856. **Plant Genetics and Molecular Biology**  
Spring: 3(3-0) Approval of department and a course in introductory genetics. Interdepartmental with Genetics and the Department of Biochemistry.  
Recent advances in genetics and molecular biology of higher plants.

864. **Plant Biochemistry**  
Spring of even-numbered years. 4(4-0)  
BCH 401, BOT 301 or approval of department. Interdepartmental with and administered by the Department of Biochemistry.  
Metabolism of nitrogen-compounds, carbohydrates, and lipids unique to plants' cell organelles; photosynthesis; photoregulation; dark respiration; cell walls; lectins; nitrogen cycle including nitrogen fixation; sulfur cycle.

865. **Advanced Growth and Development**  
Fall: 3(3-0) BOT 415 or approval of department.  
Advanced treatment of the physiological processes of growth and development. The mechanisms underlying these processes and the roles played by hormones, light, etc., in controlling them will be analyzed.

871. **Biology of Nematodes**  
Spring of even-numbered years. 4(2-6)  
ENT 470 or approval of department. Interdepartmental with and administered by the Department of Entomology. Ontogeny, taxonomy, morphology, pathology and ecology of nematodes, with special reference to plant parasitic and phytopathogenic species.

880. **Plant Virology**  
Fall of odd-numbered years. 5(2-6)  
BOT 405 or approval of instructor.  
External and internal symptomatology, transmission, interactions, purifications, assay and serology of plant viruses.

881. **Pathogenesis and Disease Resistance**  
Winter of odd-numbered years. 4(2-2)  
BOT 405 and BOT 415, or approval of department.  
Lectures, readings, and discussions on mechanisms of pathogenicity and infectivity; physiology and biochemistry of disease development; hypersensitivity; metabolic consequences of infection; nature of disease resistance; and parasitism.

884. **Phytopathology**  
Spring of odd-numbered years. 5(3-4)  
BOT 405 or approval of instructor.  
Bacterial genera associated with plant diseases. Their description, identification, physiology, and genetics. Emphasis on laboratory techniques.

885. **Plant Diseases in the Field**  
Spring: 4 credits. BOT 405 and approval of department.  
Diagnosis, distribution, and sequential development of plant diseases in the field. Field trips permit observation of diseases in the natural setting.

890. **Selected Topics in Plant Pathology**  
Fall, Winter, Spring: 2 to 5 credits. Approval of department.  
Topics will be selected from the following areas: parasitism, plant viruses, ecology, genetics, nematology, fungicidal action, and soil microbiology.

891. **Selected Topics in Botany**  
Fall, Winter, Spring: 2 to 5 credits. May reenroll for a maximum of 6 credits if different topics are taken. Approval of department.  
Topics may be selected from ecology, systematics, evolution, physiology, cytology, mycology, bryology, phycology, lichenology, anatomy, morphology, genetics, and others.

899. **Master's Thesis Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  
Research in anatomy, bryology, cytology, ecology, genetics, lichenology, mycology, paleobotany, pathology, phycology, physiology, and taxonomy.

930. **Advanced Plant Ecology**  
Winter of odd-numbered years. 3(2-4) Approval of department.  
Fundamental theories and modern research horizons.

999. **Doctoral Dissertation Research**  
Fall, Winter, Spring, Summer. Variable credit. Approval of department.  
Research in anatomy, bryology, cytology, ecology, genetics, lichenology, mycology, paleobotany, pathology, phycology, physiology, and taxonomy.

### BUILDING CONSTRUCTION MANAGEMENT

**CHEMICAL ENGINEERING**

**CHE**

**College of Engineering**

**CHE 300. Material and Energy Balances**  
Fall, Winter. 4(3-2) One year general chemistry, MTH 214 or concurrently, CPS 112 or concurrently.  

**CHE 311. Thermodynamics for Chemical Engineering**  
Winter, Spring. 3(3-0) CHE 300 or approval of department.  
First and second laws. Energy, enthalpy, entropy, free energy, the mathematics of property relationships. Energy conversion processes. Thermodynamics of flow.

**CHE 340. Transfer Processes and Separations I**  
Fall. 3(2-2) CHE 300 or concurrently, CHE 381 or concurrently or approval of department.  
Thermodynamics of fluid flow. Treatment of fluid flow as a momentum transfer process. Laminar and turbulent motion of compressible and incompressible fluids. Design of flow systems.

**CHE 341. Transfer Processes and Separations II**  
Winter. 3(2-2) CHE 340.  

**CHE 342. Transfer Processes and Separations III**  
Winter. 3(2-2) CHE 340.  

**CHE 343. Transfer Processes and Separations IV**  
Spring. 3(3-2) CHE 341, CHE 342.  

**CHE 381. Chemical Engineering Analysis**  
Fall, Spring. 3(3-0) Students may not receive credit in both CHE 381 and MTH 341. MTH 310, CPS 112. Interdepartmental with the Department of Mathematics.  
Formulation of ordinary and partial differential equations describing chemical systems. Boundary value problems, numerical methods, matrices, and applications, to chemical engineering systems.

**CHE 411. Phase and Chemical Equilibria**  
Spring. 3(3-0) CEM 361, CHE 311.  

**CHE 423. Chemical Engineering Laboratory**  
Fall, Summer. 3(1-6) CHE 425 concurrently, CHE 451 concurrently.  
Assigned laboratory problems, requiring team effort. Experimental work, involving momentum, heat and mass transfer, separation processes, such as distillation, filtration, and drying, reactor kinetics; automatic process control.

**CHE 424. Transport Phenomena and Physical Properties Laboratory**  
Winter, Spring. 3(1-6) CHE 341, CHE 342 concurrently.  
Experiments involving the transport processes and measurement of physical, chemical and thermodynamic properties of various materials. Comparison of theoretical and experimental results.

**CHE 428. Chemical Reaction Engineering**  
Fall. 4(4-0) CEM 361, CHE 311, CHE 342.  

**CHE 442. Polymer Science and Engineering**  
Spring. 3(3-0) One year organic chemistry. CEM 361.  
443. Chemical Engineering of the Solid State
Winter. 3(3-0) CEM 381.
Structure and properties of inorganic and organic solids. Relation of bond type and steric configuration to mechanical, electrical, thermal, optical properties. Macroscopic structure influence on physical properties. Surface phenomena. Applications.

451. Process Systems Control
Fall. 3(3-0) CHE 343, CHE 428 or concurrently.
Foundation of control theory for chemical processes. Integration of present and developing practice with modern theory.

460. Problems and Reports
Fall, Winter, Spring. 1 to 9 credits. Seniors. Approval of department.
Library and laboratory investigations of problems relating to departmental research.

461. Process Selection and Optimization
Winter. 3(3-0) CHE 343, CHE 428.
Application of chemical engineering principles in design calculations. Selection of the optimum design for equipment, functional units, and for the overall process. Influence of design on capital investment, operating cost, product loss, and product quality.

462. Process Design
Spring. 3(1-6) CHE 461.
Integrated design of the complete chemical engineering process. Process engineering, project engineering, instrumentation, and layout.

465. Process Optimization Methods
Spring. 3(3-0) MTH 310.
Methods for determining optimum design and operating policies of systems of varying complexity. Includes classical methods, mathematical programming and modern methods. Flowchart optimization with process simulation packages.

470. Theory of Nuclear Reactors
Winter. 3(3-0) PHY 286, MTH 310 or approval of department.
Theory and design of nuclear research and power reactors. Nuclear transformation, fission, and energy conversion. Derivation of chain reaction design criteria, and calculation of flux-power distribution. Analysis of reactor safety, reliability and economics. Approved through Fall 1989.

481. Transport Phenomena
Spring. 3(3-0) CHE 342, CHE 381.
Fundamental treatment of momentum, energy and mass transport. Use of partial differential equations and equations of change for chemical engineering applications. Analogies among the phenomena, dimensional analysis, and boundary layer theory.

501. Advanced Chemical Engineering Calculations I
Fall. 3(3-0) CHE 381.
Chemical engineering applications of advanced mathematical methods. Formulation and solution of mathematical equations which describe physical problems. Computer solutions.

502. Advanced Chemical Engineering Calculations II
Winter. 3(3-0) CHE 382.
Continuation of CHE 381.

506. Thermodynamics and Kinetics in Chemical Engineering

507. Transfer and Separation Processes
Summer. 5(7-0) B.S. with a major in chemistry, biochemistry, or a closely allied area. Mathematics through calculus. College level physics. General physical, and organic chemistry. Not open to students with B.S. in chemical engineering for graduate credit.

511. Advanced Chemical Engineering Thermodynamics I
Fall. 3(3-0) CHE 311, CHE 411. CEM 361.
Advanced treatment of the laws of thermodynamics. Cryogenic processes. Corresponding state and higher parameters in computing properties of chemical compounds and solutions.

517. Advanced Chemical Reaction Engineering I
Spring. 3(3-0) CHE 428.

526. Flow of Heat I
Spring. 3(3-0) CHE 343.
Steady and unsteady state heat transfer. Conduction and convection in flow and non-flow systems.

531. Advanced Distillation
Winter. 3(3-0) CHE 343.

532. Advanced Absorption and Extraction
Spring. 3(3-0) CHE 343.

580. Fluid Flow and Rheology
Fall. 3(3-0) CHE 481 or approval of department.
Application of fluid dynamics to chemical engineering systems. Balance principles for fluids; Newtonian and non-Newtonian behavior; theory and practice of laminar and turbulent flows.; stability.

581. Mass Transfer
Winter. 3(3-0) CHE 850.
Formulation of component material balances; Fick's first and second laws; convective mass transfer, multicomponent fluxes; boundary layer theory and interfacial mass transfer for laminar and turbulent flows.

586. Viscosity and Flow of Polymeric Materials
Spring. 3(3-0) CHE 481 or approval of department.
Time dependent response as well as steady flow properties of polymer solutions and melts related to molecular and microstructural parameters. Polymer blends, rubber modified polymers and fiber reinforced polymers.

881. Seminar
Fall, Winter, Spring. 1(0-2) May reenroll for a maximum of 6 credits.
Detailed library investigation of one or more specialized aspects of chemical engineering, such as recent theoretical developments in one of the unit operations; presentations of this studies to a seminar group. Participation generally required each term of residence.

886. Selected Topics in Chemical Engineering
Fall, Winter, Spring. 3(3-0) May reenroll for a maximum of 9 credits if a different topic is taken.
A newly developing area of chemical engineering selected by the department for offering each term. Information on the specific topic to be covered should be obtained from the department office before registration.

893. Special Problems
Fall, Winter, Spring. 3(3-0) May reenroll for a maximum of 9 credits. Approval of department.

899. Master's Thesis Research
Fall, Winter, Spring. Variable credit. Approval of department.

912. Advanced Chemical Engineering Thermodynamics II
Spring of even-numbered years. 3(3-0) Approval of department.

918. Advanced Chemical Reaction Engineering II
Fall of odd-numbered years. 3(3-0) Approval of department.
Quantitative treatment of current literature in chemical kinetics and reaction engineering.

999. Doctoral Dissertation Research
Fall, Winter, Spring. Variable credit. Approval of department.