveform. Lectures, demonstrations, and readings of relevant literature in the area will be supplemented by student lab exercises using the Festival text-to-speech system and other hands-on tools. 3 credits.

CSE 558/658 Evolutionary Computation

The field of evolutionary computation encompasses machine learning methods inspired by biological evolution, as well as the computational modeling of evolutionary processes in nature. The techniques of evolutionary computation include genetic algorithms, genetic programming, evolvable hardware, evolutionary robotics, and related methods. These methods have been used to solve problems in engineering design and optimization, robot control, bioinformatics and drug design, financial prediction, and image processing, to name a few applications. They are beginning to be widely used in the scientific and commercial worlds. This course is a hands-on introduction to these techniques and the theory behind them. Students will learn the basics of evolutionary computation by implementing various methods themselves and applying them to simple versions of real-world problems (when possible, related to the students' own research or applications interests). More advanced topics will include coevolutionary learning, agent-based and artificial life simulations, and the theoretical foundations of evolutionary computation. Prerequisites: Programming experience in any high-level language. 3 credits.

CSE 559/659 Machine Learning

This course provides a broad introduction to techniques for building computer systems that improve through experience. It provides both conceptual grounding and practical experience with several learning systems. The course provides grounding for advanced study in statistical learning methods, and for work with adaptive technologies used in speech and image processing, robotic planning and control, diagnostic systems, complex system modeling, and iterative optimization. Topics include: learning paradigms and concept learning, decision trees, artificial neural networks, statistical sampling and empirical error estimation, Bayesian learning (including an introduction to belief networks), clustering, principal and independent component analysis, generalization theory, memory-based (instance) techniques, evolutionary computation, and reinforcement learning. Students will gain practical experience implementing and evaluating systems applied to pattern recognition, prediction, and optimization problems. Prerequisites: Some experience with multi-variate calculus and linear algebra, at least one high-level programming language, and an elementary undergraduate course in probability and statistics. 3 credits.

CSE 560/660 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 561/661 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 562/662 Natural Language Processing

An introduction to artificial intelligence techniques for machine understanding of human language. This 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 563/663 Multi-Agent Systems

This course covers the emerging theory and practice of multiagent systems: semi-autonomous, semiintelligent 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. The course will examine agent communication languages, including KQML and FIPA, as well as the underlying general speech act theories. Students learn to model these systems formally and will develop and program individual agents that can participate in a multiagent system. 3 credits

CSE 564/664 Introduction to 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, a multidisciplinary approach to system design and evaluation is stressed. The course reviews basic research methods, terminology, viewpoints, and activities in the broad field of human-computer interaction. It includes coverage of research on human computer interaction, as well as practical issues in system interface 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 565/665 Advanced Topics in Human-Computer Interaction

This course reviews advanced topics and current research in the field of human-computer interaction, surveys key research challenges that exist, and discusses emerging trends in next-generation system design. Topics include advanced research and design methods, new recognition-based and multimodal interfaces, conversational interfaces and animated character design, mobile interfaces, ubiquitous and tangible interfaces, adaptive interfaces, advanced user modeling and design for universal access, and other key issues. Topics are covered from a broad multidisciplinary perspective, with an emphasis on real-world users and usage contexts. In addition to weekly classroom lectures, guest lectures, and discussion, this class includes a hands-on practicum component in which students participate in state-of-the-art research and interface design to complete a team project. Pre-requisites: CSE564 or instructor's consent. 3 credits

CSE 567/667 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 568/668 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 569/669 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 572/672 Security Protocols
This course is about the design and analysis of protocols (multi-party algorithms) for secure communication over computer networks. Following a review of cryptographic primitives, we will study common security services (confidentiality, authentication, integrity, non-repudiation, anonymity) and their integration in network protocols. Some standard solutions (Kerberos, SSL, IPsec, X.509, PGP) will be covered in detail. We will study pitfalls in the protocol design and methods for establishing protocol correctness. 3 credits

CSE 601 Ph.D. Prequalifying Research
(Formerly CSE 600)
Ph.D. supervised research activity.
Variable and repetitive credit

CSE 603 Ph.D. Dissertation Research
(Formerly CSE 800)
Research toward the dissertation for the Ph.D. degree.
Variable and repetitive credit

ENVIRONMENTAL AND BIOMOLECULAR SYSTEMS

EBS 501 M.S. Non-Thesis Research
(Formerly BMB 610 and ESE 610)
Supervised research as a component of the M.S. non-thesis degree. The plan of research and final deliverables must be approved by the research advisor and the SPC. Deliverables include a written report and/or seminar given as part of EBS 507A. A maximum of 8 credits from EBS 501 may be applied to a degree. Variable and repetitive credit

EBS 502/602 Independent Study
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 EBS 507A/607A - EBS 507B/607B - EBS 507C/607C. Selection of this course for credit and the topic to be investigated must be approved by the SPC. Variable and repetitive credit

EBS 503 M.S. Thesis Research
(Formerly BMB 700 and ESE 700)
Research toward the M.S. thesis degree.
Variable and repetitive credit

EBS 504/604 Professional Internship
(Formerly BMB 620 and ESE 620)
Professional internship credits provide students 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 following graduation. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students and Scholars before enrolling. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit

EBS 506/606 Special Topics
(Formerly BMB 58X and ESE 58X)
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently. Variable and repetitive credit

EBS 507A/607A EBS Department Seminar
(Formerly BMB 591 and ESE 599)
Weekly seminars by invited guests. Public visitors are welcome. Schedules are available on the World Wide Web at www.ebs.ogi.edu/seminars/, or by request at info@ebs.ogi.edu. 1 credit, repetitive

EBS 507B/607B Student Seminar: Metallobiochemistry
(Formerly BMB 594)
Presentations and discussions of selected topics from the recent literature and of ongoing research projects in the department. 2 credits, repetitive

EBS 507C/607C Student Seminar: Molecular Biology/Biochemistry
(Formerly BMB 596)
Presentation and discussion of journal articles from the recent literature in molecular biology, genetics and biochemistry. 2 credits, repetitive

EBS 510/610 Aquatic Chemistry
(Formerly ESE 510)
General acid/base concepts (mono- and polyprotic systems); pH calculations; making activity corrections; introduction to simple numerical methods used to make speciation calculations; titration concepts as applied to natural water 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; introduction pe-pH diagrams. 4 credits

EBS 511/611 Advanced Aquatic Chemistry
(Formerly ESE 511)
Role of complexing ligands in solution chemistry; redox chemistry in natural systems; pe-pH diagram construction and use; solid/solution interfacial considerations; the electrical double layer; and selected advanced topics. Prerequisite: EBS 510/610. 4 credits

EBS 512/612 Biochemistry I: Proteins and Enzymes
(Formerly BMB 527)
Primary, secondary and tertiary structure of proteins; enzyme mechanisms; enzyme kinetics. 4 credits

EBS 513/613 Biochemistry II: Introduction to Molecular Biology
(Formerly BMB 528)
DNA replication, RNA synthesis and protein synthesis; genetic code; gene regulation. 4 credits

EBS 514/614 Biochemistry III: Metabolism and Bioenergetics
(Formerly BMB 529)
Metabolism of carbohydrates, lipids, amino acids and nucleotides; bioenergetics; oxidative phosphorylation; photosynthesis. 4 credits

EBS 518/618 Metals in Biochemistry
(Formerly BMB 537)
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

EBS 520/620 Coordination Chemistry
(Formerly BMB 538)
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

EBS 523/623 Chemical Group Theory
(Formerly BMB 539)
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; H¸ckel molecular orbital theory; ligand field theory; electronic spectroscopy and vibrational spectroscopy.
4 credits

EBS 525/625 Bioenergetics and Membrane Transport
(Formerly BMB 532)
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

EBS 528/628 Enzyme Structure, Function and Mechanisms
(Formerly BMB 533)
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

EBS 530/630 Introduction to Bioinformatics
(Formerly BMB 544)
Primary literature of computational biology and hands-on experience in data manipulation from local and remote databases. 3 credits

EBS 535/635 Distribution and Fate of Organic Pollutants
(Formerly ESE 514)
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 those phases. Recommended prerequisite: EBS 510/610. 4 credits

EBS 537/637 Chemical Degradation and Remediation
(Formerly ESE 516)
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: EBS 511/611 and 535/635. 4 credits

EBS 538/638 Air Pollution: Origins, Chemistry and Control
(Formerly ESE 519)
This course will focus on tropospheric air pollution with particular emphasis on the urban and regional scales. It will discuss the following items: basic structure of the atmosphere and relevant meteorological considerations; sources of tropospheric air pollutants; atmospheric photochemistry; the ozone, oxide of nitrogen and hydrocarbon chemical cycles; chemistry of toxic organic compounds in the atmosphere; gas and aqueous phase chemistry of sulfur dioxide; size distributions, lifetimes, origins and formation mechanisms of aerosols; measurement and control of atmospheric pollutants. 3 credits

EBS 540/640 Instrumental Methods in Biophysics I
(Formerly BMB 534)
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

EBS 541/641 Instrumental Methods in Biophysics II
(Formerly BMB 535)
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

EBS 547/647 Uncertainty Analysis
(Formerly ESE 504)
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

EBS 550/650 Environmental Systems Analysis
(Formerly ESE 506)
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

EBS 555/655 Computational Fluid Dynamics
(Formerly ESE 508)
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 EBS 545/645. 4 credits

EBS 560/660 Introduction to Environmental Observation and Forecasting Systems
(Formerly ESE 520)
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

EBS 561/661 Introduction to Spatial Sciences
(Formerly ESE 522)
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 graticule. 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. ARCVIEW, a popular Geographic Information System (GIS) software tool, will be stressed. 4 credits

EBS 562/662 Introduction to Remote Sensing of the Environment
(Formerly ESE 523)
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 multi-spectral 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 EBS 561/661, "Introduction to Spatial Science." It is therefore recommended that students who are unfamiliar with classification methods and the fundamental concepts of Geographic Information Systems complete EBS 561/661 or equivalent. 4 credits

EBS 570/670 Groundwater and Watershed Hydrology
(Formerly ESE 540)
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

EBS 571/671 Groundwater Modeling
(Formerly ESE 541)
Applied groundwater modeling using the finite difference method. Introduction to numerical methods for solving the partial differential equations for saturated and unsaturated subsurface flow. Model execution and calibration. Prerequisite: EBS 570/670. 4 credits

EBS 572/672 Contaminant Hydrology
(Formerly ESE 542)
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

EBS 573/673 Modeling in Contaminant Hydrogeology
(Formerly ESE 543)
This course is designed to be taken concurrently with EBS 572/672. It emphasizes the hands-on use of common mathematical models for groundwater flow and transport (e.g., MODFLOW/MODPATH/MT3D/RT3D) to examine real groundwater contamination problems. Prerequisite: EBS 572/672.
4 credits

EBS 574/674 Introduction to Environmental Forecasting Systems
(Formerly ESE 538)
This course addresses the composition and novel uses of observation and forecasting systems towards the enhanced understanding and management of natural resources. 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

EBS 575/675 Transport Processes
(Formerly ESE 530)
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

EBS 578/678 Methods in Estuarine Oceanography: Field Observation
(Formerly ESE 539)
This course covers the fundamentals of estuarine and coastal oceanographic data collection using vessels and remotely moored equipment. Topics include vessel logistics and sampling, navigation systems, interfacing of instruments with personal computers, types of moorings and their deployment and recovery, and telemetry. 4 credits

EBS 580/680 Physics of Pacific Northwest Coastal Ecosystems
This course considers the impacts of climate, hydrology, and coastal, estuarine and fluvial circulation on Pacific Northwest coastal ecosystems. Special attention will be given to human impacts on ecosystem through alteration of their physical context. Examples will include downstream effects of water withdrawal, the interaction of climate change and climate cycles with salmonids and the coastal upwelling ecosystem, and the interaction of microbes, particles, consumers and estuarine circulation in estuarine turbidity maxima. Prerequisites: EBS 575/675 Transport Processes. 4 credits

EBS 581/681 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

EBS 583/683 Environmental Law and Regulation
(Formerly ESE 586)
A survey of environmental law and regulation concepts essential to practicing scientists and engineers. Topics covered include the theory and practice of environmental regulation, environmental litigation, and legislation including Superfund (CERCLA), the Clean Water Act, the Resource Conservation and Recovery Act (RCRA), the Clean Air Act, and the Toxic Substances Control Act (TSCA). 3 credits

EBS 585/685 Advanced Molecular Biology
(Formerly BMB 540)
An in-depth study of the molecular mechanisms governing the replication, recombination, transcription, and translation of genetic material. Emphasis is placed on experimental approaches that have led to our understanding of these fundamental processes.
4 credits

EBS 586/686 Molecular Genetics of Development
(Formerly BMB 541)
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

EBS 587/687 Molecular Cell Biology
(Formerly BMB 542)
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

EBS 590/690 Environmental Microbiology
(Formerly ESE 550)
This course provides an introduction to environmental microbiology, emphasizing 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 2004-2005, may be offered in combination with EBS 593/563. 4 credits

EBS 593/693 Biodegradation and Bioremediation
(Formerly ESE 554)
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: EBS 590/690.
4 credits

EBS 596/696 Principles of Toxicology and Risk Assessment
(Formerly ESE 570)
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

EBS 598/698 Current Topics in Proteomics
(Formerly BMB 543)
Proteomics is a new 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

EBS 601 Ph.D. Prequalifying Research
(Formerly BMB 600 and ESE 600)
Research toward the dissertation for the Ph.D. degree before completing the comprehensive examinations.
Variable and repetitive credit

EBS 603 Ph.D. Dissertation Research
(Formerly BMB 800 and ESE 800)
Research toward the dissertation for the Ph.D. degree after completing the comprehensive examinations. Variable and repetitive credit

ELECTRICAL ENGINEERING COURSES

EE 501 M.S. Nonthesis Project Research
(Formerly ECE 610)
Supervised project research for master's students who are not pursuing a thesis. A student's academic department may have additional requirements or restrictions. Contact your academic department for further details. Variable and repetitive credit

EE 502/602 Independent Study
(Formerly ECE 591)
Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval from the faculty member and the student's academic department. Each department may have additional requirements or restrictions. Contact your academic department for further details. Variable and repetitive credit

EE 503 M.S. Thesis Research
(Formerly ECE 700)
Research toward the thesis for the M.S. degree.
Variable and repetitive credit.

EE 504/604 Professional Internship
(Formerly ECE 620)
Professional internship credits provide students 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 following graduation. Students on F-1 or J-1 visas must obtain prior written approval for internships from OGI's Office of International Students and Scholars before enrolling. Enrollment requires a faculty advisor and is limited by the number of internship opportunities available.
Variable and repetitive credit.

EE 506/606 Special Topics
(Formerly (Formerly ECE 580-XXX)
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently. Variable and repetitive credit.

EE 511/611 Analytical Scanning Electron Microscopy
(Formerly ECE 565)
This course introduces the operation and theory of SEM and covers sources, lenses, accelerating voltage, detectors, image formation, beam-specimen interactions, beam-produced signals, the combined effects of signal-to-noise ratio and spot size in determining resolution, and stereo imaging SEM. The process of specimen preparation, metallo-graphic grinding and focused ion beam-produced transverse cross sections, planar sections, coating techniques for nonconductors, sampling of powders, and isolation of contaminants are some of the topics covered. Students are encouraged to work on materials they provide. The course covers the operation of energy dispersive X-ray detectors, qualitative analysis, quantitative analysis, elemental mapping, spectrum artifacts, and contaminant and compound identification. The lecture portion of this course can be presented on site at companies in a 6-week period. Corresponding lab sessions are done at OGI. A project requiring operation of the SEM at the students' convenience during the remainder of the quarter and a written report is the basis for a grade.
3 credits

EE 512/612 Focused Ion Beam Technology
(Formerly ECE 566)
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 student's convenience during the remainder of the quarter and a written report is the basis for a grade.
3 credits

EE 513/613 Transmission Electron Microscopy
(Formerly ECE 567)
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. This 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 diffraction, reciprocal lattice and Ewald Sphere construction. Kinematic and dynamic theories of image formation will be introduced. Combining lectures with hands-on laboratory practice, students will be instructed in the use of sample preparation equipment and an analytical transmission electron microscope. Students will be expected to carry out basic experiments on selected materials that illustrate fundamental concepts covered 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 student's convenience during the remainder of the quarter and a written report are the basis for a grade.
3 credits

EE 514/614 Failure and Reliability in Microelectronics
(Formerly ECE 568)
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 student's convenience during the remainder of the quarter and a written report are the basis for a grade.
3 credits

EE 525/625 Introduction to Electromagnetics for Modern Applications
(Formerly ECE 507)
This series (EE 525/625-527/627) covers essentials of electromagnetic theory for modern practitioners in such areas of engineering and applied science as semiconductor devices; IC design; optics, lasers, and optoelectronics; wireless and optical communications; electronic displays; electron and ion beam technology; vacuum electronic devices; and various biomedical applications. The course is practically oriented, and presents both analytical and numerical methods. The first course introduces basic experimental laws and theoretical concepts. Laplace and Poisson equations for static electric and magnetic potentials. Basic properties of electromagnetic materials. Maxwell equations for static and time-varying fields. Wave equations and Poynting theorem. Finite-difference numerical solution of boundary-value problems. Prerequisite: Some undergraduate electromagnetism, calculus through ordinary and partial differential equations, some vector calculus, or consent of instructor.
4 credits

EE 526/626 Electromagnetics for Modern Applications II
(Formerly ECE 508)
This course introduces additional mathematical tools and covers topics basic to circuit design, semiconductor device operation, IC design, optics, transmission lines, and antenna design. Waves in conductors and skin effect are included. Retarded potentials for time-varying fields. Electromagnetics of lumped-element circuit theory. Plane wave propagation, reflection, and refraction. Polarization states and Stokes parameters. Analytical methods for boundary-value problems and numerical solution by boundary-element method. Introductory (TEM) field theory of transmission lines and its relation to circuit model. Prerequisite: EE 525/625 and some linear algebra or consent of instructor. 4 credits

EE 527/627 Electromagnetics for Modern Applications III
(Formerly ECE 509)
This course covers advanced transmission line and wave guide field theory for high speed interconnects, microwave and optical wave guides; resonant cavities for frequency control and lasers; and radiation basics for communications and optics. Topics include TE and TM transmission line and wave-guide modes. Field theory of multiple-conductor transmission lines: Modes, coupling, crosstalk, and termination. Dielectric wave guides. Resonant cavities. Radiation from antennas and apertures. Additional topics as time permits, chosen from: electromagnetic properties of materials; variational formulation of field problems and finite element numerical solution; analytical and numerical calculation of charged-particle motion in electromagnetic fields; suggestions of students. Prerequisite: ECE526/626 and some linear algebra or consent of instructor. 4 credits

EE 528/628 Introduction to Electronic Materials
(Formerly ECE 515)
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 to ultimately derive the energy band structure, effective mass, and equilibrium carrier statistics. Next, we use these statistics to define carrier transport in semiconducting materials. Finally, we study and understand 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

EE 529/629 Fundamentals of Semiconductor Device Structures
(Formerly ECE 516)
Semiconductor bulk, junction and surface properties. We develop the fundamentals of semiconductor structures; bulk defects; mechanisms affecting electron/hole transport at low and high electric fields; junction formation/stability (p-n, metal-semiconductor, and metal-insulator); and relationships between semiconductor properties and device performance. The underlying concepts of minority carrier and majority carrier devices are expounded and clarified. 4 credits

EE 530/630 Advanced Semiconductor Devices: Structures and Materials
(Formerly ECE 517)
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

EE 531/631 Introduction to Quantum Mechanics for Electrical and Computer Engineers
(Formerly ECE 510)
Courses EE 531/631-532/632 present basic quantum theory for understanding practical applications such as solid state devices, lasers and other opto-electronic devices, properties of electronic materials, band-gap engineering, quantum effects due to shrinking IC feature sizes, quantum-dot and quantum-well devices, and quantum computing. The first course introduces basic concepts and results essential to understanding solid-state band structure, devices based on tunnelling, and quantum-well devices. Topics include a review of classical mechanics. The Schroedinger equation, postulates of Quantum Mechanics, and basic Hilbert-Dirac formalism. The free particle. One-dimensional quantum-well bound states and tunneling through potential barriers. Bloch functions in periodic potentials and the origin of solid-state band structure. Prerequisite: Calculus through ordinary and partial differential equations, or consent of instructor. 4 credits

EE 532/632 Advanced Quantum Mechanics for Electrical and Computer Engineers
(Formerly ECE 511)
This course covers two- and three-dimensional applications, and introduces new physical phenomena, mathematical formulations, and tools essential for understanding materials science, lasers, solid state devices, quantum optics, and quantum computing. Covered are two- and three-dimensional quantum wells. The simple harmonic oscillator and algebraic methods. Angular momentum and spin. Matrix formulation of Quantum Mechanics. Atomic structure. Approximation methods, including perturbation theory. Interaction of matter and electromagnetic waves. Prerequisite: EE 531/631 plus some linear algebra, or consent of instructor. 4 credits

EE 533/633 Advanced MOSFET Analysis I: DC Models
(Formerly ECE 512)
This is the first part of a three-course sequence addressing this important need. Starting with contact potentials and properties of semiconductor surfaces, we analyze, (within the charge sheet and depletion approximations), the charges and potentials in MOS capacitors from accumulation to flat band to inversion (including the role of oxide charge). With these results we discuss various MOSFET dc current models based on the gradual channel approach: Symmetric (body-referenced) models and the concept of extrapolated pinch-off potential, source-referenced models and the concept of extrapolated threshold voltage (including body effect); more compact models for strong inversion and for sub-threshold behavior (weak inversion); interpolation models for moderate inversion. The compact models are then modified in a semi-empirical way to describe the effects of ionimplanted 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 deletion effects). Breakdown and punch-through are discussed qualitatively. Prerequisites: basic electrostatics, semiconductors and circuits. 4 credits

EE 534/634 Advanced MOSFET Analysis II: Dynamic Models
(Formerly ECE 513)
Based on EE 533/633 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 at low and 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. Prerequisite: EE 533/633. 4 credits

EE 535/635 MOSFET Modeling for VLSI Circuit Design
(Formerly ECE 514)
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, EFLKV, PCIM. 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

EE 536/636 Operation of Semiconductor Devices
(Formerly ECE 580-OSD)
This class is aimed at professionals and full time students who wish to gain physical insight into operation of semiconductor devices. Emphasis will be on conceptual understanding of the underlying principles. The course content will include a review of junctions and MOS structures, followed by examination of basic IC devices, including memory and power devices. Students seeking in-depth coverage of BJTs and MOSFETs are recommended to take the EE 533/633-535/635 series. 4 credits

EE 537/637 Thin Film Deposition and Applications in Semiconductor Fabrication
(Formerly ECE 535)
Covers thin film deposition topics, such as thermal evaporation, plasma deposition, chemical vapor deposition (CVD and MOCVD), molecular beam epitaxy (MBE), atomic layer epitaxy (ALE), electrochemical deposition, and electroless deposition. Thin film deposition forms the basis for manufacture of modern integrated circuits; 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

EE 538/638 Surface Science for Semiconductor Technology
(Formerly ECE 536)
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 these phenomena to the study of the BET equation as a tool for the determination of surface area. 4 credits

EE 539/639 Computer-Aided Analysis of Circuits
(Formerly ECE 557)
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

EE 540/640 Microelectronic Device Fabrication I
(Formerly ECE 560)
This course is the first in a full-year, three-term sequence that treats both the science and practice of modern microelectronic fabrication. The principles of crystal growth and wafer preparation, ion implantation, doping and diffusion, and oxidation are all covered. Emphasis is placed on understanding the basic chemistry, physics, and material science of wafer processing. This includes crystal structure and defects, heterogeneous chemical reactions, the thermodynamics and kinetics of diffusion, etc. In addition, the practical implementation of these processes is also discussed. This includes realistic process flows, physical metrology, device structure and electrical behavior, trade-offs, etc. The course is intended to serve both working process engineers and matriculating graduate students. 4 credits

EE 541/641 Microelectronic Device Fabrication II
(Formerly ECE 561)
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 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

EE 542/642 Microelectronic Device Fabrication III
(Formerly ECE 562)
This class starts with electron beam, x-ray, and photolithography, including discussion of resist technology (e.g., chemically amplified resists). This followed by fundamentals and applications of plasmas for etching and deposition (e.g., high-density plasmas), including plasma damage. Other topics considered are process integration, 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

EE 543/643 Plasma Processing of Semiconductors I
(Formerly ECE 563)
Fundamental plasma properties. Plasma production, properties, and characterization. DC and RF plasmas. Sputtering. Sputtering as a deposition process for the growth of thin films. Multicomponent films. Plasma etching. 4 credits

EE 544/644 Chemical Mechanical Planarization
(Formerly ECE 580-CMP)
Chemical Mechanical Planarization (CMP) is rapidly growing in use within the microelectronics industry to planarize wafers as one of the processing steps. While simple in concept - chemical and mechanical material removal processes, the CMP is a complex tribological system. Mechanical abrasion and polishing mechanisms interact and co-exist with chemical layer removal processes. This course will present some of the historical background to CMP from its inception to the current state of knowledge, the underlying concepts behind the tribological processes of abrasion, grinding, and polishing mechanisms and the principles behind the chemical phenomena. Building on these fundamental concepts, this course will examine oxide CMP, tungsten CMP, and the role of CMP on the planarization of copper and other materials. 4 credits

EE 545/645 Electronic Materials and Device Characterization
(Formerly ECE 569)
This class is designed for engineers and scientists who wish to understand the basic principals behind the electrical and optical techniques used to characterize semiconductor materials and devices. These techniques are crucial in determining the causes of failure in semiconductor devices. Among the parameters covered are contact resistance, carrier mobility and lifetime, defects, oxide and interface trapped charges, as well as series resistance, channel length /width, threshold voltage and hot carriers in MOSFETs. This class includes some lab time. 4 credits

EE 546/646 Design of Digital Communication Circuits
(Formerly ECE 580-DDC)
Digital communications concepts including transmission, media, encoding, and synchronization. Review of BJT and CMOS circuit design and analysis. Amplifiers, filters, amplitude control, equalization. Phase locked loops, clock and data recovery. Transmitter and receiver design. Networks. Project: complete design of a serial optical link. 4 credits

EE 547/647 Statistical Process Control and DOE
(Formerly ECE 580-DOE)
Over the past 30 years design of experiments (DOE) has proven to be an extremely value tool allowing USA manufacturing to re-gain its lead as the highest quality producer in the world. Course is geared for engineers in any industry/discipline seeking a practical understanding of design of experiments. Class will cover a review of basic statistical techniques, Ttest, F-Test, full factorial design, Yates Algorithm, ANOVA, Hadamard designs, fractional factorial designs, block designs, Latin squares, regression analysis and response surface methodology. Emphasis will be on practical applications of techniques to real world problems and how to avoid some of the typical errors made in designing, executing and analyzing an experiment. Actual industrial examples will be used throughout the class to allow the student to see the value of these techniques. Class project will involve the student actually running a DOE on a topic of interest. 4 credits

EE 548/648 Fundamentals of Sensors and MEMS Fabrication
(Formerly ECE 580-FSM)
The market for Micro-Sensors and MEMS devices is expanding at an ever-increasing rate. Ranging from simple environmental sensors to electronic noses to micro-actuators, the applications are diverse. While conventional integrated circuit processing can be modified and utilized for Micro-sensors and MEMS fabrication, these devices can also be constructed using a wide variety of non-CMOS techniques and in many cases using non-CMOS materials. This course will explore micro-fabrication for Micro-Sensors and MEMS from the variety of photolithography processes (conventional, LIGA, soft lithography, micro-contact printing), additive processes (CVD, PVD coatings, electroplating), and subtractive processes (chemical etching, DRIE and RIE) which have been used to construct devices ranging from accelerometers to chemical sensors to actuators and microfluidic pumps. 4 credits

EE 549/649 Introduction to Nanomaterials
(Formerly ECE 580-IN)
As the transistor gate length approaches 50 nanometers, its electrical properties are subjected to novel quantum effects, necessitating a paradigm shift in design and fabrication of related semiconductor devices. This introductory course focuses on

applications of nanomaterials in a range of disciplines spanning from semiconductors and displays to biochips. The topics covered will include synthesis, fabrication and optoelectronic characterization. Selected device applications will emphasize (1) transistors based on silicon quantum dots and carbon nano-tubes, (2) displays, and (3) DNA/Protein biochips. This cross-disciplinary course is for electrical engineering as well as biologists wishing to learn the complementary technologies and assessing the impact of nanostructured materials on their respective disciplines. 4 credits

EE 550/650 Introduction to Sensor Microfabrication
(Formerly ECE 580-ISM)
Tired of simulating and modeling everything that you have ever learned about semiconductor devices? This course includes a lab in which students have the opportunity to build microsensors. The course will cover fundamental processing methods and introduce some background information on sensor operation. The rest of the course will be spent learning how to grow oxides, dope semiconductors, carry out a full photolithography process, evaporate metal, and perform chemical processes that result in a fully operational sensor. By the end of the course, students will have fabricated and tested their devices. This course is recommended for students who have an interest in the MEMS and Semiconductor Sensors courses. Lab fee is required. 4 credits

EE 551/651 Introduction to Liquid Crystal Displays
(Formerly ECE 580-LCD)
Introduction to nematics, cholesterics, smectics, and polymer-dispersed liquid crystals. Course emphasizes methods used to probe electro-optic properties of liquid crystals related to display device applications. Course delineates anisotropic interaction of liquid crystals with applied electromagnetic fields. Consequences of liquid crystal-electric field responses in relation to various addressing schemes (passive vs. active) used in twisted nematics, supertwisted nematics, and ferroelectric liquid crystal displays, are discussed. LIQUID, a general-purpose LCD simulation software, is used to simulate active matrix liquid crystal displays properties, switching speeds and viewing angles of LCD's. Includes lab. 4 credits

EE 552/652 Micro-electro-mechanical Systems
(Formerly ECE 580-MEM)
Combining the miniaturization and processing techniques of semiconductor technology with mechanical structures, MEMS offer new opportunities for 'devices' and solutions. Graduating from initial development as electro-mechanical locks, MEMS devices are now ubiquitous in mirror assemblies for digital projectors, and optical handlers. Other applications include micro-manipulators, fluid handling units, micro-turbines, and even rocket engines. This course covers the types, design, processing, and analysis of MEMS devices. 4 credits

EE 553/653 Modern Photolithographic Engineering
(Formerly ECE 580-MPE)
An in-depth course designed for students and industry engineers seeking a better understanding of the photolithographic process as used to fabricate integrated circuits. All material presented is supported with examples from actual processes used by industry leaders. 4 credits

EE 554/654 Reliability and Failure of Electronic Devices, Packages, and Assemblies
(Formerly ECE 580-RFD)
An overview of electronic devices, packages and their reliability. Defects, contaminants, and yield; the mathematics of failure and reliability; mass transport-induced failure; electronic chargeinduced damage; environmental damage to electronic products; packaging materials, process and stresses; degradation of contacts and package interconnections; degradation and failure of electrooptical materials and devices; characterization and failure analysis of materials and devices; future directions and reliability issues. 4 credits

EE 555/655 Simulation & Modeling of VLSI Interconnect
(Formerly ECE 580-SMV)
Review of Maxwell's equations and mathematical methods relevant for computational electromagnetics for VLSI. Boundary element / method of moments, finite difference (2D/3D), finite element and stochastic methods for computation of capacitance and resistance. Fast capacitance simulation using multipole and random walk methods. Inductance simulation using partial equivalent element models (PEEC). Introduction to finite difference time domain (FDTD) and full-wave solution techniques. Large-scale extraction of capacitance, resistance and inductance from layout: algorithms and models. Construction of equivalent circuits and network reduction techniques. Wireability issues in VLSI circuits. Rents rule and stochastic wiring distribution models. Circuit design issues related to interconnect: a discussion based on analytical models and metrics for noise and delay. Inductance effects in high speed digital circuits. Interconnect issues related to clock distribution and power grid networks. Brief review of circuit simulation algorithms relevant to interconnect such as AWE and scattering parameter based methods. Simulation of frequency dependent elements using convolution techniques. Review of lossy transmission line algorithms in SPICE . Thermal and reliability issues and models relevant to VLSI interconnect. The course will include projects where students will implement algorithms and also use existing simulators and extractors to obtain hands on experience. 4 credits

EE 556/656 Semiconductor Sensors
(Formerly ECE 580-SSE)
The emergence of MEMS and the continual size reduction of the transistor have enabled engineers to design micro- and nano-sensor technologies for a wide range of applications. In this course, we investigate the physics of sensing, the characteristics of different categories of sensors, and materials and fabrication fundamentals in a case-based format. This course is intended for both electrical engineering students and scientists whose work is expected to require interaction with sensor technologies. Students will be asked to research and write a sensor case study or to research and demonstrate to the class a specific sensor technology. Although not required, it is recommended students take EE 550/650, Introduction to Sensor Microfabrication and EE 552/652, Micro-electro-mechanical Systems in conjunction with this course. 4 credits

EE 557/657 Technology of Photoresists
(Formerly ECE 580-TP)
Modern semiconductor fabrication relies heavily on the use of photoresists to fabricate integrated circuits. This course will introduce basic chemical and photo-physical properties of resists, with a discussion of resists that are currently in use. Various resist-processing steps involved in lithography, such as surface-preparation, coating, optical/radiation exposure, developing, etching and resist stripping will be presented. We will conclude with a discussion of materials used in emerging soft lithographic techniques that allow nanometers resolution. 4 credits

EE 560/660 Introduction to Electronics and Instrumentation
(Formerly ECE 500)
Review of fundamental electronics components and design: passive components, transistor circuits, op amps, RC circuits, frequency domain, and time domain response. Feedback theory, op amp limitations, precision op amp circuits. Noise, interference, grounding, and shielding. Phase-locked loops, lockin amplifiers. Practical advice on component selection and circuit design. Equipment and circuit demonstrations in class. Homework includes Pspice circuit simulation problems. 4 credits

EE 561/661 Analog Integrated Circuit Design
(Formerly ECE 571)
Design techniques for analog integrated circuits. Silicon bipolar and JFET analog integrated circuit design. Technology overview, device structures, Ebers-Moll equations, hybrid-pi model. Single-stage amplifiers, current sources, active loads, output stages. Operational amplifiers, bandgap references, frequency response, feedback, stability. Design project. 4 credits

EE 562/662 Digital Integrated Circuit Design
(Formerly ECE 572)
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

EE 563/663 Analog CMOS Integrated Circuit Design
(Formerly ECE 580-AC)
Design techniques for CMOS analog integrated circuits. Technology overview and models. Single-stage amplifiers, current sources, biasing, active loads,

class AB output stages. Low-voltage design, bandgap references, operational amplifiers, frequency response, compensation. Design project.
4 credits

EE 564/664 High Speed Interconnect Design
(Formerly ECE 558)
Analysis, design, and measurement of digital interchip interconnects operating at multi-gigabits per second. Topics include: transmission line analysis, timing analysis, measurement equipment and techniques, lossy and coupled transmission lines, frequency domain analysis, differential signaling, equalization, modulation techniques, and design methodology. A design/research project is used to give students practical insight into high-speed differential signaling challenges. 4 credits

EE 565/665 Introduction to Wireless Integrated Circuit Design
(Formerly ECE 580-ACD)
Analog integrated circuit design for wireless communications. Transistor models, biasing, distortion, matching networks, noise modeling, low noise amplifiers, mixers, power amplifiers. Design project.
4 credits

EE 570/670 Advanced Logic Design
(Formerly ECE 573)
This course constitutes a basic introduction to the design and implementation of computer logic. Basic principles of discrete logic will be presented, including Boolean algebra, finite-state machine design, logic minimization and optimization using both hand-compiled (Karnaugh maps) and EDA tool based techniques. Students will apply logic design techniques to PLD (Programmable Logic Devices) and FPGA (Field Programmable Gate Array) devices. In addition, students will learn the basics of Verilog (HDL) Hardware Description Language. The last part of the course will include a Verilog HDL design project using the ModelSim logic simulator. This course or its equivalent is a prerequisite to all other Computer Engineering (EE) Design courses.
4 credits

EE 571/671 System On a Chip (SOC) Design with Programmable Logic
(Formerly ECE 559)
Programmable logic, such as FPGA and PLD devices, has become a major part of digital design. Recent advances in semiconductor technology have made it possible to implement an entire system on a single chip. This course will discuss tools and techniques for designing, validating and implementing System-on-Chip (SoC) designs using programmable logic. Designs are first expressed in Verilog, a Hardware Design Language (HDL), simulated to verify design correctness, then synthesized to logic primitives, and finally placed and routed into a programmable logic device. The course has a project orientation - students will take designs from concept to HDL description and validation through synthesis and then to programmable device implementation. Industrial EDA tools will be used. Prerequisites: EE570/670 required or consent of instructor.
4 credits

EE 572/672 Advanced Digital Design — Timing Analysis and Test
(Formerly ECE 580-TNT)
This course focuses on timing and design-for-test topics in FPGA and ASIC design and implementation. The course uses industrial EDA tools. Topics covered include fundamentals of digital system timing, multi-clock design issues such as synchronization and clock domain boundary crossing, metastability and synchronization failure, timing-driven logic synthesis, static timing analysis, skew and jitter analysis, clock distribution, phaseand delay-locked loops, faults in digital systems, scan testing and automated test pattern generation. Prerequisites: EE 571/671 required or consent of instructor. 4 credits

EE 573/673 Computer Organization and Design
(Formerly ECE 580-COD)
Basic computer organization. Memory hierarchy (including caches), pipelining, computer arithmetic, number representation, floating point arithmetic processors, controllers, input/output, buses, DMA. Data formats, addressing modes, instruction sets, and microcode. This course bridges the gap between the Computer Engineering (EE) Design courses and CSE 521/621 - Introduction to Computer Architecture. Prerequisites: EE 570/670 recommended, or taken concurrently. 4 credits

EE 574/674 CMOS Digital VLSI Design I
(Formerly ECE 574)
An 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/flip-flops) and subsystem design (adders, multipliers, etc.). An understanding of basic digital design concepts is assumed. Lab exercises use industry-standard design tools. Laboratories include circuit validation and characterization. Prerequisite: EE 570/670.
4 credits

EE 575/675 CMOS Digital VLSI Design II
(Formerly ECE 575)
Concentration on advanced digital VLSI circuit design techniques. Architecture and micro-architecture of VLSI components, clocking schemes, input/output circuits, and special functional blocks such as random access memories, read only memories and programmable logic arrays. The course covers design tradeoffs, especially considering cost, power and performance. The course devotes a considerable amount of time to layout, parasitics and performance verification. Introduction to design and verification tools with hands-on experience. Prerequisites: EE 574/674, familiarity with MOS transistor operation; computer architecture and organization; logic design. 4 credits

EE 576/676 Algorithms for VLSI Design & Test
(Formerly ECE 580-VDT)
Computer-aided Design (CAD) of integrated circuits require complex algorithms and software tools to enable designers develop designs that meet a host of specifications such as area, performance, testability and power to state a few. In this course we review the underlying algorithms and methods used in design of integrated circuits and provide insight into the challenges faced today. This course may be of interest to graduate students in the area of digital circuit design where the students are introduced to underlying algorithms and principles of design tools used in design of integrated circuits. This understanding will enable the designer to make appropriate educated choices required during the design process. The next type of students interested in this course will be students of computer science who are interested in seeing applications of algorithms and optimization techniques to the integrated circuit design process. 4 credits

EE 580/680 Linear Systems
(Formerly ECE 550)
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 a general framework for time-varying linear systems, but places major emphasis on the time-invariant systems, whose structure and dynamics are knowable to the very utmost detail. Both continuous-time and discrete time linear systems are studied. The course provides a strong body of foundational material, which is utilized in virtually all applications-specific areas pertaining to system analysis/design and signal/information processing. The major topics covered are: canonical realizations, equivalent systems, canonical transformations, canonical decompositions, solution of state equations, stability, controllability and observability, design of asymptotic observers, state-feedback compensation schemes. Linear Quadratic Regulator and Kalman Filter are also introduced. 3 credits

EE 581/681 Introduction to Signals, Systems and Information Processing
(Formerly ECE 544)
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. Studied next are 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 which 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 EE 581/681 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 EE 582/682. A goal of the presentation this course is to impart the essential unity of all the transforms and the almost perfect correspondence of approach in continuous-time and discrete-time contexts. This course is a useful prerequisite or co-requisite to EE 582/682 and all other courses in the information processing area.
3 credits

EE 582/682 Introduction to Digital Signal Processing
(Formerly ECE 551)
The representation and processing of signals and systems in the discrete or digital domain is the preferred mode in today's computer and information driven technologies. DSP provides the core building block from cell phones to modems, HDTV to video conferencing, or from speech recognition to MP3 audio. This classes covers the fundamental concepts and mathematics including representation and analysis of discrete time signals and systems, Z-Transforms, Discrete-Time Fourier Transform (DTFT), and the Discrete Fourier Transform (DFT), sampling and windowing techniques pertaining to discrete time processing of continuous signals, analysis and design of recursive (IIR) and nonrecursive (FIR) digital filters, and applications of the Fast Fourier Transform (FFT) to convolution, spectral analysis, and audio processing. Prerequisite: EE 581/681 or equivalent. 3 credits

EE 583/683 Digital Signal Processing II
(Formerly ECE 552)
This follow-up course to EE 582/682 examines several widely used advanced signal processing methods. 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.
3 credits

EE 584/684 Introduction to Image Processing
(Formerly ECE 542)
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, multi resolution 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: EE 582/682. 3 credits

EE 585/685 Introduction to Digital Video Processing
(Formerly ECE 543)
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: EE 584/684. 3 credits

EE 586/686 Adaptive and Statistical Signal Processing
(Formerly ECE 554)
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. Course designed for electrical and computer engineers specializing in signal processing and the information sciences. This course provides background for additional classes offered in machine learning. Prerequisites: EE 582/6821 plus an undergraduate level course in probability and statistics. 3 credits

EE 587/687 Data and Signal Compression
(Formerly CSE 546/646)
The need for signal and data compression is ubiquitous in image, video and speech processing, finance and computational science. Where data stores become very large (e.g. video, finance, earth science), the need is not met by simple lossless file compression schemes, and we must turn to sophisticated coding techniques. This course addresses both the theoretical basis and practical algorithms for data and signal compression. Topics include lossless entropy-based coding, including Huffman and Lempel-Ziv, and lossy compression techniques including scalar quantizers, transform coding (Karhunen-Loeve, DCT and nonlinear transform codes), predictive coding, vector quantization, adaptive codes and wavelets. The relation between compression schemes and probabilistic data modeling is emphasized in conjunction with each technique. Application to speech, image and video coding are discussed. Students will have the opportunity to design compression schemes for such diverse applications as earth science data, finance, speech or video, depending on their interests. Prerequisites: Undergraduate calculus, introductory probability and statistics, some programming experience. 3 credits

EE 590/690 Digital Communication I
(Formerly ECE 526)
Communications system models for various modulation and demodulation band limited base-band systems. Optimum detection, source encoding/ decoding. Waveform communications and signal space representation. Pre-requisite: undergraduate course in digital or analog communications. 3 credits

EE 591/691 Digital Communication II
(Formerly ECE 527)
Channel noise and capacity. Typical random and fading channels, optimum filters and signal design. Probability of error in noisy band limited channels for different modulations. Optimal design of BFSK, BPSK, QPSK, m-QAM, CPM modulators and demodulators via MAP and ML techniques. Phase lock loops and Costas detectors. Energy-bandwidth tradeoffs in digital modulation. Pre-requisite: EE 590/690 or permission, and statistics with probability. 3 credits

EE 592/692 Digital Communication Systems
(Formerly ECE 529)
Convolutional and RS coding, Viterbi decoding. Multi-path fading and its effects on performance and diversity signaling. Synchronization architectures. Spread spectrum. Channel equalization. Pre-requisite: EE591/691 or equivalent or permission.
3 credits

EE 593/693 Analytical Techniques in Statistical Signal Processing and Communications
(Formerly ECE 525)
Development of the mathematical techniques needed to analyze systems involving random variables and/or stochastic processes with particular application to communications and instrumentation. Topics include Bayes Theorem (discrete and continuous forms), Tchebycheff inequality, Chernoff Bound, Central Limit Theorem, stationary processes and linear systems, mean square estimation, Poisson process, Gaussian process, Markoff process, and series representations. MATLAB and the MATLAB Statistics Tool Box are used in this course. 3 credits

EE 601 Prequalifying Ph.D. Research
(Formerly ECE 600)
Supervised research participation. Pre-qualifying Ph.D. research prior to passing qualifying examination. Variable and repetitive credit

EE 603 Ph.D. Dissertation
(Formerly ECE 800)
Research toward the dissertation for the Ph.D. degree.
Variable and repetitive credit

APPLIED MATHEMATICS

MATH 510/610 Multivariate Calculus and Differential Equations
(Formerly CSE 555a)
This course reviews essential mathematical methods required for the analysis of continuous time processes in science and engineering, focusing on multivariate differential and integral calculus and the solution of ordinary differential equations. Calculus topics include: continuity and convergence, Taylor's theorem, gradients and directional derivatives, chain rules, and implicit functions. In the second half of the course, the fundamentals of ordinary differential equations are examined. Differential equations topics include: exact, numerical and power series solution methods, systems of coupled ODEs, qualitative analysis of autonomous and nonautonomous linear and non-linear systems, linearization of non-linear systems, and Lyapunov stability analysis. An introduction will also be provided to the topics of bifurcations and chaos. 3 credits

MATH 511/611 Introduction to Discrete Numerical Methods
(Formerly ESE 500)
This course provides an introduction to discrete numerical methods. Lectures cover the theory and application of methods for the numerical solution of initial-value, boundary-value and mixed initial-boundary- value problems by finite differences, weighted residuals, numerical integration and finite elements. Prerequisite: Calculus. 3 credits

MATH 513/613 Linear Algebra
This course covers the fundamentals of linear algebra. Major topics include: vector spaces and subspaces, linear transformations and linear operators, orthogonal bases and orthogonal projections, and the properties of eigenvalues and eigenvectors. Particular emphasis will be given to: similarity transformations to canonical forms such as the Jordan form, canonical operator representations such as the Spectral Factorization and the Singular Value Decomposition, and the interpretation of all matrix results as an application of general operator theory to the particular class of finite-dimensional linear operators. Properties of determinants, Moore-Penrose pseudoinverse, and solutions to systems of linear equations will also be studied in detail. 3 credits

MATH 517/617 Probability and Statistics
(Formerly CSE 544a and CSE 544b)
This course provides an introduction to probability, statistical inference and statistical analysis. The aims of the course are to provide scientists and engineers with a comprehensive introduction to essential concepts in probability and statistics, and for students to gain proficiency in applying these concepts to data analysis. Topics include exploratory data analysis, sampling distribution theory, confidence intervals, hypothesis testing, maximum likelihood estimation, linear regression, goodnessof-fit, ANOVA, and parametric and non-parametric tests. The primary analysis tool for this course is Excel. 3 credits

MATH 519/619 Engineering Optimization
(Formerly CSE 556 and CSE 556b and ECE 555)
This course introduces advanced numerical optimization methods for quantitative work in science and engineering. The course will cover important traditional methods for constrained and unconstrained multivariate optimization, including line search methods and gradient-based techniques, as well as linear, quadratic and dynamic programming. In addition, more heuristic techniques such as genetic algorithms, differential evolution and simulated annealing will also be presented. The primary programming tool for this course is Matlab. Some knowledge of linear algebra and multivariate calculus is required, as is a basic grasp of probability and statistics. 3 credits

MATH 521/621 Random Processes and Simulation
This course provides an introduction to random processes and their application in science and engineering. The approach is non-theoretical, where key results are explained heuristically and the focus is on application of the concepts. Topics include Poisson and Gaussian processes, Markov chains, spectral analysis, and Monte Carlo simulation. The primary analysis tool for this course is Matlab. 3 credits

MATH 523/623 Combinatorics and Graph Theory
Discrete mathematical models based on combinatorics and graph theory have a wealth of applications, to computer science, communications, transportation, genetics, experimental design, scheduling, and so on. This course is an introduction to the tools of combinatorics from an applied point of view. Topics covered include counting techniques, generating functions and recurrence relations, modeling using graphs, digraphs and weighted graphs, graph properties and algorithms. 3 credits

MATH 525/625 Partial Differential Equations
This course addresses the most common of the Partial Differential Equations used in science and engineering, namely second order linear equations. Topics covered are complex variable theory, a review of Linear Algebra (including vector spaces, matrices, and eigenvectors), Fourier Series, Fourier and Laplace Transforms, and Elliptic, Parabolic and Hyperbolic equations. The use of Separation of Variables in solving these types of equations will be a focus as will Boundary Conditions of the first, second and third kinds. Sturm-Liouville theory for expansion and solutions in the Cartesian and Polar coordinate systems will also be discussed. 3 credits

MATH 527/627 Applied Functional Analysis
(Formerly ECE 580-AFA)
This course aims to make the guiding ideas of Real Analysis, Complex Analysis and formal Functional Analysis accessible to students, researchers and practitioners in applied engineering areas. Basic algebraic, geometric and measure structures are defined, including: Group, Ring, Field, Vector Space, Inner Product Space, Topological Space, Metric Space, Measure Space, Probability Space, Normed Linear Space, Banach Space, Hilbert Space. We study the distinctive properties of mappings between mathematical objects of these sorts, ranging from the simplest set correspondences, through the basic real and complex functions, up to the highly structured class of Hilbert Space operators, with particular emphasis on generalized Fourier Analysis. Knowledge of this material greatly enhances one's ability to read sophisticated technical material and to conduct one's own advanced work in any highly mathematical area. 3 credits

MANAGEMENT IN SCIENCE AND TECHNOLOGY

MST 502 Independent Study
Independent study allows a student to work one-on-one with a faculty member on selected topic(s) of interest. Registering for independent study requires pre-approval from the faculty member and the student's academic department.
Variable and repetitive credit

MST 506 — Special Topics
(Formerly MST 58X)
Special topics courses are offered in areas of particular relevance to the research interests of faculty or in response to industry needs. Special Topic courses are subject to change and are offered intermittently.
Variable and repetitive credit

MST 507HC Seminar for Healthcare Management
A Healthcare Management student participation seminar and a topical paper or product. 2 credits

MST 509 Commercialization Practicum
(Formerly MST 543)
This hands-on practicum focuses on commercializing emerging technologies. Students learn the entrepreneurial development skills necessary to move a new technology from "mind to market." Student teams, working with emerging technologies held by OHSU, produce assessments and plans for bringing a new technology to market. Teams determine the commercial viability of a product by looking at the market and business channel options as well as the technical feasibility. Students gain an understanding of strategic considerations in the product commercialization process, how to determine market viability and technology and market timelines, application of intellectual property issues in the product commercialization process, and determination of how to reach the customer. M.S. in Management students may be able to extend work from this practicum into their MST 550 Capstone project. 3 credits

MST 510 Principles and Trends in Technology Management
This course focuses on how companies choose, develop and/or acquire the technologies that they use to design, manufacture, deliver and support profitable products. Students look at these practices from three different (but related) perspectives, namely the R&D manager, the product line manager, and the vice president of marketing. The course examines the issues in managing technology throughout its lifecycle, from research and development, through product development, and on into the marketplace.

Technologies of interest span electronics, information technology, biosciences, materials, energy and environment. The focus is on today's "emerging technology" environment of rapid innovation, short time cycles and rapid price reductions. 3 credits

MST 511 Quality Management
This course is about managing quality in today's competitive environment. The focus is on the issues that quality managers face and the principles, strategies, methods, and tools that might be used to build an effective quality system. The class examines how management systems impact the delivery of quality, and considers the roles of process management and quality systems for building and sustaining quality. The emphasis of this class is on management practice rather than the technical or engineering attributes of quality. 3 credits

MST 512 Project Management
This course briefly reviews essential tools of traditional project management, followed by an examination of advanced concepts and techniques, including politics, communications, customer satisfaction, dealing with change, managing complexity, team-based solutions, managing managers and dealing with risk. The traditional tools of project management, such as CPM and PERT, are examined in the context of these much more critical issues that determine the success or failure of almost all technology projects. Since effective communication is so crucial to project management, the course includes sessions of instruction and coaching on effective presentation skills. 4 credits

MST 513 Operations Management and Practices
This course introduces the study of business process management in the operation of a firm. Students learn systems thinking and systems analysis skills with an emphasis on the understanding of current process performance as well as learning practices to enable higher levels of performance. Given the increasing trend toward contracting out many operational functions, the course also introduces key concepts of value chain management. The course instills two distinct perspectives: that of a process management consultant equipped with the right skills to help their business become more competitive, and that of a senior operations executive who needs to be knowledgeable about how their organization works. 3 credits

MST 514 Issues in R & D Management
This course examines 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 distinctive technical competence. 3 credits

MST 515 Supply Chain Management
This course focuses on the strategic aspects of supply chain management. Supply chain management is the management of processes across complex networks of companies that while independent are in reality interdependent. Therefore, the ability of a company to generate high profits in an uncertain economy is often a direct result of the effectiveness of its supply chain. Supply chain management 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
This course emphasizes operations and logistics in firms that source, produce, distribute and market in multiple nations. The management of logistics in such firms differs from its domestic counterpart along several key dimensions. First, the company must be able to identify and analyze factors that differ across nations and that influence the effectiveness of the logistics function. In addition, because of the distances involved, transportation and distribution are of greater significance. Finally, these geographically dispersed facilities and markets must be integrated and managed to enhance the strategy of the business unit. Therefore, some sessions will focus on cross-national decisions and others on managing across nations. This course is built on a robust financial foundation to help students to develop analytical skills required for managers in companies committed to global markets doing business across borders. 3 credits

MST 517 Supply Chain Management: Advanced Modeling
This course introduces optimization in supply chain modeling. The emphasis is mainly on large-scale real-world supply chain distribution network design. The major skills taught are problem definition, model formulation, and solution analysis. Students use commercial software such as SAILS and GSCM for large mixed-integer programming, and GAMS for hands-on mathematical modeling. Other topics of the course focus on how to manage financial uncertainty under market chaos using real options methodology with Crystal Ball Monte Carlo-based software. 3 credits

MST 520 Becoming an Effective Manager
This course develops participants' ability to understand and influence human behavior within technology-intensive organizations. Students learn to manage themselves, manage one-on-one relationships at work, manage their careers, and manage teams, all using ethical approaches to building coalitions and influencing others without formal authority. A major emphasis in the course is the practice of "reframing" ñ the ability to rethink and re-conceptualize a situation so as to widen one's perspective and available responses. Reframing is an important skill for managing people and projects in fast-changing organizations that are creating or using new technologies. Participants learn and practice setting and managing agendas (while juggling multiple demands), building and sustaining networks (while satisfying various stakeholders), and taking productive, ethical action (while honoring the values and culture of the organization). 4 credits

MST 521 Managing Human Resources
This course focuses on the professional management of people, including the fundamentals of recruiting, hiring, motivating, rewarding and appraising workers. The course focuses on how human resource (HR) management can create value and deliver results. Participants will examine the relationship between an organization's HR practices and the organization's effectiveness and competitive success. HR systems must be designed to fit each organization and group of people; all managers must know and practice good HR management for the organization to be successful. After completing the course, students will have mastered a variety of best practices for managing people at work. 3 credits

MST 522 Influencing Change in Organizations
This course focuses on designing effective organizations and managing change in organizations in which engineering, manufacturing, and/or scientific technologies are critical. Tools for assessment and redesign of organizations are emphasized. The course pays special attention to organizing for lateral coordination and integration, as this is a required capability in technology-intensive organizations. Topics also include: change methodology; roles in a change initiative; competencies and mind-sets required to effectively lead change; and the impact of change on people and organizations. Students are encouraged to design their own organizational change using a combination of the frameworks. Taking MST 520 first is recommended. 3 credits

MST 523 New Product Development
This course is aimed at managing innovation and creativity while at the same time achieving reliable robust products that hit market objectives aligned with the company's business strategy. Learning how to bring new products to market that hit pricing/cost targets, on a predictable competitive launch date, with winning performance criteria, is the primary goal for this class. By the end of the course, students will be able to put together a product concept definition, carry out a pro forma financial analysis, and produce a product specification. Additional topics include identifying and managing the technological and programmatic risks associated with a new product, and understanding the trade-off between cycle time and product quality risks. 4 credits

MST 524 eBusiness: Strategy and Roadmap
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, inform and empower employees better than ever before. The course will provide students with a practical understanding of what it takes to develop the "digital enterprise". The first part will address the issue of developing a robust business model that capitalizes on the new opportunities. The second part will cover the e-business architecture and applications (like customer relationship management, supply chain management, selling chain management), and how to develop and implement the e-business strategy. Cases and articles will be utilized to illustrate the successful strategies and techniques used by lead-

ing companies. Taking MST573 and MST530 previously is highly recommended. 4 credits

MST 530 Strategic Management and Planning
This course focuses on the analysis of fast-changing competitive environments and on the decision-making process leading to the formulation and implementation of strategy. The class explores using time, knowledge, and technology as competitive advantages, managing strategic change, and developing strategic plans for a future that cannot be known with certainty. Several different models for strategy formulation such as game theory, portfolio analysis, the "Five-Forces", and "Competing on the Edge" will be examined. As the ultimate test of strategy in the business world is running a company, class teams will play a computer simulation of operating a multi-product business in a dynamic, competitive environment. Prerequisites: MST 572, MST 573, MST 520 or instructor permission. 4 credits

MST 531 Software Commercialization
This course investigates the rapidly changing software industry, and how to work in and run a commercial software company. The course provides real-world perspective on the current issues involved in creating and commercializing software. Because the business models for hardware and software companies are quite different, the course focuses on the special problems of marketing, entrepreneurship, globalization, and alliances experienced by software firms. Special attention is given to the creation of value, standardization, and competitive strategy for high-volume software markets. One class project will probe issues and current trends in the software industry, and another will conduct a strategic assessment of a selected software company. 3 credits

MST 532 Issues & Trends in Managing Information Systems
This course focuses on how organizations choose information systems strategies and adopt best practices for managing information systems. The course examines the frameworks that have evolved to provide guidance in the selection of technologies and the management of critical processes and services. A key issue to be addressed is the evolution of methods to acquire solutions in response to the growth of information technology service offerings. Additional issues related to the legal and regulatory environment will be examined to trace the effects on information systems policies and investment priorities. A brief examination of the history and economics of information systems will be considered in conjunction with questions concerning the relevancy of information systems to strategic business advantage. This is a core course for students choosing the MIS area of emphasis. 3 credits

MST 533 Project & Program Management for MIS
This course focuses on the skills needed to plan, implement and complete information systems projects. The students will learn successful methods of management for achieving the project goal based on acceptable quality within the specified time and available resources. This course will also explore the challenges of program management, which involve managing a portfolio of multiple projects through capital budgeting processes and strategic priorities. This is a core course for students choosing the MIS area of emphasis. 4 credits

MST 534 Linking MIS and Corporate Strategy
This course addresses corporate strategy and management from the perspective of Management Information Systems, enabling increased utilization of technology to facilitate the effective business model execution, identification of skill sets needed to manage in a dynamic environment caused by accelerating change, and human resource forecasting in a global workforce. Elements necessary for successful integration of the MIS activities with the business strategy will be developed. Students gain an understanding of the concepts of strategy and how the formulation and implementation of an MIS strategy supports the overall enterprise strategy. This is a core course for students choosing the MIS area of emphasis. 4 credits

MST 535 Business Process Mapping
Tracing the flows of information and materials in the firm allows for efficiency improvements and effective application of IT. The course explains how to map these flows, streamline them prior to the introduction of IT, automate them with information technologies, and ensure that IT solutions enhance rather than impede good management of business processes. Students are introduced to enterprise resource planning (ERP) tools. 4 credits

MST 536 Managing Information Systems Security and Operations
The course analyzes the concerns of top management regarding liability issues in file sharing, hacking, and identity theft; compliance; disaster recovery; and risk management. The topics of costing, constructing, maintaining and policing a secure IT facility are addressed. Students will understand the profit impacts of security breaches, liability areas, and nondisclosure and non-compete agreements. Balanced attention is given to the nature of hacking, worms and viruses; to physical plant issues; and to personnel policies. Other legal and homeland security issues are also addressed. The course also focuses on managing a data center, managing a call center, managing outsourced IT/IS functions, interfacing with users, managing software licenses, managing the maintenance and support functions within the life cycle of purchased hardware, and managing the flow of jobs. 4 credits

MST 537 Leading Innovation in Managing\ Information Systems
The chief information officer (CIO) is responsible for the effective implementation of the organization's information systems and culture, and for managing relationships with the chief executive officer and chief financial officer; with vendors and customers; and with his/her own project managers. This course addresses collaboration, contract negotiation, and project negotiation from the perspective of the CIO. The firm is viewed as a socio-technical system, in which IT innovations must mesh with business profitability and the psychology and value systems of managers and employees in order to be successful. Professionals already working in IT are invited to use the course as an opportunity to explore aspects of MIS beyond their sphere of professional expertise. 3 credits

MST 538 Database Systems in a Business Context
This course focuses on the management challenges of designing, implementing and managing database applications within a corporate environment. Topics include database architecture, database features, database design, query languages, data modeling, data warehousing, database security, database implementation and management. The class emphasizes understanding the issues and concepts critical to managing database systems as well as an appreciation for the underlying technology and complexity of successful database systems. 4 credits

MST 540 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. The course is constructed to give students a grounding in both theoretical and hands-on aspects of international business. Course readings and lectures will focus on international trade theory, history and trends. Classroom discussions involve problem-solving exercises in which students develop skills for dealing with real world problems in international management. The group international management projects give students an opportunity to work as members of a team to accomplish international business objectives. 3 credits

MST 541 Leadership and Communication Skills
Effective interpersonal communication is the core competency from which we build the skills of personal influence, coaching, conflict resolution, personal awareness, and leadership. This course helps students develop interpersonal communication and negotiation skills for effective leadership. The focus is on personal skill building through effectively influencing in-class working groups. The course explores six leadership styles to discover where and when each is most effective. Students discover and assess their negotiations skills based on five standard negotiation styles. Personal reflection and learning are required for maximum skill development. 3 credits

MST 542 Business Ethics and Corporate Social Responsibility
This course focuses on ethical dilemmas, social issues and responsibilities, and government regulations and influences. First, the course examines different frameworks for individual decision making in an organizational setting. Next, the impact of organizational policies and practices, and the words and actions of managers on the behavior of individuals within those organizations is examined. Finally, the course focuses on the relationships between organizations and the societies in which they operate,

examining the perspectives of multiple stakeholders, including government regulators, community representatives, customers, employees, managers, and stockholders. 3 credits

MST 544 Strategic Alliances

Alliances have become an essential strategic element in growing a business. This course studies the structure of various types of alliances, and go into detail about best practices (what works) as well as unsuccessful practices (what doesnπt work). Guest speakers from industry bring in live examples of alliance experience. The class looks at a variety of companies as well as industries and geographies in order to understand the key issues in alliance development from several perspectives. The overall goal of the course is for the student to understand how an alliance fits into overall strategy, different types and characteristics of alliances, and best practices in the planning, selection, negotiation, and operation of alliances. 3 credits

MST 549 Applied Business Forecasting

This web-based course 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 that are 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. Anybody seeking to enhance his or her understanding of business forecasting from an applied perspective would benefit from taking this course. Knowledge of basic statistics and regression analysis is highly recommended, but not required. 4 credits

MST 550 Capstone Project: Business Plan

Entrepreneurship is, by its very nature, an integrative exercise. When designing and building companies, small teams must holistically integrate many discrete business skills in a very fluid, chaotic environment. This course presents students with the opportunity to put all of their business skills to the test as they work with actual high technology or healthcare startups, meet veteran entrepreneurs and startup experts, and prepare and pitch business plans. Experiencing the opportunity to “bridge the gap between theory and practice” is one of the goals of this course. Students take away a methodology for identifying and analyzing entrepreneurial opportunities throughout their careers. The course emphasizes business formation from the point of view of the founders/ senior executive team and explores the behaviors, talents, skills and experiences that can be acquired to prepare future senior executives. Capstone course students will plan, research, prepare and present a business plan in teams of 3 to 5 members. Presentation of the plan will be in both written and oral form. Prerequisites: MST 571, MST 572, MST 573, MST 512, MST 520, MST 530 and instructor approval. 4 credits

MST 560 The Organization, Financing, and History of Health Care Delivery in the United States

(Formerly MST 583)

There are increasing demands for administrators and managers who understand the complexities of the healthcare field and can provide effective leadership in these organizations. Besides specialized knowledge needed for a particular service area, or product line, each manager must understand the broader environment in which they work. This course provides a historical context for the current system: the current economic drivers, political pressures, ethical issues, and the roles of insurance and pharmaceutical companies. In addition, the course introduces students to the technological changes ñ both administrative and clinical ñ that will influence service delivery. Finally, a section of the course focuses on important issues in healthcare that influence the field at the time the course is presented. 4 credits

MST 561 Managerial and Financial Accounting for Health Care Professionals

(Formerly MST 581)

Principles of managerial and financial accounting are developed and used to examine difficult strategic and operational decisions confronting healthcare professionals. The course provides the healthcare decision maker with the necessary tools in managerial and financial accounting theory and concepts to make better financial management decisions on the job, as well as to make sound judgments regarding financial analyses performed by others. Topics include the interpretation of the income statement, balance sheet and cash flow statements, with a particular concern for how to analyze these statements, using financial ratios and other analytic tools. Students acquire an understanding of the complexities of cost behavior. The financial management decision-making processes addressed include financial projections, cost behavior, cost-volume-profit analyses, special decisions such as make-or-buy, costing, cost allocation and pricing. Students gain an enhanced conceptual and technical understanding of the managerial planning and control process, including strategic planning, operational budgeting, and capital budgeting and net present value analysis. 4 credits

MST 562 Health Care Program Management

This course focuses on the skills and tools needed to manage and develop a health care program, with detailed emphasis on business planning, program design, scheduling, and resource management, including human resources, capital equipment, and software infrastructure. Students gain an understanding of the basic tools of project management and how, when, and where those tools may apply to health care improvement or development projects. Upon completion of the course students will be able to establish a project plan that will permit the successful meeting of the objectives within the cost, time and available resource constraints. 4 credits

MST 563 The Regulation and Legislation of Health Care Delivery

The course reviews how governmental and non-governmental organizations influence health care delivery. Special emphasis is placed on current regulatory and legislative initiatives. Participants gain an increased understanding of the federal and state regulatory/reporting framework within which healthcare is delivered and the role of accreditation bodies within that framework. The course provides examples of the evolution of new legislative initiatives, both at the federal and state level, in order to demonstrate the complexity and impact of regulatory oversight on healthcare delivery. Guest lectures provide the perspectives of experienced authorities in areas of Risk Management, Legislation, Environmental Safety, Healthcare Law, Internal Audit, Medicare Reimbursement, and Healthcare Compliance. 4 credits

MST 564 Business Planning and Strategy in the Health Care Industry

The strategic management and planning of health care functional units, clinics and hospitals in today's fast-changing technology intensive environments is extremely challenging. The class focuses on analyzing, planning, decision-making, formulation of strategy and its implementation in a world where "growing" today's organization into an essentially unknowable future is essential for long-term success. The course examines the major drivers towards change in the health care environment, approaches to empowering the consumer in health care management, and the changing value proposition for health care. Students examine potential scenarios for the future of health care, the potential major drivers, and the question of who the “customer” really is in health care. Invited speakers who are strategic decision makers in the health care industry share their expertise with the class. 4 credits

MST 565 Human Resources in Health Care

This course focuses on the management of people in healthcare organizations. This course is designed to provide the knowledge and tools for healthcare managers to manage people in all aspects of their work: recruiting, hiring, motivating, and managing performance, conflict and change. In addition, aspects of the external environment that affect how people are managed in the workplace, including employment laws and regulations and labor unions will be examined. The general objective of this course is to provide the healthcare manager with current thinking, theory, and best practices for the management of people in healthcare organizations in order that s/he can be a better manager of people. 4 credits

MST 566 Health Care Information Systems Management

This course is aimed at health professionals, both administrators and health care providers, who more and more find themselves needing to understand how to manage the high technology systems, tools and products that have become such an integral part of the health delivery spectrum. Today’s health practitioner has to use technology to find medical information and use accounting systems, personnel systems, health insurance company systems, inventory systems, patient billing systems, purchasing systems, as well as input and retrieve data. This course focuses on the business of health care and how to understand, use and manage technology and systems in a medical environment. The overall goal is to give students a conceptual framework for understanding how to use technology to reduce costs and improve productivity, efficiency and effectiveness in their current and future work situations. 4 credits

MST 567 Health Care Technology — New Medical Advances
Highlighting the role of technology and its influence on treatment and health care delivery in the US, this course includes the role of medical technology suppliers in shaping delivery as well as decision-making and strategy for acquisition of new technology. 4 credits

MST 568 New Trends in Health Care Delivery
This course surveys timely topics in health care (e.g. Compliance, Patients Rights, Patient Safety, health care and he Internet, B to B Internet transactions, etc.). It is taught by a specialist in the appropriate field and focuses on practical knowledge needed by managers. 2-4 credits

MST 571 Managerial and Financial Accounting for Science and Technology
(Formerly MST 501)
This course offers a survey of financial and managerial accounting, intended to provide students with a basic background of accounting principles as they are used in decision-making. Financial accounting, which is prepared for external users, represents the base of information that is generated by companies. Managerial accounting, which is prepared by and for internal users, follows different rules and principles because it is relevant to strategic decision-making: what to make or buy, when and what to invest in, what costs are relevant, and what the long-term direction of the company will be. Topics include the analysis of financial statements, the accounting equation and accounts, understanding cash flows and the cash flow statement, the nature of costs, and capital budgeting. 4 credits

MST 572 Financial Management for Science and Technology
(Formerly MST 502)
This course offers a survey of financial management concepts intended to prepare you with a basic background of modern corporate finance, the decision-making process used by financial managers of large and growing corporations, and the analytical tools to measure achievement of financial and operational objectives that result from an integrated structural approach. Topics include a review of accounting statements and cash flows, value and capital budgeting, risk and the capital asset pricing model, capital structure, leverage, dividend policy, long-term debt financing, short-term financial planning, cash and credit management, performance management and economic value added. Special topics include mergers and acquisitions, defensive tactics, and financial distress. Prerequisite: MST 571. 4 credits

MST 573 Technology Marketing: Planning for Market
(Formerly MST 503)
The course is designed to provide an advanced understanding of the marketing process for technology- based products and organizations, from opportunity identification to product introduction and market development. The course is articulated around three core areas: 1) how to create value for the customers, 2) how customers and value change along the technology adoption lifecycle, and 3) how to develop competitive advantage. Particular emphasis is placed on the front end of the marketing process: understanding what customers value and then developing strategies and offerings that capitalize on that knowledge. A wide range of topics is explored: how to identify value opportunities, how disruptive innovation becomes accepted by the market place, how values change along with time, how to segment and select markets, how to understand and outmaneuver competitors, how to develop a marketing strategy that creates strong competitive advantage, and, last but not least, how to price products and go to market. 4 credits

MST 574 Going to Market: Delivering Value to Customers and Shareholders
(Formerly MST 504)
The course provides an understanding of the tools, mechanics and management of operational marketing implementation processes in high-technology environments. 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 goal is to show how to turn strategy into practice by implementing the marketing plan begun in MST 573, developing the specifics of a product or service's business model and persuasively outlining the blueprint of the business case. The course drills 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 complements and completes the marketing knowledge and expertise gained through MST 573, which is a prerequisite. 4 credits

MST 577 Principles for Process Technology Development & Introduction to Manufacturing
This is a project-oriented course on the management procedures and key underlying concepts for effective manufacturing technology planning, development, and introduction into volume production in a competitive environment. While emphasis will be on semiconductor technology and manufacturing, 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 improvement, and concurrent engineering principles will be explored to identify effective management approaches for shortening time to volume production, minimizing risks, and minimizing engineering effort. As part of the course students will form teams assigned either to develop a corporate procedure for the introduction of new products and manufacturing processes, each for a specific company situation, applying the concepts learned, or to carry out a case study of a specific company's procedures. There are no prerequisites for the course, although some technical background and/or experience in industry are desirable. 4 credits

MST 590 Effective Business Writing for Management
Tailored to meet the individual writing needs of management professionals, this course reviews and practices standard conventions in grammar and punctuation, and innovative stylistics using a highly interactive format. The course addresses both electronic (email) and traditional (letter, summary, report) managerial writing tasks with the goal of clearer, more concise business communication. For native speakers of English and bilinguals with a native-level of written English. 1 credit

MST 591 Effective Business Writing for Non-native Speakers
Tailored to meet the individual writing needs of management professionals, this course reviews and practices the English grammar, punctuation, and stylistics that challenge the advanced-level non-native and bilingual speaker of English. Using a highly interactive format, this course addresses both electronic and traditional managerial writing tasks with the goal of clearer, more concise business communication. 1 credit

OREGON MASTER OF SOFTWARE ENGINEERING

OMSE 500 Principles of Software Engineering
In this course you will study alternative software development models and processes. This course will cover the actual benefits of these models and processes as well as the problems that can arise. You will learn how to choose appropriate models for actual projects and then customize the processes to produce the best combination of control, quality, and rapid product development. You will also consider how software processes can be reviewed and improved on a continuous basis using improvement models such as the Software Engineering Institute's Software Capability Maturity Model, their Integrated Maturity Model, and the ISO SPICE Model. Students may not receive credit for both CSE 516/616 and OMSE 500 because there is significant overlap in content. 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 513 Professional Communication Skills for Software Engineers
This course examines the leadership skills that make all the difference when software is developed by a team. Using individual assignments and group projects, you will learn the skills you need to make effective presentations and write persuasive proposals. You will also learn the skills you need to (1) conduct efficient meetings (keep everyone focused), (2) resolve disputes (be a good listener), (3) work successfully in a team environment (suppress the urge to dominate), and (4) make ethical decisions when faced with conflicting goals (be true to personal values). Prerequisite: OMSE 500. 3 credits

OMSE 521 Using Metrics and Models to Support Quantitative Decision Making
This course will cover how metrics can be combined with formalized decision models to support decision-making by software project leaders and managers. It provides the knowledge and skills needed to apply quantitative tools to make decisions in situations where a great deal of uncertainty exists. You will learn to recognize decision-making opportunities in the software development process, and be equipped to address them in a scientific, organized manner using all appropriate information sources. 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. You will study the 1) major architectural styles, 2) strengths and weaknesses of each style, 3) application of domain analysis, 4) impact of platform dependence and independence, 5) relation of software architecture to requirements, 6) domain analysis and the architectural design process, and 7) products in a real-world context. 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. Students may not receive credit for both CSE 519/619 and OMSE 533 because there is significant overlap in content. 3 credits

OMSE 535 Software Implementation and Testing
Covers implementation and testing topics including 1) coding techniques and styles, 2) module packaging principles, 3) creating testable and maintainable code, 4) code reviews and inspections, 5) specification-based (black-box) testing and structural (clear box) testing and 6) test planning test tools, and test administration. Prerequisite: OMSE 500 3 credits

OMSE 551 Strategic Software Engineering
This course introduces the principles, methods, and tools for strategic software development. The tools include (1) long-term process modeling and improvement, (2) developing programs as families of systems, (3) systematic approaches to code generation, and (4) the reuse of non-code products including requirements and design. Prerequisite: OMSE 500. 3 credits

OMSE 555 and OMSE 556 Software Development Practicum I and II
The Development Practicum provides an opportunity for students to apply the knowledge and skills gained in other courses as they synthesize a solution to a significant, realistic, and practical problem. Students work to analyze a problem, develop a software concept, plan a software development effort, define requirements, and implement a solution. 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. Prerequisite: OMSE 500.
3 credits each