852 Systems Modeling and Simulation
Fall of even years. 3(3-0) Interdepartmental with Fisheries and Wildlife; Forestry; Resource Development. Administered by Department of Fisheries and Wildlife. RB: (STT 422 or STT 442 or STT 464 or GEO 463)
General systems theory and concepts. Modeling and simulation methods. Applications of systems approach and techniques to natural resource management, and to ecological and agricultural research.

853 Applied Systems Modeling and Simulation for Natural Resource Management
Spring of odd years. 3(2-2) Interdepartmental with Fisheries and Wildlife; Forestry; Resource Development; Zoology. Administered by Department of Fisheries and Wildlife. RB: (FW 820 or BE 486 or ZOL 851) or approval of department. R: Open only to seniors and graduate students
Mathematical models for evaluating resource management strategies. Stochastic and deterministic simulation for optimization. System control structures. Team modelling approach.

882 Irrigation and Water Management Engineering
Spring of even years. 3(3-0) RB: (BE 481 and CE 321) SA: AE 882
Design and management of systems for supplemental irrigation. Water supply and transport. Economic and engineering optimization of irrigation design.

890 Special Problems
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Approval of department; application required. SA: AE 890
Individual study in biosystems engineering.

891 Advanced Topics in Biosystems Engineering
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to graduate students in the College of Engineering. Approval of department. SA: AE 891
Biosystems engineering topics not covered in regular courses.

892 Biosystems Engineering Seminar
Spring. 1(1-0) R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering. SA: AE 892
Current topics in biosystems engineering.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 10 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to master's students in the Biosystems Engineering major. SA: AE 899
Master's thesis research.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to doctoral students in the Biosystems Engineering major. SA: AE 999
Doctoral dissertation research.

BUILDING CONSTRUCTION MANAGEMENT BCM

Department of Agricultural Engineering
College of Agriculture and Natural Resources

810 Construction Systems
Fall, Spring. 1(0-2) R: Open only to graduate students in Building Construction Management, Civil Engineering, and Interior Design and Facilities Management majors. Not open to students with credit in BCM 124 or BCM 210.
Construction materials and methods in the U.S. Steel and wood construction.

811 Advanced Project Scheduling
Fall. 3(2-2)
Critical path analysis for effective and logical scheduling of construction projects. Identification of project activities and their relationships. Schedule development, analysis, and updating. Relationship of project costs and resources to the schedule. Effective communication of schedule information.

817 Construction Management Information Systems
Spring. 3(2-2) R: Open only to graduate students in Building Construction Management, Civil Engineering, and Interior Design and Facilities Management majors.
Information generation and utilization for the management of construction projects. Integration of construction management software, conceptual modeling and knowledge-based models.

822 Legal Issues in Construction
Spring. 3(3-0) RB: A degree or experience in construction management, civil engineering, human environment and design, interior design, architecture, urban planning, landscape architecture or law.
Application of Michigan and Federal case law to construction and development claims and litigation.

823 Advanced Construction Project Management
Fall, Spring. 3(3-0) RB: (BCM 411 and BCM 415) R: Open only to graduate students in Building Construction Management.
Project management issues, services and documentation. Bidding, cost accounting, scheduling. Project planning and controlling.

890 Special Problems
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 4 credits in all enrollments for this course. R: Open only to graduate students in College of Agriculture and Natural Resources. Approval of department; application required.
Individual study in land acquisition and development, design, construction, management, finance, marketing, and structural analysis.

891 Advanced Topics in Building Construction Management
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 8 credits in all enrollments for this course. R: Open only to graduate students in College of Agriculture and Natural Resources. Approval of department.
Advanced topics in building construction management.

892 Construction Management Research Seminar
Fall. 2(2-0) R: Open only to graduate students in the College of Agriculture and Natural Resources or College of Engineering, or College of Human Ecology.
Current areas and topics of research in construction management. Resources of research results, analysis of existing research and development of preliminary proposal.

898 Master's Research
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to master's students in the Building Construction Management major.
Master's degree research paper.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 10 credits. A student may earn a maximum of 99 credits in all enrollments for this course. R: Open only to master's students in Building Construction Management.
Master's thesis research.

CELL AND MOLECULAR BIOLOGY CMB

College of Natural Science

800 Cell and Molecular Biology Seminar
Fall, Spring. 1(1-0) A student may earn a maximum of 5 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Current literature in such areas of cell and molecular biology as gene expression, intracellular transport, cell signalling, regulation of cell growth and cell structure.

880 Laboratory Rotation
Fall, Spring, Summer. 1 to 4 credits. A student may earn a maximum of 12 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Participation in research projects in laboratories of Cell and Molecular Biology faculty.

890 Independent Study
Fall, Spring, Summer. 1 to 8 credits. A student may earn a maximum of 8 credits in all enrollments for this course.
Non-thesis research for Plan B master's students.

892 Research Forum
Fall. 1(1-0) A student may earn a maximum of 4 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Advanced graduate students present their laboratory research.

899 Master's Thesis Research
Fall, Spring, Summer. 1 to 9 credits. A student may earn a maximum of 36 credits in all enrollments for this course.
Master's thesis research.

999 Doctoral Dissertation Research
Fall, Spring, Summer. 1 to 24 credits. A student may earn a maximum of 120 credits in all enrollments for this course. R: Open only to students in the Cell and Molecular Biology major.
Doctoral dissertation research.

CHEMICAL ENGINEERING CHE

Department of Chemical Engineering and Materials Science
College of Engineering

101 Molecular Frontiers in Chemical Engineering
Fall. 1(2-0) RB: High school chemistry, biology, algebra, physics.
Influence of chemical engineering on society. History of the profession and future directions. Career opportunities in chemical engineering. Hands-on illustrations of chemical engineering principles. Problem solving skills and development of creativity. Computers and computations in chemical engineering. Development of written and oral communication skills.

201 Material and Energy Balances
Fall, Spring. 3(4-0) P:M: (MTH 133) and (CEM 142 or CEM 143 or CEM 152) and (CSE 101 or concurrently or CSE 131 or concurrently)
Chemical engineering calculations. Synthesis of chemical process systems. Analysis of chemical processes using material and energy balances. Enthalpy calculations for changes in temperature, phase transitions, and chemical reactions.

210 Modeling and Analysis of Transport Phenomena
Fall, Spring. 3(3-0) P:M: (MTH 235 or concurrently and CSE 131 or concurrently) RB: (CHE 201 or concurrently)
Steady and unsteady state material and energy balances. Fluxes and rate processes. Shell balances. Balance equations for mass, heat, and momentum transport. Analogies among mass, heat, and momentum transport. Analytical and numerical solutions. Application of computational methods to problem solutions.

301 Chemical Engineering as a Profession
Fall. 1(2-0) P:M: (CHE 201 or concurrently) RB: Junior standing in chemical engineering R: Open only to students in the Chemical Engineering major.
Professional aspects of chemical engineering. Communication skills, professionalism and ethics, teamwork skills, contemporary engineering issues, career planning, project management, industrial processes.

311 Fluid Flow and Heat Transfer
Fall. 3(4-0) P:M: (CHE 201 or concurrently and CHE 210 or concurrently) R: Open only to juniors or seniors in the College of Engineering.
Thermodynamics of fluid flow. Laminar and turbulent flow. Design of flow systems. Heat transfer in solids and flowing fluids. Interphase heat transfer. Radiant heat transfer. Multiple effect evaporation. Design of heat exchange equipment.

312 Mass Transfer and Separations
Spring. 4(5-0) P:M: (CHE 201 and MTH 235 or concurrently) R: Open only to students in the College of Engineering.
Diffusion. Mass transfer coefficients. Design of countercurrent separation systems, both stagewise and continuous. Distillation, absorption, extraction. Multicomponent separations. Batch processes. Computer-aided design methods.

316 Laboratory Practice and Statistical Analysis
Spring, Summer. 4(2-6) P:M: (CHE 311 and CHE 312 or concurrently and CHE 321 or concurrently and CHE 431 or concurrently) and completion of Tier I writing requirement. R: Open only to students in the Department of Chemical Engineering and Materials Science.
Practical experience with unit operations equipment, including separations processes, reactor systems, and chemical processes requiring analysis of heat, mass and momentum transport. Laboratory assignments requiring teamwork. Engineering statistics with focus on model building, experimental design, and statistical quality control.

321 Thermodynamics for Chemical Engineering
Spring. 4(5-0) P:M: (CHE 201)
First and second laws. Thermodynamics of flow and energy conversion processes. Properties of single and multi-component systems. Phase equilibria. Chemical equilibria in reacting systems.

422 Transport Phenomena
Spring. 3(3-0) P:M: (CHE 311 and CHE 312)
Mathematical and physical analogies among mass, energy and momentum transfer processes. Dimensional analysis and solutions to multivariable boundary value problems. Numerical solutions to nonlinear problems.

431 Chemical Reaction Engineering
Fall. 4(5-0) P:M: (CHE 210 or concurrently and CHE 201) R: Open only to juniors or seniors in the Chemical Engineering major.
Design and analysis of homogeneous flow and batch reactors. Chemical kinetics and equilibria. Reaction rate expressions from mechanisms and experimental data. Mass and heat transfer in heterogeneous reactors. Heterogeneous reactor design. Catalysis.

432 Process Analysis and Control
Spring. 3(3-0) P:M: (CHE 431)
Modeling of process dynamics. Basics of control theory. Design of control systems and specification of control strategies. Integration of control theory with modern practice.

433 Process Design and Optimization I
Fall. 4(5-0) P:M: (CHE 432 or concurrently) and completion of Tier I writing requirement. R: Open only to students in the Department of Chemical Engineering.
Applications of chemical engineering principles in design calculations. Selection of optimum design. Influence of design on capital investment, operating cost, product loss and quality. Mathematical programming methods for optimization.

434 Process Design and Optimization II
Spring. 2(0-4) P:M: (CHE 433)
Design project requiring an integrated design of chemical engineering processes. Process and project engineering. Instrumentation and control systems. Flowsheet layout and optimization. Process simulation.

472 Composite Materials Processing
Fall. 3(2-3) P:M: (CHE 311 or ME 332 or CE 321)
Manufacturing processes for thermoset and thermoplastic matrix composites. Mechanical and thermal evaluation of composites. Rheology and molding of fiber-filled materials.

473 Chemical Engineering Principles in Polymers and Materials Systems
Spring. 3(3-0) P:M: (CHE 311 and CHE 321 and CHE 431 and CEM 352) SA: CHE 371
Application of chemical engineering principles to polymer and materials systems. Structures and properties of metals, ceramics and polymers. Thermodynamics,synthesis, rubber elasticity, viscoelasticity, kinetics, rheology, and processing of polymers systems. Application of statistics and problem-solving skills to materials systems.

481 Biochemical Engineering
Fall. 3(2-3) P:M: (CHE 431)
Applications of microbiology and biochemistry to biochemical engineering. Kinetics and thermodynamics of biochemical reactors. Transport phenomena in biological systems. Bioreactor design and scale-up.

490 Independent Study
Fall, Spring, Summer. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors or graduate students in the Department of Chemical Engineering. Approval of department.
Theoretical or experimental studies of current research topics in chemical engineering. Individual interaction with faculty adviser.

491 Selected Topics in Chemical Engineering
Fall, Spring. 1 to 3 credits. A student may earn a maximum of 6 credits in all enrollments for this course. R: Open only to juniors or seniors or graduate students in the Department of Chemical Engineering.
Study of newly developing or non-traditional chemical engineering topics in a classroom environment.