

Department of Chemical and Biomedical Engineering

Degrees Offered

- Masters of Science, Chemical Engineering (M.S.Ch.E.)
- Doctor of Philosophy, Chemical Engineering (Ph.D.)

The Department of Chemical and Biomedical 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 and Biomedical 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 and Biomedical 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

- Brian J. Anderson - Ph.D. (Massachusetts Institute of Technology)
Director, Energy Institute; GE Materials Professor. Natural gas hydrates, Sustainable energy development, Molecular dynamics, Quantum chemical calculations
- Eugene V. Cilento - Ph.D. (University of Cincinnati)
Dean, Physiological Transport Phenomena, Biomedical Engineering, Image Analysis, Mathematical Modeling
- Pradeep Fulay - Ph.D. (University of Arizona)
Associate Dean for Research, Advanced Electronics, Magnetic Materials and Devices, Flexible Electronics, Synthesis and Processing of Nanomaterials
- John (Jianli) Hu - Ph.D. (Tsinghua University)
Statler Energy Chair. Shale Gas Utilization, Catalysis in Refining Processes, Coal and Biomass Conversion
- 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

- Debangsu Bhattacharyya - Ph.D. (Clarkson University)
Integrated Gasification Combined Cycle (IGCC), Chemical Looping, Fuel Cells (SOFC & PEM), Optimization, Dynamic Modeling of Process Systems, Process Control
- Zoica Cerasela Dinu - Ph.D. (Max Planck Inst of Molecular Cell Biology & Genetics & Dresden University of Technology)
Associate Chair, BMEG. Nanomaterials, Bionanotechnology, Biomimetics
- 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

- Ahmed E. Ismail - Ph.D. (Massachusetts Institute of Technology)
Biomass and biopolymers, Interfacial phenomena, Multi-scale modeling, Algorithm development
- Fernando V. Lima - Ph.D. (Tufts University)
Process Design and Operability, Model-based Control and Optimization, State Estimation and Process Identification, Emerging Energy Systems and Sustainable Processes
- Jeevan Maddala - Ph.D. (Texas Tech University)
Microfluidics, cell screening, nanomaterial synthesis
- Hanjing Tian - Ph.D. (Lehigh University)
Chemical looping combustion, CO₂ capture, Shale gas utilization, Biomass gasification and refinery
- Yong Yang - Ph.D. (Ohio State University)
Stem Cell Technology, Polymer Micro/Nanotechnology, Biomaterials

RESEARCH ASSOCIATE

- Sushant Agarwal - Ph.D. (West Virginia University)
Polymer Processing, Rheology, Nano-composites, Dispersions

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
- Stephen Zitney - Ph.D. (University of Illinois at Urbana-Champaign)
Dynamics, Control and optimization of energy systems; Computational fluid dynamics (CFD) and Process Co-simulation; Pulverized coal combustion; Integrated gasification combined cycle (IGCC); Chemical looping; Supercritical CO₂ power cycles; CO₂ capture

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
- Dady B. Dadyburjor - Ph.D. (Delaware)
Catalysis, Reaction Engineering
- Edwin L. Kugler - Ph.D. (Johns Hopkins)
Catalysis, Adsorption, Coal Liquefaction
- Joseph A. Shaeiwitz - Ph.D. (Carnegie-Mellon University)
Design, Design Education, Outcomes Assessment
- Alfred H. Stiller - Ph.D. (University of Cincinnati)
Physical/Inorganic/Solution Chemistry, Coal Liquefaction, Carbon Science
- Ray Y.K. Yang - Ph.D. (Princeton)
Biochemical and Chemical Engineering, Nonlinear Dynamics

RESEARCH ASSISTANT PROFESSOR

- Nasagree Garapati - Ph.D. (West Virginia University)
Carbon dioxide capture and storage (CCS) in various geologic media, utilizing carbon dioxide in gas hydrate reservoirs, petroleum reservoirs and geothermal reservoirs for enhanced gas, oil and heat recovery
- Huali Wang - Ph.D. (Wayne State University)
Shale gas, renewable energy, clean energy, energy catalysis, and reaction engineering

Chemical Engineering Masters and Doctoral Admissions Requirements

All applicants for Chemical Engineering Masters and Doctoral Programs must satisfy the following criteria to qualify for admission.

- A minimum cumulative grade point average of 3.0, or equivalent, (on a 4.0 scale) in all previous college work.
- Three letters of reference.
- International students must demonstrate proficiency in communicating in English (a minimum TOEFL score of 550, or iBT score of 79, or IELTS score of 6.5).
- International students must provide Graduate Record Examination scores. (This is recommended for all students and may be required of some students to assist in judging their chances for success in the program.)
- A baccalaureate degrees in chemical engineering, other engineering fields, mathematics, or basic sciences.

Chemical Engineering Masters and Doctoral Degree Programs

Students holding a baccalaureate degree in chemical engineering are eligible for the Master of Science in Chemical Engineering (M.S.Ch.E.) Program.

- Students not holding a baccalaureate degree in chemical engineering are eligible for the Masters of Science in Engineering (M.S.E.) Program. These students must take an additional nine hours of junior level course work in the first two semesters. Alternatively, students taking a total of 18 hours at junior level in the first two semesters are eligible for the M.S.Ch.E. Program. Admitted students will receive a letter specifying the course work required in the first two semesters.
- Admission to the Ph.D. Program is open to all qualified students. Generally, students without a B.S. or M.S. in chemical engineering are not admitted directly to the Ph.D. Program.

- A maximum of twelve semester hours from other institutions may be accepted at WVU for credit toward either the masters or doctoral degrees.
- 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.

Curriculum in Master of Science in Chemical Engineering

A candidate for the M.S. degree in chemical engineering must comply with the rules and regulations as outlined in the WVU Graduate Catalog and the specific requirements of the Statler College and the Chemical Engineering Department.

Program Requirements

All M.S. degree candidates are required to perform research and follow a planned program of study. The student's research advisor, in conjunction with the student's Advising and Examining Committee (AEC) will be responsible for determining the plan of study appropriate to the student's needs. The underlying principle of the planned program is to provide the students with the necessary support to complete their degree and prepare them for their career.

Curriculum Requirements

A minimum GPA of 3.0 is required in all courses

Course Requirements *		
A minimum of 60% of courses must be from 500 level or above		
A grade of C or higher must be earned in all required courses		
CHE 615	Transport Phenomena	3
CHE 620	Thermodynamics	3
CHE 625	Chemical Reaction Engineering	3
Full-time Students are required to take a Seminar course each semester		4-10
CHE 796	Graduate Seminar	
Select courses from the following based on degree path:		15
Any BIOM, CE, CHE, CHEM, CPE, CS, EE, IENG, IH&S, MAE, MATH, MINE, PHGE, PHYS, SAFM, SENG, or STAT courses 400-799		
Complete 1 of the following options:		6-9
Thesis Option - 6 hours		
CHE 697	Research (6 hours)	
Written Proposal/Oral Presentation		
Oral Defense		
Thesis		
Final Oral or Written Examination		
Problem Report Option - 9 hours		
Complete 6 additional hours of coursework		
CHE 697	Research (3 hours)	
Written Proposal/Oral Presentation		
Oral Defense		
Formal written report or professional report/paper		
Final Oral or Written Examination		
Total Hours		34-43

* Students who do not hold a baccalaureate degree in chemical engineering are required to take a set of undergraduate chemical engineering courses above and beyond the minimum coursework requirements.
For students without a B.S.Ch.E., the junior level courses may include: CHE 310, CHE 311, CHE 312, CHE 315, CHE 320, and CHE 325.
M.S.E. students take only CHE 315, CHE 320, and CHE 325.

EXAMINATION

M.S. students following the thesis or problem report option must prepare a written research proposal and oral presentation. The proposal must be approved by the student's AEC at least one semester prior to the final oral examination. 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.

All students, regardless of option, are required to pass a final oral or written examination, administered by their AEC, covering the thesis or problem report and/or related course material.

Suggested Plan of Study

The plan below illustrates the Thesis Option. 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.

It is important for students to take courses in the order specified as much as possible; all prerequisites and concurrent requirements must be observed. A typical M.S.Ch.E degree program that completes degree requirements in two years is as follows.

First Year

Fall	Hours Spring	Hours
CHE 796	1 CHE 796	1
CHE 615	3 CHE 625	3
CHE 620	3 Additional Course	3
Additional Course	3 CHE 697	3
		10

Second Year

Fall	Hours Spring	Hours
CHE 796	1 CHE 796	1
CHE 697	3 CHE 697	6
Additional Course	3 Additional Course	3
Additional Course	3	
		10

Total credit hours: 40

Curriculum in Doctor of Philosophy – Chemical Engineering

A candidate for the Ph.D. degree with a major in chemical engineering must comply with the rules and regulations as outlined in the WVU Graduate Catalog and the specific requirements of the Statler College and the Chemical Engineering Department.

Program Requirements

The doctor of philosophy degree with a major in chemical engineering is administered through the college's interdisciplinary Ph.D. program. 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.

All Ph.D. degree candidates are required to perform research and follow a planned program of study. The student's research advisor, in conjunction with the student's Advising and Examining Committee (AEC) will be responsible for determining the plan of study appropriate to the student's needs. The underlying principle of the planned program is to provide the students with the necessary support to complete their degree and prepare them for their career.

Curriculum Requirements

A minimum GPA of 3.0 is required in all courses exclusive of research credits.

A minimum GPA of 3.0 is required in all CHE courses exclusive of research credits.

A grade of C or higher must be earned in all required courses

Course Requirements *

CHE 615	Transport Phenomena	3
CHE 620	Thermodynamics	3
CHE 625	Chemical Reaction Engineering	3
Select from the following based on degree path: **		9

Any BIOM, CE, CHE, CHEM, CPE, CS, EE, IENG, IH&S, MAE, MATH, MINE, PNGE, PHYS, SAFM, SENG, or STAT courses 500-799 excluding courses numbered 785, 796, or 797

Full-time Students are required to take one Seminar course each semester		4-10
CHE 796	Graduate Seminar	
Research		24

CHE 797	Research	
Examinations		
Qualifying Exam		
Candidacy Exam		
Final Exam		
Total Hours		46-52

- * Students who do not hold a baccalaureate degree in chemical engineering are required to take a set of undergraduate chemical engineering courses above and beyond the minimum coursework requirements. A minimum of thirty-six hours of coursework and twenty-four hours of independent research beyond a bachelor's degree, or eighteen hours of coursework and twenty-four hours of independent research beyond an M.S. degree are required.
- ** Students must complete 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.

Examinations

QUALIFYING EXAM

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.

CANDIDACY EXAMINATION

In order to be admitted to candidacy, the student must pass a candidacy exam, which is designed to evaluate the student's overall ability to engage in high-level research.

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.

FINAL EXAMINATION

At the completion of the dissertation research, candidates must prepare a dissertation and pass the final oral examination (defense) administered by their AEC.

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.

Suggested Plan of Study

It is important for students to take courses in the order specified as much as possible; all prerequisites and concurrent requirements must be observed. A typical doctoral degree program that completes degree requirements in three years is as follows.

First Year

Fall	Hours Spring	Hours
CHE 796	1 CHE 796	1
CHE 615	3 CHE 625	3
CHE 620	3 Additional Course	3
Additional Course	3 CHE 797	3
	10	10

Second Year

Fall	Hours Spring	Hours
CHE 796	1 CHE 796	1
CHE 797	6 CHE 797	9

Additional Course	3	
	10	10
Third Year		
Fall	Hours Spring	Hours
CHE 796	1 CHE 796	1
CHE 797	7 CHE 797	7
	8	8

Total credit hours: 56

Major Learning Goals

CHEMICAL ENGINEERING

Upon graduation, Chemical Engineering students will have:

- Understanding of advanced principles of chemical engineering, which include reaction engineering, transport phenomena, and thermodynamics
- Expert-level understanding of the background and theory/principles of their research topics.
- Ability to plan research projects, to perform the tasks, and to draw conclusions based on sound scientific and engineering principles.
- Ability to write technical articles for publication in refereed journals and to make oral and poster presentations at technical meetings.
- Demonstrated initiative in research planning and management, including safety and environmental issues.
- Been technically prepared for a lifetime of continuing education.
- Understanding of professional and ethical responsibilities.

COURSES

CHE 531. Mathematical Methods in Chemical Engineering. 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 Materials 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 topics not covered in regularly scheduled courses.

CHE 593A-E. Special Topics. 1-6 Hours.

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. 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. Special Topics. 1-6 Hours.

A study of contemporary topics selected from recent developments in the field.

CHE 694. 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. Applied Statistical and Molecular Thermodynamics. 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.

PR: CHE 230 or consent. Methods for nonlinear algebraic equations, methods for initial and boundary value ordinary differential equations, methods for parabolic, hyperbolic, and elliptical partial differential equations, numerical stability and methods for stiff equations, optimization techniques. (3 hr. lec.).

CHE 731. Optimization of Chemical Engineering 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 791. Advanced Topics. 1-6 Hours.

PR: Consent. Investigation of advanced topics not covered in regularly scheduled courses.

CHE 792. Directed Study. 1-6 Hours.

Directed study, reading, and/or research.

CHE 793. Special Topics. 1-6 Hours.

A study of contemporary topics selected from recent developments in the field.

CHE 794. 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. Thesis or 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.