Department of Chemical Engineering

Degrees Offered

- Masters of Science in Chemical Engineering
- Masters of Science in Engineering with a major in Chemical Engineering
- Doctor of Philosophy with a major in Chemical Engineering

The Department of Chemical Engineering, with fourteen active tenure-track faculty members, approximately 130 undergraduates, and thirty-four graduate students, has one of the oldest doctoral-granting programs in the university. From the initial doctoral degree in 1932, the graduate course program has been based on advanced chemical engineering fundamentals, while the research program has reflected a balance of fundamental research areas and their application to relevant technological areas such as biomedical, bioengineering, catalysis, coal conversion, energy, fuels, materials, polymer processing, systems control, and dynamic simulation.

Degree Programs

The department is authorized to admit students to the following degree programs: master’s of science in chemical engineering (M.S. Ch.E.), master’s of science in engineering (M.S.E.), and doctor of philosophy (Ph.D.). A problem report option is also available as an alternative to the traditional research based master’s degree. Students in these programs must comply with the rules and regulations as presented in the general requirements for graduate work in the college and in the Department of Chemical Engineering. Students interested in pursuing work for a master’s or doctoral degree in chemical engineering should contact the department for copies of the required guidelines and application information.

Program Outcomes

Holders of graduate degrees will understand the advanced principles of chemical engineering, which include reaction engineering, transport phenomena, and thermodynamics.

- Holders of graduate degrees will have an expert-level understanding of the background and theory/principles of their research topics.
- Holders of Ph.D. degrees will be able to initiate research ideas in order to solve specific problems and to write research proposals on these ideas.
- Holders of Ph.D. degrees will have furthered a novel research idea.
- Holders of graduate degrees will be able to plan research projects, to perform the tasks, and to draw conclusions based on sound scientific and engineering principles.
- Holders of graduate degrees will be able to write technical articles for publication in refereed journals and to make oral and poster presentations at technical meetings.
- Holders of graduate degrees will demonstrate initiative in research planning and management, including safety and environmental issues.
- Holders of graduate degrees will be technically prepared for a lifetime of continuing education.
- Holders of graduate degrees will understand professional and ethical responsibilities.

Areas of Research

The Chemical Engineering faculty are presently involved in a broad spectrum of research areas which include biomedical and biochemical engineering, systems biology, cancer, bionanotechnology, biomaterials, stem cell technology, dynamic simulation, control systems, molecular dynamics, polymers and biopolymers, catalysis, energy, hydrates, fuels, fuel cells, low-dimensional and high-temperature electronic materials, and reaction engineering. These research activities impact economic development, national security, the stability and sustainability of the energy supply, and many quality-of-life issues.

Faculty members possess a wide variety of industrial experience and are routinely in contact with their counterparts in industry. This contact with real engineering problems enables them to convey a practical experience to students while keeping in perspective many of the fundamental concepts involved in graduate study. The faculty is nationally and internationally recognized through the publication of text books, monograph series, and technical papers. They routinely participate in national and international conferences and advisory meetings. In addition, faculty members have taught short courses throughout the United States and abroad.

FACULTY

CHAIR
- Rakesh Gupta - Ph.D. (University of Delaware)
  Berry Professor and Chair, Polymer Processing, Rheology, Composite Materials

PROFESSORS
- Eugene V. Cilento - Ph.D. (University of Cincinnati)
Dean, Physiological Transport Phenomena, Biomedical Engineering, Image Analysis, Mathematical Modeling

• Dady B. Dadyburjor - Ph.D. (University of Delaware)
  Catalysis, Reaction Engineering, Micellization, Fuels and Chemicals from Synthesis Gas, Synthesis Gas from Coal
• Pradeep Fulay - Ph.D. (University of Arizona)
  Associate Dean for Research, Advanced Electronics, Magnetic Materials and Devices, Flexible Electronics, Synthesis and Processing of Nanomaterials
• Edwin L. Kugler - Ph.D. (Johns Hopkins University)
  Catalysis, Partial Oxidation, Fischer-tropsch Processing, In-situ Reaction Studies
• Richard Turton - Ph.D. P.E. (Oregon State University)
  Bolton Professor, Fluidization, Chemical Process Design, Particle Processing, Powder Processing
• John W. Zondlo - Ph.D. (Carnegie Mellon University)
  Coal Enhancement and Utilization, Carbon Science, Fuel Cells

ASSOCIATE PROFESSOR

• Brian J. Anderson - Ph.D. (Massachusetts Institute of Technology)
  GE Materials Professorship, Natural Gas Hydrates, Sustainable Energy Development, Molecular Dynamics, Quantum Chemical Calculations
• Debangsu Bhattacharyya - Ph.D. (Clarkson University)
• David J. Klinke - Ph.D. (Northwestern University)
  Systems Biology, Kinetics, Cellular Signal Transduction Pathways, Immunology, Mathematical Modeling, Bioengineering
• Charter D. Stinespring - Ph.D. (West Virginia University)
  Semiconductor Growth and Etching, Surface Kinetics, Thin Films, Electronic Materials

ASSISTANT PROFESSOR

• Cerasela Z. Dinu - Ph.D. (Dresden University of Technology)
  Nanomaterials, Bionanotechnology, Biomimetics, Synthetic and Molecular Biology
• Fernando V. Lima - Ph.D. (Tufts University)
• Yong Yang - Ph.D. (Ohio State University)
  Stem Cell Technology, Polymer Micro/Nanotechnology, Biomaterials

RESEARCH ASSISTANT PROFESSOR

• Sushant Agarwal - Ph.D. (West Virginia University)
  Polymer Processing, Rheology, Nano-composites, Dispersions
• Ruifeng (Ray) Liang - Ph.D. (Chinese Academy of Science)
  Polymer Processing and Modeling, Smart Materials, Composites

TEACHING ASSISTANT PROFESSOR

• Robin S. Hissam - Ph.D. (University of Delaware)
  Biomaterials, Polypeptides, Drug delivery, Bioengineering and materials science

ADJUNCT PROFESSORS

• Deepak Doraiswamy - Ph.D. (University of Delaware)
• Joseph D. Henry - Ph.D. (University of Michigan)
  Energy Management, Science and Technology Policy
• Charles M. Jaffe - Ph.D. (University of Colorado)
  Theoretical Chemistry, Molecular and Atomic Physics, Nonlinear Dynamics, Astrodynamics, Forensics
• George E. Keller, II - Ph.D. (Pennsylvania State University)
  Separations, Commercial Practice
• Mahesh Padmanabhan - Ph.D. (University of Minnesota)
  Foods, Polymer Science, Rheology
• David L. Walker - Ph.D. (West Virginia University)
  Signal Analysis, Neural Nets, Forensics
• Robert H. Wildi - B.Ch.E. (Cleveland State University)
  Polymer Extrusion
ADJUNCT ASSOCIATE PROFESSOR
• Bingyun Li - Ph.D., (Chinese Academy of Sciences)
  Associate Professor of Orthopedics, Bioengineering and Advanced Biomedical Devices, Nanotechnology Sorbents, Coatings and Capsules

PROFESSORS EMERITUS
• Eung H. Cho - Ph.D. (University of Utah)
  Mineral Processing, Leaching, Solvent Extraction, Environmental Science
• Alfred H. Stiller - Ph.D. (University of Cincinnati)
  Physical/Inorganic/Solution Chemistry, Coal Liquefaction, Carbon Science

Masters Admission Requirements
Students holding baccalaureate degrees in chemical engineering, other engineering fields, mathematics, or basic sciences are eligible for admission to the Master of Science in Chemical Engineering (M.S.Ch.E.) Program. Students not holding a B.S.Ch.E. will be required to take a series of six junior-level courses. Alternatively, these students have the option of obtaining a master of science in engineering (M.S.E.). The M.S.E. requires fewer junior-level courses and enables students to begin their research within the first semester. A maximum of twelve semester hours from other institutions may be accepted at WVU for credit toward the master's degree. The Chemical Engineering Department may require Graduate Record Examination (GRE) scores or other evidence to assist in judging a student's chances for success in a graduate program. To be eligible for admission as a regular student, an applicant must have a baccalaureate degree as specified above and a grade point average (GPA) of 3.0 (on a 4.0 scale) in all previous college work. Students entering the program without a B.S.Ch.E. will receive a letter specifying the additional course work which they must take in the first two semesters. To remain in good-standing, a regular student must achieve and maintain a minimum overall 3.0 GPA in all graduate level courses as well as in all junior level courses. Applicants who cannot meet these conditions may be considered for admission in a conditional category. Students admitted with deficiencies in their undergraduate programs are required to take some chemical engineering courses as prerequisites for graduate courses. International students must demonstrate proficiency in communicating in English (a minimum TOFEL score of 550, or iBT score of 79, or IELTS score of 6.5). International students must also provide Graduate Record Examination (GRE) scores. These requirements are stated as a condition for admission.

Doctoral Admission Requirements
Admission to the Ph.D. program is open to students who qualify as regular graduate students and who have obtained a B.S. or M.S. degree in science or engineering. Students admitted must have demonstrated an excellent academic record in previously completed college coursework with a minimum cumulative grade point average of 3.0 (on a 4.0 scale). Three letters of recommendation and GRE scores (international students only) are required by the department. International students must demonstrate proficiency in communicating in English (a minimum TOFEL Score of 550, or iBT Score of 79, or IELTS Score of 6.5). A maximum of twelve semester hours from other institutions may be accepted at WVU for credit towards the Ph.D. degree.

Masters Programs
PLANNED PROGRAMS
For students with a B.S.Ch.E., twenty-four months are typically required to complete the M.S.Ch.E. degree work. For students without a B.S.Ch.E., the time to complete the M.S.Ch.E. is typically thirty-six months, while the time to complete the M.S.E. is typically thirty months. All M.S. degree candidates are required to perform research and will follow a planned program which conforms to either of the following outlines:

• A minimum of thirty semester credit hours, excluding seminar and any required junior level courses; not more than six of which are in research leading to an acceptable thesis
• A minimum of thirty-three semester credit hours, excluding seminar and any required junior level courses; not more than three of which are in research leading to an acceptable problem report

A pure coursework M.S.Ch.E. degree option is not presently offered by the Department of Chemical Engineering.

CURRICULUM REQUIREMENTS
A minimum GPA of 3.0 is required in all courses
A minimum GPA of 3.0 is required in all CHE courses
A grade of C or higher must be earned in all required courses

<table>
<thead>
<tr>
<th>Course</th>
<th>Title</th>
<th>Credits</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHE 615</td>
<td>Transport Phenomena</td>
<td>3</td>
</tr>
<tr>
<td>CHE 620</td>
<td>Adv Ch E Thermodynamics</td>
<td>3</td>
</tr>
<tr>
<td>CHE 625</td>
<td>Chemical Reaction Engineering</td>
<td>3</td>
</tr>
<tr>
<td>CHE 697</td>
<td>Research</td>
<td>6</td>
</tr>
<tr>
<td>CHE 796</td>
<td>Graduate Seminar</td>
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Full-time Students are required to take a Seminar course each semester 4-10
Select from the following based on degree path:

<table>
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<tr>
<th>Course Type</th>
<th>Hours</th>
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<tr>
<td>Any CE courses 400-799</td>
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<tr>
<td>Any CHE courses 400-799</td>
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<tr>
<td>Any CHEM courses 400-799</td>
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<td>Any IENG courses 400-799</td>
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<td>Any MAE courses 400-799</td>
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<td>Any MATH courses 400-799</td>
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<td>Any PHYS courses 400-799</td>
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<td>Any SAFM courses 400-799</td>
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<tr>
<td>Any STAT courses 400-799</td>
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Total Hours: **34-40**

For students without a B.S.Ch.E., the junior level courses may include:

<table>
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<tbody>
<tr>
<td>M.S.E. students take only CHE 315, CHE 320, CHE 325</td>
<td>0</td>
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</tbody>
</table>

The research advisor, in conjunction with an advisory and examining committee (AEC) to be designated by each student, will be responsible for following departmental guidelines to determine the plan of study appropriate to the student’s program.

**RESEARCH PROPOSALS**

A written thesis research proposal and oral presentation of this proposal is required of all M.S. students. This oral defense is administered by the student’s AEC and must be completed by the end of the second semester after the student begins his/her research.

**FINAL EXAMINATION**

All students are required to pass a final oral examination, administered by their AEC, covering both the thesis or problem report (depending on the program selected) and related course material.

**Doctor of Philosophy**

The doctor of philosophy degree is administered through the college’s interdisciplinary program; chemical engineering may be the major. A candidate for the degree of doctor of philosophy must comply with the rules and regulations outlined in the general requirements of the Statler College of Engineering and Mineral Resources. The research work for the doctoral dissertation must show a high degree of originality on the part of the student and must constitute an original contribution to the art and science of Chemical Engineering.

Students who are interested in pursuing a Ph.D. degree in the Department of Chemical Engineering should contact the department for specific information. A program with a major in chemical engineering, designed to meet the needs and objectives of each student, will be developed in consultation with the student’s research advisor and advisory and examining committee (AEC). It should be emphasized that the Ph.D. degree is primarily a research degree, and therefore the research work for a doctoral dissertation should show a high order of originality on the part of the student and must offer an original contribution to the field of engineering science. Students in the Ph.D. program should expect to complete the requirements in three to four years.

**CURRICULUM REQUIREMENTS**

A minimum GPA of 3.0 is required in all courses
A minimum GPA of 3.0 is required in all CHE courses
A grade of C or higher must be earned in all required courses

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<td></td>
</tr>
<tr>
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Any MATH courses 500-799
Any PNGE course 500-799
Any PHYS course 500-799
Any SAFM course 500-799
Any STAT course 500-799

Full-time Students are required to take one Seminar course each semester
CHE 796 Graduate Seminar 4-10

Student must complete Research hours
CHE 797 Research 24

Students must complete a Qualifying Exam
Students must complete a Candidacy Exam
Students must complete a Final Exam

Total Hours 46-52

* Courses numbered 795, 796 and 797 do not count toward the 18 required hours.

Students must complete a minor consisting of a minimum of nine semester hours of a coherent set of courses taken outside of the department. These courses may be related to the major research area. Non-technical courses are considered only under exceptional circumstances. All courses must be approved by the AEC and the academic advisor. Students must complete graduate courses with an overall coursework average of 3.0 or better (exclusive of research credits) and complete all chemical engineering courses with an overall grade point average of 3.0 (exclusive of research credits). A minimum of twenty-four credit hours in dissertation research is required. Also, two semesters of full-time attendance at the Morgantown campus is required to complete the residency requirement.

QUALIFYING EXAMINATION
All Ph.D. students must pass a Ph.D. qualifying examination given in their first year at WVU. This examination is designed to assess the basic competency of students in the chemical engineering field to determine whether or not they have sufficient knowledge to undertake independent research.

RESEARCH PROPOSAL
Within a maximum of one semester after passing the PhD qualifying examination or entering the Ph.D. program, whichever is later, a student must successfully defend his/her dissertation research proposal. This proposal is a written document which must be reviewed and accepted by their AEC and subsequently defended in an oral presentation. The research work for the doctoral dissertation should show a high order of originality on the part of the student and must offer an original contribution to the field of engineering science.

A student who has successfully completed all coursework, passed the qualifying examination, and successfully defended the research proposal is defined as one who is a candidate for the Ph.D. degree.

RESEARCH AND DISSERTATION
In order to complete the Ph.D. requirements, a student must pass a final oral examination on the results embodied in the dissertation. This examination is open to the public and, in order to evaluate critically the student’s competency, may include testing on material in related fields, as deemed necessary by the AEC. In addition, since the Ph.D. degree is primarily a research degree that embodies the results of an original research proposal and represents a significant contribution to scientific literature, the student must submit a manuscript on this research to the AEC.

COURSES

CHE 531. Mathematical Methods in CHE. 3 Hours.
PR: MATH 261 and consent. Classification and solution of mathematical problems important in chemical engineering. Treatment and interpretation of engineering data. Analytical methods for ordinary and partial differential equations, including orthogonal functions and integral transforms. Vector calculus. (3 hr. lec.).

CHE 565. Corrosion Engineering. 3 Hours.
PR: CHE 320 or CHEM 341 or equivalent. Basic mechanisms of various types of corrosion such as galvanic corrosion, pitting corrosion and stress corrosion cracking; methods of corrosion prevention such as cathodic and anodic prevention, by using coatings and inhibitors, and by selecting proper alloys. (3 hr. lec.).

CHE 566. Electronic Material Processing. 3 Hours.
PR: Graduate Standing in Engineering, Physics, Chemistry, or instructor consent. Design and application of thermal, plasma, and ion assisted processing methodologies; design and function of key process tools and components; vacuum technology; solid state, gas phase, surface, and plasma chemistry underpinnings; thin film nucleation, growth, and etching; effects of processing methods and conditions on materials properties.
CHE 580. Advanced Cellular Machinery. 3 Hours.
PR: Consent. Coverage and application of principles of cellular biology to enable the integration of cell components into biotechnological applications.

CHE 591A-Z. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CHE 593A-Z. Special Topics. 1-6 Hours.
PR: Consent. A study of contemporary topics selected from recent developments in the field.

CHE 610. Fluidization Engineering. 3 Hours.
PR: Consent. Fundamentals of fluidization, two-phase flow theory and powder characteristics, structure and property of the emulsion phase and bubbles, mass and heat-transfer in fluidized beds with and without chemical reaction. (3 hr. lec.).

CHE 611. Powder Technology. 3 Hours.
PR: Consent. Characterization of powders, structure of powders, powders in two-phase flow, measurement techniques, static and dynamic behavior of powders, grinding and agglomeration, chemistry of powders. (3 hr. lec.).

CHE 615. Transport Phenomena. 3 Hours.
PR: Consent. Introduction to equations of change (heat, mass, and momentum transfer) with a differential-balance approach. Use in Newtonian flow, turbulent flow, mass and energy transfer, radiation, convection. Estimation of transport coefficients. (3 hr. lec.).

CHE 620. Adv Ch E Thermodynamics. 3 Hours.
PR: Consent. Logical development of thermodynamic principles. These are applied to selected topics including development and application of the phase rule, physical and chemical equilibria in complex systems, and nonideal solutions. Introduction to nonequilibrium thermodynamics. (3 hr. lec.).

CHE 625. Chemical Reaction Engineering. 3 Hours.
PR: Consent. Homogeneous and heterogeneous reaction systems, batch and flow ideal reactors, macro- and micro-mixing, non-ideal reactors, diffusion and reaction in porous catalysts, reactor stability analysis, special topics. (3 hr. lec.).

CHE 687. Materials Engineering. 3 Hours.
A study of materials engineering fundamentals emphasizing semiconductor, polymer, metal, and ceramic/cementitious material systems. Mechanical and physical properties, theoretical aspects, testing, design criteria, manufacturing, and economics of material systems. Laboratory testing and evaluation. (Equivalent to CE 687, EE 687, MINE 687, IMSE 687 and MAE 687.) (3 hr. lec.).

CHE 693A-Z. Special Topics. 0-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CHE 694A-Z. Seminar. 1-6 Hours.
Seminars on current research by visitors and graduate students.

CHE 697. Research. 1-15 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/ U.).

CHE 716. Advanced Fluid Dynamics. 3 Hours.
PR: Consent. Analysis of flow of fluids and transport of momentum and mechanical energy. Differential equations of fluid flow; potential flow, laminar boundary-layer theory, and non-Newtonian fluids. (3 hr. lec.).

CHE 717. Advanced Heat Transfer. 3 Hours.
PR: Consent. Theory of transport of thermal energy in solids and fluids as well as radiative transfer. Steady state and transient conduction; heat transfer to flowing fluids; evaporation; boiling and condensation; packed- and fluid-bed heat transfer. (3 hr. lec.).

CHE 718. Advanced Mass Transfer. 3 Hours.
PR: Consent. Theory of diffusion, interphase mass-transfer theory, turbulent transport, simultaneous mass and heat transfer, mass transfer with chemical reaction, high mass-transfer rates, and multicomponent macroscopic balances. (3 hr. lec.).

CHE 720. Appld Stat/Mol Thermodyn. 3 Hours.
PR: CHE 620 and consent. The connection between macroscopic phenomena (thermodynamics) and microscopic phenomena (statistical and quantum mechanics). Thermodynamics modeling for process analysis. Equations of state, perturbation theories, mixing rules, computer simulation, group-contribution models, and physical-property prediction. (3 hr. lec.).

CHE 726. Catalysis. 3 Hours.
PR: CHE 625 or consent. Physical and chemical properties of catalytic solids, nature and theories of absorption, thermodynamics of catalysis, theories of mass and energy transport, theoretical and experimental reaction rates, reactor design, and optimization. (3 hr. lec.).

CHE 730. Advanced Numerical Methods. 3 Hours.

CHE 731. Optimizaton Ch E Systems. 3 Hours.
PR: Consent. Optimization in engineering design, unconstrained optimization and differential calculus, equality constraints optimization, search technique, maximum principles, geometric and dynamic programming, linear and nonlinear programming, and calculus of variations. (3 hr. lec.).
CHE 761. Polymer Rheology. 3 Hours.
Qualitative behavior of polymeric liquids; Rheometry; stress, strain and rate of strain tensors; equations of motion; Hookean solids and Newtonian liquids, linear viscoelasticity; constitutive equations for solutions and melts. (3 hr. lec.).

CHE 790. Teaching Practicum. 1-3 Hours.
PR: Consent. Supervised practice in college teaching of chemical engineering. Note: This course is intended to insure that graduate assistants are adequately prepared and supervised when they are given college teaching responsibility. It will also present a mechanism for students not on assistantships to gain teaching experience. (Grading may be S/U.).

CHE 791A-Z. Advanced Topics. 1-6 Hours.
PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CHE 792A-Z. Directed Study. 1-6 Hours.
Directed study, reading, and/or research.

CHE 793A-Z. Special Topics. 1-6 Hours.
A study of contemporary topics selected from recent developments in the field.

CHE 794A-Z. Seminar. 1-6 Hours.
Special seminars arranged for advanced graduate students.

CHE 795. Independent Study. 1-9 Hours.
Faculty supervised study of topics not available through regular course offerings.

CHE 796. Graduate Seminar. 1 Hour.
PR: Consent. Each graduate student will present at least one seminar to the assembled faculty and graduate student body of his or her program.

CHE 797. Research. 1-15 Hours.
PR: Consent. Research activities leading to thesis, problem report, research paper or equivalent scholarly project, or a dissertation. (Grading may be S/U.).

CHE 798. Dissertation. 1-6 Hours.
PR: Consent. This is an optional course for programs that wish to provide formal supervision during the writing of student reports (698), or dissertations (798). Grading is normal.

CHE 799. Graduate Colloquium. 1-6 Hours.
PR: Consent. For graduate students not seeking coursework credit but who wish to meet residency requirements, use the University’s facilities, and participate in its academic and cultural programs. Note: Graduate students who are not actively involved in coursework or research are entitled, through enrollment in their department’s 699/799 Graduate Colloquium to consult with graduate faculty, participate in both formal and informal academic activities sponsored by their program, and retain all of the rights and privileges of duly enrolled students. Grading is S/U; colloquium credit may not be counted against credit requirements for masters programs. Registration for one credit of 699/799 graduate colloquium satisfies the University requirements of registration in the semester in which graduation occurs.