Appendix I - Additional Program Information

B. Course Syllabi

This section of the self-study document contains the course syllabi for those chemical engineering undergraduate (1000 to 6000-level) courses taught by the department and accepted for credit in the undergraduate program of the department. This includes both required chemical engineering courses and chemical engineering technical elective courses.

The syllabi of courses taken to satisfy the mathematics, basic science and engineering topics required by Criteria 4 not taught by the department were assembled by the college of engineering and are contained in Appendix II. These courses are identified with an asterisk following the course number.

Note: At the present, only required courses designated with "reqd" have specific course outcomes. Course outcomes for elective courses will be developed in the future.

CHEN 2100	Principles of Chemical Engineering	reqd
CHEN 2101	Principles of Chemical Engineering Lab	reqd
CHEN 2610	Transport I	reqd
CHEN 3090	Pulp and Paper Technology	elect
CHEN 3100	Chemical Engineering Processes	elect
CHEN 3370	Phase and Reaction Equilibria	reqd
CHEN 3410	Creativity and Critical Thinking in Engineering	elect
CHEN 3620	Transport II	reqd
CHEN 3650	Chemical Engineering Analysis	reqd
CHEN 3660	Chemical Engineering Separations	reqd
CHEN 3700	Chemical Reaction Engineering	reqd
CHEN 3820	Chemical Engineering Lab I	reqd
CHEN 4100	Pulp and Paper Processing Laboratory	elect
CHEN 4160	Process Dynamics and Control	reqd
CHEN 4450	Process Economics and Design	reqd
CHEN 4560	Pulp and Paper Process Simulation	elect
CHEN 4570	Pulp and Paper Process Design	elect
CHEN 4750	Nuclear Chemical Engineering	elect
CHEN 4860	Chemical Engineering Laboratory II	reqd
CHEN 4880	Pulp and Paper Engineering Laboratory	elect
CHEN 4900	Independent Study	elect
CHEN 4970	Special Topics in Chemical Engineering	elect
CHEN 4980	Undergraduate Research	elect
CHEN 4997	Honors Thesis	elect
CHEN 6110	Pulp and Paper Engineering	elect
CHEN 6120	Surface and Colloid Science of Papermaking	elect
CHEN 6170	Digital Process Control	reqd
CHEN 6400	Molecular Engineering	elect
CHEN 6410	MacroMolecular Engineering	elect

CHEN 6420	Polymer Chemical Engineering	elect
CHEN 6430	Business Aspect of Chemical Engineering	elect
CHEN 6440	Electrochemical Engineering	elect
CHEN 6460	Process Simulation Synthesis and Optimization	reqd
CHEN 6470	Process Design Practice	reqd
CHEN 6630	Introductory Transport Phenemena	elect
CHEN 6650	Hazardous Materials Management and Engineering	reqd
CHEN 6651	Process Safety Management and Engineering	reqd
CHEN 6660	Multimedia Waste Reduction	elect
CHEN 6670	Pollution Prevention Engineering	elect
CHEN 6680	Energy Conversion & Conservation	elect
CHEN 6700	Advanced Separation Processes	elect
CHEN 6800	Biochemical Engineering	elect
CHEN 6810	Biomedical Engineering	elect
CHEN 6820	Advanced Topics in Environmental Biotechnology	elect
ENGR 1110	Introduction to Engineering	reqd
ENGR 2010	Thermodynamics	reqd
ENGR 2200	Introduction to Thermodynamics, Fluids and Heat	serv
COMP 1200*	Intro Engr Computations	reqd
ELEC 3810*	Electrical Engineering	reqd
ENGR 1100*	Engr Orientation	reqd
PHYS 1600/1*	Engr Physics I	reqd
CHEM1110/1*	Gen Chem I	reqd
CHEM1120/1*	Gen Chem II	reqd
CHEM 2070/1*	Org Chem II	reqd
CHEM 2080*	Org Chem II	reqd
CHEM6070/1*	Phy Chem I	reqd
MATH 1610*	Calculus I	reqd
MATH 1620*	Calculus II	reqd
MATH 2630*	Multivariable Calculcus	reqd
MATH 2650*	Differential Equations	reqd

CHEN 2100 - PRINCIPLES OF CHEMICAL ENGINEERING (3)
CHEN 2101 - PRINCIPLES OF CHEMICAL ENGINEERING LAB (1)

Required Core Course

2003-2004 Catalog Data	CHEN 2100: Application of multicomponent material and energy balances to chemical processes involving phase changes and chemical reactions. CHEN 2101: Process engineering and computer applications laboratory. Application of spreadsheet programming and process engineering principles to multicomponent material and energy balances of chemical processes involving phase changes and chemical reactions.
Prerequisites	CHEM 1110 or CHEM 1030, MATH 1610 or MATH 1710. Coreq. CHEM 1120 or CHEM 1040, MATH 1620 or MATH 1720, PHYS 1600
Class/Lab Schedule	2100: Three one-hour class sessions per week. 2101: Two ninety-minute lab session per week.
Course Objectives	This course is intended to comprehensively investigate the solution of problems based on the principles of material and energy balances. Students are expected to achieve understanding of fundamental concepts and generalized patterns of solutions of a wide variety of chemical engineering problems.

Textbooks
Felder, *Elementary Principles of Chemical Processes*, 3e, Wiley, 2000.

Lecture Topics Covered
1. Processes and process variables: (2 classes)
2. Fundamentals of material balances: (14 classes)
3. Multi-phase systems: (5 classes)
4. Energy and energy balances: (5 classes)
5. Balances on nonreactive processes: (8 classes)
6. Balances on reactive processes: (9 classes)

Lab Topics Covered
1. Processes and process variables (2 labs)
2. Material balance spread sheet applications (3 labs)
3. Multi-phase systems (3 labs)
4. Energy balance spread sheet applications (3 labs)
5. Reacting systems mass and energy balances (2 labs)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. State if the units in an equation are consistent and homogeneous and convert values between different unit systems, with an appropriate number of significant figures. (1)
2. Calculate intermediate values between given points in a table or graph using linear interpolation. (1)
3. Find the most appropriate equation of a line through a given set of data where the variables may be related logarithmically ($y = ax^b$), semi-logarithmically ($y = ae^{bx}$), or linearly ($y = ax + b$). (1)
4. Calculate process flow rates in mass, molar, and volumetric units given the appropriate process data. (1)
5. Construct a flow chart from a written description of a process. (2)
6. Determine the limiting and excess reactants in a reaction. (1)
7. Balance material flow sheets incorporating multiple process units with recycle, purge, and bypass streams for processes without chemical reactions. (2)
8. Balance a material flow sheet incorporating multiple process units, and recycle, purge, and bypass streams for reactive processes given extents of reaction and/or yield and selectivity data for the reactions. (2)

9. Obtain physical property values from reference literature. (4)
10. Use the ideal gas law to calculate properties (P, V, n, and T) of pure gases and gas mixtures. (1)
11. Estimate the properties of real gases using a non-ideal equation of state. (1)
12. Estimate the properties of real gases using a generalized compressibility chart. (1)
13. Use vapor pressure data to calculate the molar composition of the gas phase of saturated and unsaturated gas-vapor systems in terms of relative saturation or absolute composition. (1)
14. Calculate the compositions of binary multiphase systems using tabulated vapor-liquid equilibrium data and Raoult's and Henry's Laws. (1)
15. Calculate the change in energy that occurs as a result of a change in a simple closed system. (1)
16. Perform energy balances on a simple open system to calculate the quantity of heat transferred to or from the system. (2)
17. Use steam tables in the solution of energy balance problems. (1)
18. Calculate process flow rates and heat transferred by performing simultaneous mass and energy balances. (2)
19. Calculate changes in the internal energy and enthalpy of a single-phase system using heat capacities. (1)
20. Perform energy balances on systems involving phase changes. (2)
21. Perform energy balances for a system involving mixing or dissolution. (2)
22. Select useful reference states for energy balance problems. (1)
23. Calculate heats of reaction using heats of formation and heats of combustion. (1)
24. Calculate quantity of heat transferred by performing energy balances on reactive processes. (1)
25. Calculate the adiabatic flame temperature for a combustion process. (1)
26. Use computer programs to solve problems based on the preceding concepts. (2,4)
27. Incorporate mass and energy balance principles and concerns in designing a unit or piece of equipment, a process, or the operating parameters within a process as part of a term design process (solution/design of a large scale, open ended problem). (2,4,5)
28. Collect experimental data and be able to analyze and interpret that data in solving material and energy balance problems. (2,3)
29. Professionally present their written work with particular attention given to effective communication, neatness and punctuality. (8)
30. Appreciate the need for academic honesty and professional integrity via frank discussions regarding issues of cheating, fabrication, plagiarism and ethical responsibilities in the practice of engineering. Follow-up on these issues occurs throughout the semester by bringing to their attention current business situations and contemporary issues. (6,7)
31. The student will feel comfortable employing information from traditional and novel sources including the internet, databases, news and technical journals. (11)
32. Be aware of the dynamic, evolving nature of science, engineering, and technology that requires continuous learning and retraining beyond the B.S. degree. (11)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	4 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
☐	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
☐	6	Understand professional ethical responsibility
☐	7	Contemporary issues, business practices, environmental, health, safety issues
☐	8	Effective written communication
	9	Effective oral communication
☐	10	Function successfully on a multidisciplinary team

☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Guin: March 3, 2004

CHEN 2610 - TRANSPORT I: FLUID MECHANICS (Lec 3)

Required Core Course

2003-2004 Catalog Data	Introduction to fluid statics and dynamics; dimensional analysis; compressible and incompressible flows; design of flow systems; introduction to fluid-solids transport including fluidization, flow through process media and multiphase flows.
Prerequisites	MATH 2630, PHYS 1600, Completion of CHEN 2100 with grade of C or better. Coreq. ENGR 2010.
Class/Lab Schedule	Three one-hour class sessions per week.
Course Objectives	This course introduces students to fluid dynamics and the processes and phenomena associated with fluid and fluid solid transport.

Textbooks
Roberson, *Engineering Fluid Mechanics*, 7e, Wiley, 2001.

Topics Covered
1. Introduction to fluid dynamics (2 classes)
2. Integral balances (4 classes)
3. Laminar flow (5 classes)
4. Non-Newtonian fluids (2 classes)
5. Differential equations of fluid motions (3 classes)
6. Cylindrical coordinates (3 classes)
7. Approximations of the Navier-Stokes equations (4 classes)
8. Boundary layers (3 classes)
9. Turbulent flow (3 classes)
10. Flow through pipes and fittings (3 classes)
11. Special topics (8 classes)
12. Design of fluid transport systems (2 classes)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Use the hydrostatic and barometric equations to determine pressure, density, or elevation for fluids at rest. (1)
2. Explain and properly employ the concepts of absolute pressure, gauge pressure, buoyancy, and manometry. (1)
3. Explain the concepts of streamline, stream tube, fluid acceleration, mass flow rate, volumetric flow rate, velocity profile, average velocity. (1)
4. Use appropriate tables to find actual pipe and tubing dimensions given the nominal pipe size and schedule number. (1)
5. Use the continuity equation for steady flow to calculate flow rates in closed conduits of constant and varying cross section, with and without multiple branches. (1)
6. Determine volumetric flow rate, average velocity, momentum correction factor, kinetic energy correction fact for a given velocity profile. (1)
7. Explain the concepts of Newtonian and non-Newtonian fluid, viscosity, laminar and turbulent flow, Reynolds number, pipe roughness, and friction factor. (1)
8. Employ the equations for velocity profile, pressure drop, and friction factor for developed laminar flow of a Newtonian fluid in a circular pipe. (1)
9. Calculate the friction factor for turbulent flow in a circular pipe and other simple geometries, given the Reynolds number and pipe roughness, using the friction factor plot and appropriate equations. (1)
10. Calculate the mechanical energy loss due to friction in a piping system containing various kinds of valves and fittings. (1)
11. Employ the mechanical energy balance to calculate required brake and fluid horsepower for specific piping

configurations. (1)
12. Use the mechanical energy balance to calculate flow rate or pipe sizes as appropriate. (1)
13. Describe the characteristics of centrifugal and positive displacement pumps, and select an appropriate pump to deliver a specified flow rate. (1)
14. Explain the concepts of form and skin drag. Explain the concepts of life and drag.
15. Calculate the drag on a submerged object of simple shape in a flowing fluid using drag coefficient correlations. (1)
16. Explain the concepts of porosity, void fraction, specific volume, specific surface area, particle equivalent diameter. (1)
17. Calculate pressure drop for flow through a packed bed in various flow regimes. (1)
18. Explain the advantages and disadvantages of venturi meters, orifice meters, pitot tubes, rotameters to measure velocity or flow rate. Establish flow rate and velocity using these devices and appropriate equations. (1)
19. Successfully solve closed and open-ended chemical engineering problems. Demonstrate critical thinking skills and strategic problem solving methods. (2)
20. Demonstrate an appreciation of the responsibilities and expectations of the profession. (10,11)
21. Successfully work as effective team members on group assignments. (10)
22. Use appropriate computer software in solving homework problems. (2,4)
23. Turn in on time class work that is neat and professional in appearance and which is effective in conveying the solution. (8)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
☐	8	Effective written communication
☐	9	Effective oral communication
☐	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 3090 - PULP AND PAPER TECHNOLOGY (3)

Technical Elective Course

2003-2004 Catalog Data An introductory course on the technology of pulp and paper manufacturing with emphasis on raw materials, pulping, bleaching, paper making, coating and environmental control.

Prerequisites CHEM 1110 or CHEM 1030, ENGR 2010 and junior standing or department approval.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives This course introduces students to fluid dynamics and the processes and phenomena associated with fluid and fluid solid transport.

Textbooks
Smook, *Handbook for Pulp and Paper Technologists*, 2e, Angus Wilde, 1993.

Topics Covered
1. Introduction to the pulp and paper industry, history, economic impact, and industry's place in national economy (1 class).
2. Raw material, wood structure, chemical composition, cellulose, hemicellulose and lignin reactions (3 classes)
3. Wood procurement and preparation (1 class)
4. Kraft pulping, pulping reaction, batch and continuous digester operation, pulping variables (12 classes)
5. Sulfite pulping, pulping reaction, digester operation, pulping variables (2 classes)
6. Mechanical pulping-groundwood, RMP, TMP (2 classes)
7. Semichemical, chemimechanical and high yield pulping (2 classes)
8. Bleaching of pulp and brightness enhancement (2 classes)
9. Paper properties (1 class)
10. Mechanical and chemical treatment of pulp (3 classes)
11. Papermaking operation - wet end, dry end, surface treatment, printing (11 classes)
12. Pollution abatement (1 classes)
13. Recycling (1 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication

	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Krishnagopalan: March 3, 2004

CHEN 3100: CHEMICAL ENGINEERING PROCESSES (2)

Technical Elective Course
(This course is scheduled to be deleted Fall 2004)

2003-2004 Catalog Data Principles and applications of process technologies, process flow sheets, and manufacturing routes, in the processing of agrichemicals, food, petrochemicals, petroleum plastics, pharmaceuticals and specialty chemicals.

Prerequisites CHEN 3370, 3620. Coreq. CHEN 3660, 3700, 3820.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide working knowledge to students in chemical technology flowsheeting and processing.

Textbooks
Chenier, *Survey of Industrial Chemistry*, 2e, VCH Publishers, 1992.

Topics Covered
1. Overview of industrial processes (6 classes)
2. Market forces and chemical processing (3 classes)
3. Pulp and paper industry (2 classes)
4. Industrial gases (2 classes)
5. Petroleum refining (1 class)
6. Basic organic chemicals (1 class)
7. Petrochemical industry (1 class)
8. Inorganic nitrogen compounds (1 class)
9. Sodium chloride derivatives (1 class)
10. Fertilizers (1 class)
11. Pharmaceutical industry (1 class)
12. Soap, surfactants and detergents (1 class)
13. Elastomers and plastics (1 class)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
☐	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team

☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 3370: PHASE AND REACTION EQUILIBRIA (3)

Required Core Course

2003-2004 Catalog Data Molecular thermodynamics of phase and chemical reaction equilibria including non-ideal thermodynamics and multicomponent applications.

Prerequisites Completion of CHEN 2100, 2101, ENGR 2010 with grade of C or better.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives This course teaches chemical engineering students applications of thermodynamics principles to gas and liquid mixtures, non-ideal solutions, phase equilibria, and chemically reacting systems.

Textbooks
Elliott, *Introductory to Chemical Engineering Thermodynamics*, 1e, Prentice Hall, 1999.

Topics Covered
1. Volumetric properties of pure fluids (4 classes)
2. Thermodynamics properties of fluids (4 classes)
3. Solution thermodynamics: theory (7 classes)
4. Solution thermodynamics: applications (7 classes)
5. Vapor/liquid equilibria (VLE) at low to moderate pressures (4 classes)
6. Thermodynamics properties and VLE from equations of state (4 classes)
7. Topics in phase equilibria (4 classes)
8. Chemical reaction equilibria (7 classes)
9. Summary (1 class)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Understand relationship between pressure, volume, temperature, energy, and entropy for pure substances (1)
2. Apply equations of the state (ideal gas, virial, cubic, and generalized correlation equations) to obtain above properties (1,2)
3. Calculate non-ideal properties and phase diagrams (1,2)
4. Calculate chemical potential and fugacity of substances in pure form and in mixtures (1,2,4)
5. Apply fugacity concept to calculate phase equilibria (1,2)
6. Apply ideal solution and excess property concept to calculate fluid properties (1,2)
7. Use existing and develop new models for excess Gibbs energy (1,2,4)
8. Calculate property change upon mixing (1,2)
9. Use molecular basis to predict and correlate mixture behavior (1)
10. Perform dew point, bubble point, and two- phase flash calculations (1,2,4)
11. Apply equations of state to predict vapor-liquid equilibria (1,2)
12. Calculate liquid-liquid equilibria using activity coefficient concept (1,2)
13. Calculate solid-vapor and solid-liquid equilibria using fugacity concept (1,2)
14. Calculate extent of equilibrium reactions for varying temperature, pressure and composition (1,2)
15. Perform yield calculations for multiple equilibrium reactions (1,2)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome

		◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Neuman: March 3, 2004

CHEN 3410: CREATIVITY AND CRITICAL THINKING IN ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Application of creativity and critical thinking principles to effectively approach solving engineering problems. How to convincingly present information to technical audiences.

Prerequisites Junior standing in college of engineering.

Class/Lab Schedule One one-hour class session and two ninety-minute lab sessions per week.

Course Objectives This course teaches engineering students how to apply creativity and critical thinking principles to effectively approach solving engineering problems and how to convincingly present information to technical audiences. Lab sessions are used to develop oral and written communications skills.

Textbooks
Ruggieko, *The Art of Thinking*, 5e, Addison-Wesley, 1997.
Fogler, *Strategies for Creative Problem Solving*, 1e, Prentice-Hall, 1994.

Topics Covered
1. Critical thinking (2 classes)
2. Arguments - core concepts (2 classes)
3. Informal fallacies of reasoning (1 class)
4. Problem solving (2 classes)
5. Teams and teamwork (2 classes)
6. Effective communications (2 classes)
7. Planning skills (2 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	1 Credit	1 Credit

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 3620: TRANSPORT II (3)

Required Core Course

2003-2004 Catalog Data Fundamentals and applications of heat and mass transfer in chemical processes including conduction, convection and radiation, heat exchange, evaporation, chemical reaction, gas absorption, drying and humidification.

Prerequisites MATH 2650, ENGR 2010. Completion of CHEN 2610 with grade of C or better.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives This course is designed to provide knowledge of fundamentals and applications of heat and mass transfer in chemical processes.

Textbooks
Geankoplis, *Transport Processes and Separation Process Principles*, 4e, Prentice Hall, 2003.

Topics Covered
1. Mechanisms of heat transfer, Fourier's law and thermal conductivity (3 classes)
2. Energy conservation equation, steady state and transient conduction (3 classes)
3. Convection, dimensional analysis, laminar boundary layers (3 classes)
4. Turbulent heat transfer, natural and forced convection, correlations for convective heat transfer (3 classes)
5. Boiling and condensation (3 classes)
6. Heat transfer equipment (3 classes)
7. Radiation (3 classes)
8. Mechanism of mass transfer, diffusivity, Fick's law, fluxes (3 classes)
9. Differential equations of continuity, 1-D diffusion (3 classes)
10. Diffusion with chemical reaction, transient diffusion (3 classes)
11. Convective mass transfer, laminar concentration boundary layers (3 classes)
12. Mass transfer in turbulent flow, mass, heat, and momentum transfer analogies (3 classes)
13. Interphase mass transfer, mass transfer correlations (3 classes)
14. Packed towers, humidification, gas-liquid contacters (4 classes)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Demonstrate an understanding of the basic mechanisms of heat and mass transfer within a single phase and between phases (1)
2. Model and solve heat and mass transfer problems in well-defined geometries (1,2)
3. Explain the effect of temperature and pressure on thermal conductivity and molecular diffusivity (1,2)
4. Determine temperature and concentration profiles in steady-state and unsteady-state heat and mass transfer (1,2,4)
5. Calculate the thickness of the hydrodynamic and thermal boundary layers (1,2)
6. Predict individual heat and mass transfer coefficients (1,2)
7. Use individual heat and mass transfer coefficients to obtain overall heat and mass transfer coefficients (1,2)
8. Use analogies between momentum, heat and mass transfer for engineering calculations (1,2)
9. Analyze experimental heat and mass transfer data obtained in laboratory setting (1,2,3,4,8)
10. Demonstrate an understanding of the diffusion of gases in a single capillary and porous media (1,2)
11. Apply the general diffusion equation to homogeneous chemical reactions and chemical reactions at a catalyst surface (1,2,4)
12. Perform calculations on single-effect and multiple-effect evaporators (1,2,5)
13. Explain the effects of processing variables on evaporator operation (1,2)
14. Size heat exchangers (1,2,5)

15. Design packed-columns for simultaneous heat and mass transfer (i.e, cooling towers, gas absorption) in terms of number and height of transfer units (1,2,4,5)
16. Construct drying-rate curves from experimental data and predict the effect of changing drying process variables (1,2,3)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
☐	8	Effective written communication
	9	Effective oral communication
☐	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Neuman: March 3, 2004

CHEN 3650: CHEMICAL ENGINEERING ANALYSIS (3)

Required Core Course

2003-2004 Catalog Data	Mathematical modeling, analytical, numerical, and statistical analysis of chemical processes.
Prerequisites	Completion of CHEN 2100, CHEN2101 and CHEN 3620 with grade of C or better. ENGR 2010.
Class/Lab Schedule	Two one-hour class sessions and one three-hour lab session per week.
Course Objectives	This course is designed to teach students methods to mathematically model and computer simulate any type of process or equipment based on fundamental transport, kinetic, and thermodynamic principles.

Textbooks
Elnashaie, *Conservation Equations & Modeling of Chemical & Biochemical Processes*, 1e, Dekker, 2003.
Devor**,** *Statistical Quality Design & Control: Contemporary Concepts & Methods*, 1e, Prentice-Hall, 1992.

Lecture Topics Covered
1. Class overview (1 class)
2. Fundamental laws (4 classes)
3. Mathematical modeling (6 classes)
4. Numerical methods (2 classes)
5. Statistical methods (2 classes)
6. Simulation (3 classes)
7. Time domain dynamics (4 classes)
8. Laplace domain dynamics (3 classes)
9. Process analysis (2 classes)

Lab Topics Covered:
10. Introduction to computers (4 labs)
11. Mathematical modeling (4 labs)
12. Statistical analysis (1 lab)
13. Numerical analysis (2 labs)
14. Computer simulation (3 labs)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Classify chemical engineering systems according to system theory, which is more general and fundamental than other more classical classifications (5,10,11).
2. Determine, by application of system theory a priori of solution and analysis, the basic steady state (stationary non-equilibrium state) and dynamic characteristics of the system (1,5,11)
3. Able to apply set theory, probability theory and statistics to chemical engineering problems (3,5)
4. Able to use statistical analysis of experimental / industrial data for Quality Control (QC) and Statistical Process Control (SPC). The student will be fluent regarding all the necessary techniques, e.g.: Quality Control Assurance and Improvement, Risk and errors in Hypothesis testing, construction and use of the Shewart chart and Western electric rules, Exponential Weighted Moving Average (EWMA), etc. (1,2,3)
5. Develop generalized modular material and energy balance equations which are applicable to all reacting and non-reacting systems, including systems with single reaction as well as systems with multiple reactions, systems with Single Input Single Output (SISO) as well as systems with Multiple Input Multiple Output (MIMO) (1,4)
6. Transform the mass and energy balance equation into design equations for lumped steady state systems (1,3,5)
7. Transform mass and energy balance equations into design equations for distributed systems (1,3,5)

8. Develop dynamic models for both isothermal and non-isothermal systems (1,2,3,5)
9. Utilize design equations as steady state and unsteady state models for reacting and non-reacting systems (1,2,3,5)
10. Apply the equations for design, simulation and experimentation through the change of the vector of unknowns, input data and method of solution (1,2,3,5)
11. Develop the necessary knowledge for the analytical solution of linear systems; this includes the solution of sets of linear algebraic equations as well as initial value and two-point boundary value linear differential equations (1,5)
12. Develop the necessary knowledge regarding numerical solution of non-linear systems, this include the iterative solution of nonlinear algebraic equations as well the marching techniques (Euler, Runge-Kutta, etc) for the solution of initial value ODEs. The student will also gain the necessary knowledge for solving non-linear two-point boundary value differential equations using iterative techniques (e.g.: Fox's method) as well as polynomial approximation techniques (e.g.: orthogonal collocation) (1,5)
13. Use the necessary math/engineering software's for the solution of non-linear equations (4)
14. Demonstrate competency in the development of control loops structure (feed-back, feed forward, cascade) and their preliminary analysis (1,4,5)
15. Apply Laplace transformation and use block diagram algebra (1,4,5)
16. Use textbooks and other sources of scientific literature (papers, technical reports, etc) (11)
17. Produce good technical reports and present their results in a professional manner (8)
18. Meaningful technical presentations using different presentation techniques (classical overhead projector, Power Point, etc.) (8,9)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
◆	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Elnashaie: March 3, 2004

CHEN 3660: CHEMICAL ENGINEERING SEPARATIONS (3)

Required Core Course

2003-2004 Catalog Data Separation processes including distillation, extraction, membrane separation, and other separation operations.

Prerequisites Completion of CHEN 2100, 2101, 2610 and ENGR 2010 with a grade of C or better. Coreq. CHEN 3370, 3650.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives The goal of this course is to introduce the principles and calculation methods required to solve industrial problems involving staged unit operations including application of multiphase equilibrium data and the analysis and design of single stage flash separations, binary distillation columns, multi-component distillation columns, and liquid-liquid extraction columns. Theory and design of other separation processes are also considered.

Textbooks
Seader, *Separation Process Principles*, 1e, Wiley, 1998.

Topics Covered
1. Introduction to separation processes (2 classes)
2. Vapor-liquid equilibrium (5 classes)
3. Single equilibrium stages and flash calculations (6 classes)
4. Cascades (3 classes)
5. Distillation of binary mixtures (5 classes)
6. Liquid-liquid extraction with ternary systems (4 classes)
7. Approximate methods for multi-component, multi-stage separations (5 classes)
8. Supercritical extraction (4 classes)
9. Membrane separations (4 classes)
10. Adsorption, ion exchange, chromatography separations (4 classes)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Explain and define the following equilibrium concepts: K value, relative volatility, equilibrium, azeotrope, DePriester (K) chart, bubble point and dew point, Gibb's phase rule, lever-arm rule. (1)
2. Employ binary equilibrium diagrams (x-y, T-x-y, H-x-y) to identify the state of a system, the composition of its phases, the temperature dependences (bubble point, dew point, superheat temperature). (1)
3. Employ relationships K-charts or equations to be able to determine the bubble point and dew point of multicomponent systems. (1)
4. Be able to convert and redraw equilibrium data between x-y, T-x-y, and H-x-y diagrams. (1)
5. Be able to employ graphical programs (Excel, MATLAB, MathCAD) to be able to produce quality equilibrium diagrams. (4)
6. Sketch and provide notation for basic flash distillation processes. (2)
7. Derive and plot the operating line for binary flash distillation on a x-y diagram. (1)
8. Use specified sequential techniques and simultaneous techniques to solve binary and multicomponent flash problems after identifying which technique is appropriate for a given situation. (2,4)
9. Derive the Rachford-Rice equation and employ it to determine the solution to problems where vapor fraction is specified. (1)
10. Explain why narrow boiling and wide boiling mixtures are handled differently when simultaneous multicomponent flash problems are encountered. (1)
11. Explain physically how a distillation column works. Sketch and identify the internal features and auxiliaries. (2)

12. Differentiate between total and partial condensers and reboilers including the fashion in which equilibrium data is employed. (1)
13. Write and solve the external mass and energy balances associated with two product single feed distillation columns. (2)
14. Explain the difference between design problems and rating problems. (5)
15. Explain the source and purpose of reflux liquid and reboiled vapor. (1)
16. Identify and differentiate between rectification (enriching) and stripping sections. Be able to derive operating equations (lines) for both sections. Be able to derive the equation for the feed operating line. (1)
17. Discuss the expected temperature profile in a distillation column and its affect on tray compositions. (1)
18. Understand the assumptions made when employing the constant molal overflow condition. (1)
19. Calculate the feed quality and explain its effect on vapor and liquid flow rates above and below the feed stage. Be able to work with the concepts of superheated feeds and subcooled feeds. (1)
20. Use the McCabe-Thiele method to design/rate distillation columns. Employ stage efficiency data to determine actual number of stages. Correctly differentiate between internal stages and equilibrium situations in column externals. (1)
21. Understand and employ the concepts of limiting conditions (total reflux, minimum reflux, other pinch conditions) (1)
22. Perform calculations on columns that do not employ condensers (liquid feed at top) or reboilers (vapor feed at bottom, steam extraction, etc). (1)
23. Explain multicomponent distillation concepts such as key components, non-key components, distributing components (sandwiches components), and optimum feed stage. (1)
24. Explain and outline the general procedure for stage-by-stage analysis of multicomponent distillation. Solve these procedures for constant relative volatility systems. Solve these procedures using bubble point or dew point calculations on each stage. (1,2)
25. Explain the use of various shortcut methods (Fenske, Underwood, Gilliland). Employ these techniques to develop approximate column designs. Appreciate the limitations of each of these approaches. Be able to calculate an appropriate average relative volatility when variable volatility is encountered. (1,5)
26. Explain and define liquid-liquid extraction terminology including solubility envelope, plait point, extract, raffinate, solvent, solute, conjugate line. (1)
27. Read and employ the data from equilateral triangular diagrams, right triangular diagrams. Be able to convert from one diagram representation to another as well as to be able to switch axes on the latter diagram. (1)
28. Solve single contact extractions, cross current extractions and counter current extractions graphically. (1,5)
29. Explain how solute removal is affected by solvent rate. Explain what is analogous to minimum reflux ratio in distillation. Explain what happens as the solvent to feed ratio is altered. Define the concept of "delta" and be able to derive the values of "delta" composition. (1)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation:
Gupta: March 3, 2004

CHEN 3700: CHEMICAL REACTION ENGINEERING (3)

Required Core Course

2003-2004 Catalog Data Design of chemical reactors with homogeneous reaction systems

Prerequisites MATH 2650, ENGR 2010, completion of CHEN 2100, 2101, 2610 with grades of C or better. Coreq. COMP 1200, CHEN 3620, 3650.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives This course is designed to give chemical engineering students the ability to incorporate rate expressions into various energy and material balances for designing various types of chemical reactors with homogeneous reaction systems.

Textbooks
Fogler, *Elements of Chemical Reaction Engineering*, 3e, Prentice-Hall, 1998.

Topics Covered
1. Introduction (3 classes)
2. Polymath exercise (3 classes)
3. Mole balance in reactors (6 classes)
4. Rate laws and stoichiometry (5 classes)
5. Isothermal reactor design (10 classes)
6. Nonisothermal reactor design (8 classes)
7. Multiple reactions (6 classes)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Prepared by Dr. Ronald Neuman, Professor of Chemical Engineering, on March 3, 2004

CHEN 3820: CHEMICAL ENGINEERING LABORATORY I (2)

Required Core Course

2003-2004 Catalog Data Experimental study of chemical thermodynamics, heat and momentum transfer with analytical, numerical, and statistical analysis.

Prerequisites Completion of 3620 and 3650 with a grade of C or better.

Class/Lab Schedule One one-hour class session and one three-hour lab session per week.

Course Objectives

1. To provide students with an understanding of the relationship between chemical engineering theory and the performance of actual experimental laboratory operations.
2. To provide students with the skills and experience of working in teams.
3. To promote professional written reports and oral presentations.

Textbooks

Geankoplis, *Transport Processes and Separation Process Principles*, 4e, Prentice Hall, 2003.

Lecture Topics Covered

1. Class overview (1 class)
2. Fluid dynamics (2 classes)
3. Heat transfer (2 classes)
4. Report writing (1 class)
5. Analytical and statistical analysis of data (2 classes)
6. Valves, piping, steam systems (1 class)
7. Oral presentations (5 classes)

Lab Topics Covered:

8. Fluid dynamics (8 labs)
9. Heat transfer (6 labs)

Course Outcomes *(Numbers in parentheses refer to PEO's)*

Upon successful completion of this course, students should be able to:

1. Have experience in and the ability to carry out experiments in fluid dynamics and energy transport. (3,4)
2. Integrating technical topics from previous coursework, and to "learn on their own" to analyze and solve chemical engineering problems. (1,4)
3. Demonstrate an expanded knowledge of process hardware and related operations such as pipes, fittings, welding, pumps, etc. (4)
4. Demonstrate technical expertise in momentum and energy transport of a qualified entry-level chemical engineer. (1,4)
5. Use technical literature such as handbooks, textbooks, papers, manuals, etc. to analyze data. (1,4)
6. Understand the difference between variables that can be controlled (independent variables) and variables that need to be measured (dependant variables), and be able to properly plot in graphical form. (1,2,3)
7. Analytically derive via energy and material balances, equations needed in the understanding and analysis of elementary experiments involving fluid dynamics and heat transfer. (1,2)
8. Use appropriate software to solve complex equations and statistically evaluate data (4)
9. Apply statistical methods and error analysis techniques to estimate uncertainties in experimental results. (4)
10. Accurately interpret (without over interpreting) graphical data. (4)
11. Appreciate the importance of producing clear, accurate, and meaningful technical reports and will have experience writing acceptable 5 page industrial type memos and comprehensive in-depth technical reports based on chemical engineering experiments (8,11)
12. Make acceptable technical presentations as judged by industrial standards (9)
13. Use the latest software technology to generate slides for technical presentations (4)

14. Competent in and understand the critical importance of safe work practices in laboratory and pilot scale industrial processes. (7)
15. Work in teams to perform, analyze, and communicate results of chemical engineering experiments. (10)
16. Understand and appreciate the ethical importance of submitting accurate results and rejecting plagiarism and falsified data. (6)
17. Defend technical presentations by addressing questions and challenges from supervisors and peers. (1,9)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
☐	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
☐	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
☐	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation:
Mills: March 3, 2004

CHEN 4100: PULP AND PAPER PROCESSING LABORATORY (2)

Technical Elective Course

2003-2004 Catalog Data Experimental study of pulping and papermaking operations.

Prerequisites CHEN 2610, CHEN 3090, CHEN 3820 or departmental approval.

Class/Lab Schedule One six-hour lab session per week.

Course Objectives To familiarize the student with industrial pulping and bleaching operations, beating and handsheet making, laboratory testing procedures and use of TAPPI standards, and application of statistics in the laboratory and industry.

Textbooks
No text.

Topics Covered
1. Optical microscopy, fiber staining, fiber identification, qualitative and quantitative fiber analysis. (2 labs)
2. Measurement of pulp consistency and freeness. (2 labs)
3. Kraft pulping, screening, yield and kappa number determination. (6 labs)
4. Bleaching, bleached pulp brightness and viscosity measurements. (6 labs)
5. Beater run, hand sheet making, property evaluation. (6 labs)
6. Filler retention, sizing, and physical and optical property evaluation. (6 labs)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Krishnagopalan: March 3, 2004

CHEN 4160: PROCESS DYNAMICS AND CONTROL (4)

Required Core Course

2003-2004 Catalog Data Dynamic modeling of chemical processes, feedback systems and analog controller tuning and design, sequential control systems, sensors and instrumentation.

Prerequisites CHEN 3820, COMP 1200. Completion of CHEN 3620, 3650, 3660, 3670 with grades of C or better.

Class/Lab Schedule Three one-hour class sessions and two ninety-minute lab sessions per week.

Course Objectives This course is designed to teach students how to: 1) develop dynamic models from unsteady-state mass/energy balances and tools to analyze linear/nonlinear dynamics; 2) setup feedback control systems; 3) select standard control system instrumentation; 4) estimate the dynamic behavior of dynamic closed-loop control systems; and 5) tune and trouble-shoot control loops.

Textbooks

Elnashaie, *Conservation Equations & Modeling of Chemical & Biochemical Processes*, 1e, Dekker, 2003.
Doyle, *Process Control Modules*, 1e, Prentice-Hall, 1999.

Lecture Topics Covered

1. Steady state non-reacting isothermal systems (3 classes)
2. Steady state reacting isothermal systems (3 classes)
3. Steady state non-isothermal systems (2 classes)
4. Dynamic modeling (3 classes)
5. Bifurcation and stability (3 classes)
6. Utilization of models for design and control (3 classes)
7. Laplace transformation (2 classes)
8. Applications of Laplace transformation (2 classes)
9. Block diagram algebra (3 classes)
10. Dynamic behavior of 1^{st} and 2^{nd} order systems (4 classes)
11. Linearization of non-linear systems (1 class)
12. Dynamic response of complicated systems (4 classes)
13. Feedback, feed forward and cascade control (4 classes)
14. Feedback and servo control system (3 classes)
15. Design criteria for control systems (2 classes)

Lab Topics Covered:

1. Steady state of chemical/biochemical processes (3 labs)
2. Introduction to simulation of dynamical systems (3 labs)
3. Simulation of simple dynamical system (3 labs)
4. Simulation of complex dynamical system (5 labs)
5. Bifurcation and stability exercises (3 labs)
6. Linearization exercises (2 labs)
7. Introduction to use of Laplace transformation (3 labs)
8. Block diagram algebra exercises (3 labs)
9. Design of PID control systems (3 labs)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	4 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
☐	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
◆	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
■	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Elnashaie: March 3, 2004

CHEN 4450: PROCESS ECONOMICS AND DESIGN (2)

Required Core Course

2003-2004 Catalog Data	Fundamentals and applications of process economics and design, computer-aided cost estimation, profitability analysis and process improvement.
Prerequisites	Completion of CHEN 3620, 3650, 3660, 3700 with grades of C or better. Coreq. CHEN 3820.
Class/Lab Schedule	Two one-hour class sessions per week.
Course Objectives	This course allows students to explore economic principles that play a role in process design. Learning objectives include understanding economic principles that play a role in process design, estimating equipment and product costs, calculating interest and depreciation costs, evaluating capital investment profitability, and optimizing process designs based on economic objectives. Students experience working on teams and making oral technical presentations.

Textbooks
Peters, *Plant Design & Economics for Chemical Engineers*, 5e, McGraw-Hill, 2003.

Topics Covered

1. Cost estimation (7 classes)
2. Interest and investment costs (5 classes)
3. Taxes and insurance (1 class)
4. Depreciation (2 classes)
5. Profitability analysis (8 classes)
6. Benefit-to-cost analysis (2 classes)
7. Optimum design and design strategy (3 classes)
8. Student oral presentations (1 class)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Use cost charts and historical data to estimate equipment and plant costs (1,4,7)
2. Update cost information with appropriate cost indices (1,4,7)
3. Determine fixed, working, and total capital investment estimates for chemical manufacturing processes given process flowsheets, equipment specifications, and material and energy balances (1,2,4,5)
4. Locate and utilize resources to estimate raw material, product, waste, labor, and utilities costs (1,2,7)
5. Estimate product (manufacturing and operating) costs (1,2,4,5)
6. Use discrete and continuous interest (1,2,7)
7. Understand the time value of money and discounting (1,2,5,7)
8. Use annuity equations to determine periodic payments for loans or savings (1,5,7)
9. Determine depreciate costs and tax write-offs (1,5,7)
10. Determine cash flow given sales income, operating costs, and tax rates (1,2,4,5,7)
11. Calculate profitability measures including rate of return on investment, net present value, payback period, and discounted cash flow rate of return (1,2,4,5,7)
12. Evaluate a capital project's profitability to recommend a course of action based on a company's expectation (minimum acceptable rate of return) (4,5,6,7)
13. Identify the most profitably option between several alternatives (4,5,6,7)
14. Understand elementary concepts of economic optimization (5,7)
15. Calculate benefits to costs ratios for evaluating public and non-profit projects (1,4,5,6,7)
16. Incorporate economic concerns in designing manufacturing plants (1,2,4,5,7)
17. Work on a team to complete a semester long cost and profitability project (6,10)

18. Analyze team effectiveness and their contributions to team efforts (4,6,7,9)
19. Prepare and deliver an effective oral presentation with visual aids (4,6,7,9)
20. Write an effective technical design-type report (4,5,6,7,8,10)
21. Prepare a resume (6,7,8,11)
22. Understand expectations for interviews and other contacts with perspective employers (6,7,9,11)
23. Locate and utilize resources to help with career searches (4,7,11)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Duke: March 3, 2004

CHEN 4560: PULP AND PAPER PROCESS SIMULATION (2)

Technical Elective Course

2003-2004 Catalog Data Fundamentals of microcomputer process simulation with applications to the pulp and paper industry. Design of pulp and paper unit operations and small scale processes using commercial simulation software.

Prerequisites CHEN 3090, completion of CHEN 3620, 3650, 3660, 3700 with grades of C or better. CHEN 3820. Coreq. CHEN 4100, CHEN6110.

Class/Lab Schedule One one-hour class session and two ninety-minute lab sessions per week.

Course Objectives This course emphasizes the application of computer simulation and flowsheeting, optimization, and process synthesis techniques to the design of processes and equipment in the pulp and paper industry. After successfully completing this course, the student will be able to analyze and model industrial processes such as pulping, bleaching, papermaking, recovery, and steam and power operations. The student will also be able to use commercial process simulation software to solve relevant material and energy balances and employ the fundamentals of technical exposition and description especially in writing engineering reports.

Textbooks
No text

Lecture Topics Covered
1. Introduction (1 class)
2. Overview of process simulation software and simulation history (1 class)
3. Major design features and operation of WinGEMS simulator (1 class)
4. Basic unit operations including mixing splitting, and dilution (2 classes)
5. Use of controller blocks to control simulation variables (2 classes)
6. Sensitivity studies (1 class)
7. Stream and stream component concepts (1 class)
8. Unit and unit set concepts (1 class)
9. Use of compound blocks (1 class)
10. Use of client/server functions (1 class)
11. Professional report writing fundamentals (1 class)

Lab Topics Covered:
12. Design problem involving basic mixing, splitting and dilution (2 labs)
13. Design problem involving controller blocks (2 labs)
14. Design problem involving model selection (2 labs)
15. Design problem involving process design (2 labs)
16. Design problem featuring process improvement (2 labs)
17. Advanced design problem featuring process design (2 labs)
18. Design problem involving compound blocks (2 labs)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 4570: PULP AND PAPER PROCESS DESIGN (2)

Technical Elective Course

2003-2004 Catalog Data Application of process simulation and process economics to complex, open-ended design, retrofitting and operation problems in pulp and paper. Design of pulp and paper unit operations and processes. Screening of alternatives and economic optimization.

Prerequisites CHEN 4560.

Class/Lab Schedule One one-hour class session and one three-hour lab session per week.

Course Objectives This course allows students to develop and analyze one or more large-scale process design problems typical of those encountered in the pulp and paper industry. Learning objectives include employing a process simulator (WinGEMS), synthesizing preliminary process designs, development of process flow diagrams and equipment specifications, applying process economic analysis, and assessing alternative designs and technologies. Students experience working on teams, preparing technical reports, and making oral technical presentations.

Textbooks: No text.

Topics Covered
1. Comprehensive design project discussions (7 classes)
2. Individual design project discussions (2 classes)
3. Design project management and oral reporting (3 classes)
4. Design consultations (18 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
◆	6	Understand professional ethical responsibility
◆	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
◆	9	Effective oral communication
◆	10	Function successfully on a multidisciplinary team
■	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Duke: March 3, 2004

CHEN 4750: NUCLEAR CHEMICAL ENGINEERING (2)

Technical Elective Course
(This course is scheduled to be deleted Fall 2004)

2003-2004 Catalog Data Nuclear reactor design, chemical ore processing, isotope enrichment, handling and decay, spent fuel-reprocessing, plasmas, radiation.

Prerequisites CHEM 6070, CHEN 3620, 3660, 3700.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide an overview of nuclear engineering from a chemical engineering perspective. At the completion of this course, students should be well versed in the chemical aspects of nuclear processes as well as understand the basics of fission and fusion processes.

Textbooks
Connolly, *Foundations of Nuclear Engineering*, 1e, Wiley, 1978.

Topics Covered
1. Course overview (1 class)
2. Energy conversion (3 classes)
3. Nuclear reactions (3 classes)
4. Radioactivity (4 classes)
5. Interactions of radiation with matter (3 classes)
6. Health effects of nuclear radiation (3 classes)
7. Nuclear fission (5 classes)
8. Nuclear fusion (5 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
■	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 4860: CHEMICAL ENGINEERING LABORATORY II (2)

Required Core Course

2003-2004 Catalog Data Experimental study of mass transfer, separations, and reaction engineering. Emphasis is on open-ended laboratory projects with electronic instrumentation; experimental design with analytical, numerical, and statistical analysis of data.

Prerequisites CHEN 3660, 3820. Coreq. CHEN 3620, 3700.

Class/Lab Schedule One one-hour class session and one three-hour lab session per week.

Course Objectives (1) To further develop the laboratory, data analysis, and communication skills learned in CHEN 3820, (2) to teach students the safe operation of larger-scale chemical engineering equipment, and (3) to foster independent learning and synthetic thinking as related to engineering research.

Textbooks
Geankoplis, *Transport Processes & Separation Process Principles*, 4e, Prentice Hall, 2003.
Taylor, *An Introduction to Error Analysis*, 2e, University Science Books, 1997.

Lecture Topics Covered
1. Class overview (1 class)
2. Mass transfer (2 classes)
3. Reaction kinetics/engineering (2 classes)
4. Heat transfer (1 classes)
5. Data analysis (2 classes)
6. Report writing (1 class)
7. Oral presentations (3 classes)
8. Instrumentation and data acquisition (2 classes)

Lab Topics Covered:
1. Mass transfer (5 labs)
2. Reaction kinetics/engineering (6 labs)
3. Heat transfer (3 labs)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Have experience in and the ability to carry out experiments in chemical reactions/reactors, mass transfer, combined heat and mass transfer, modern separations techniques including distillation, ion-exchange, reactive absorption (3,4)
2. Demonstrate the ability to use higher order thinking/learning skills by synthesizing from previous coursework and technical literature the knowledge needed to perform and analyze sophisticated chemical engineering experiments (1,4)
3. Apply Design of Experiments (DOE) methodology and show proficiency in applying these techniques to the design of a chemical engineering experiment (5)
4. Perform "open-ended" chemical engineering experiments and to design their own experimental procedures (5)
5. Competently use technical literature such as handbooks, textbooks, papers, manuals, etc. to analyze data. (1,4)
6. Derive via energy and material balances, equations needed in the understanding and analysis of unit operations. (1,2)
7. Use appropriate software such as Excel, Polymath, Matlab, and TableCurve 2D to solve complex equations, statistically evaluate data, and to model chemical engineering processes (4)
8. Apply statistical methods and error analysis techniques to estimate uncertainties in experimental results and receive formal instruction and an appreciation of how these techniques can be used industrially in Statistical Process Control (SPC) and how SPC is used industrially in combination with DOE (4,5)

9. Accurately interpret (without over interpreting) more complex graphical data. (4)
10. Appreciate the importance of producing clear, accurate, and meaningful technical reports and will have further experience writing acceptable 5 page industrial type memos and comprehensive in-depth technical reports based on more complex and open-ended chemical engineering experiments (8,11)
11. Make acceptable technical presentations as judged by industrial standards (9)
12. Use the latest software technology to generate slides for technical presentations (4)
13. Competent in and understand the critical importance of safe work practices in laboratory and pilot scale industrial processes. (7)
14. Work in teams to perform, analyze, and communicate results of chemical engineering experiments. (10)
15. Understand and appreciate the ethical importance of submitting accurate results and rejecting plagiarism and falsified data. (6)
16. Defend technical presentations by addressing questions and challenges from supervisors and peers. (1,9)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
☐	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Mills: March 3, 2004

CHEN 4880: PULP AND PAPER LABORATORY (2)

Technical Elective Course

2003-2004 Catalog Data Comprehensive open-ended projects on pulp and paper topics.

Prerequisites CHEN 3620, 3700, 4100, 6110.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives Open-ended pulp and paper lab projects.

Textbooks
No text.

Topics Covered
1. Project discussion (2 labs)
2. Project proposal and presentation (2 labs)
3. Laboratory experimentation (22 labs)
4. Final oral report (2 Labs)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Krishnagopalan: March 3, 2004

CHEN 6170: DIGITAL PROCESS CONTROL (3)

Required Core Course

2003-2004 Catalog Data Introduction to digital control systems including operator/machine interface design and operation. Application of process dynamics and digital control systems in experimental control laboratory.

Prerequisites CHEN 4160, ELEC 3810.

Class/Lab Schedule Two one-hour class sessions and two ninety-minute lab sessions per week.

Course Objectives This course is designed to teach students how to 1) use digital controllers in the chemical process industry and 2) design man-machine interfacing programs.

Textbooks

Rigs, *Chemical Process Control*, 1e, Ferret, 1999.
Stenerson, *Fundamentals of Programmable Logic Controllers, Sensors & Communications*, 2e, Prentice-Hall, 1999.

Topics Covered

1. Introduction of digital control system and instrumentation (1 class)
2. Advanced control strategies (4 classes)
3. Control of multiple input, multiple output processes (MIMO systems) (4 classes)
4. Supervisory control (2 classes)
5. Sampling and filtering of continuous measurements (4 classes)
6. Discrete time models (4 classes)
7. Design of digital controllers (2 classes)
8. Predictive control techniques (6 classes)

Lab Topics

1. Design and program man-machine interfaces (4 labs)
2. Feedback control (2 labs)
3. Cascade control (2 labs)
4. Ratio control (2 labs)
5. Sampling time studies (2 labs)
6. MIMO control (2 labs)

Course Outcomes

Upon successful completion of this course, students should be able to:

1. Use sequential process controls, classical proportional-integral-derivative controls (PID), advanced single-input-single-output (SISO) controls (specifically cascade control, feed-forward control, rule-based fuzzy control, enhanced PID control using model predictive techniques) to synthesize control algorithms for complex process systems.
2. Demonstrate an increased proficiency in comprehending multi-variable control systems (specifically standard state-variable notation, SVN; relative gain array, and dynamic matrix control).
3. Understand and apply some basic concepts regarding Laplace transform analyses, frequency response analyses, and process stability analyses.
4. Apply VBA/EXCEL programming to predict the dynamic behavior of complex chemical engineering processes using fundamental lumped parameter, time-variant differential equations derived from fundamental principals.
5. Synthesize the computer coding required to implement sequential control (or discrete control) of complex processes including the specification of inputting and outputting (I/O) of associated signals to/from the computer controller.
6. Knowledgeable about the state of the art, the importance and the current limitations of signal communications (including sampling time importance/limitations) in several different advanced control systems.
7. Use appropriate software to synthesize human/machine interfaces for complex control systems.

8. Use standard terminology (based on Laplace transform analyses and linear algebra concepts) to characterize experimentally the dynamics of complex chemical processes.
9. Competent in and understand the critical importance of performing "what if" analysis for different operational modes (startup, operation, and shutdown) for both liability and safety purposes.
10. Appreciate to the rapid advances being made in the computer controls/ signal communications/ instrumentation field and the need for continuing personal development/awareness.
11. Defend synthesized control systems for real world problems by critical analysis of proposed systems by invited consultants working on the assigned problems.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Tarrer: March 3, 2004

CHEN 4900: INDEPENDENT STUDY (1)

Technical Elective Course

2003-2004 Catalog Data Supervised study in specialized areas of chemical engineering. Topic must be arranged with instructor during pre-registration. May be taken only once. Project report.

Prerequisites Junior standing and departmental approval.

Class/Lab Schedule One credit. Time arranged with instructor.

Course Objectives Study in specialized areas of chemical engineering to provide a greater depth of understanding.

Textbooks
No text.

Topics Covered
1. Independent Study Project (14 labs)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	1 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Chambers: March 3, 2004

CHEN 4970 - SPECIAL TOPICS IN CHEMICAL ENGINEERING

Technical Elective Course

2003-2004 Catalog Data Topical courses in special areas. May be taken more than once. Topic must be arranged with instructor during pre-registration.

Prerequisites Departmental approval.

Class/Lab Schedule Variable credit course. Time arranged with instructor.

Course Objectives This course is designed to provide special topics for undergraduate students.

Textbooks
No text.

Topics Covered
1. Example: Coal Processing Technology: Structure, properties, chemistry, and utilization of coal.

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	Variable Credit	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Chambers: March 3, 2004

CHEN 4980: UNDERGRADUATE RESEARCH

Technical Elective Course

2003-2004 Catalog Data Individual and small group projects. May be taken twice. Topic must be arranged with instructor during pre-registration. Research report.

Prerequisites Junior standing, departmental approval, GPA above 3.0.

Class/Lab Schedule Variable credit course. Time arranged with instructor.

Course Objectives Undergraduate research with individual or group projects.

Textbooks
No textbook.

Topics Covered
1. Undergraduate Research Project. Conduct literature review and undergraduate research, analyze results and prepare project report.

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	Variable Credit	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
◆	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
◆	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Chambers: March 3, 2004

CHEN 4997: HONORS THESIS (1-6)

Technical Elective Course

2003-2004 Catalog Data For Honors College students only. May be taken twice for a maximum total of 6 hours.

Prerequisites Junior standing, departmental approval.

Class/Lab Schedule Variable credit course. Time arranged with instructor.

Course Objectives This course is intended to give students an opportunity to work with faculty members on an independent research project which will provide an honors thesis for chemical engineering honors students.

Textbooks
No textbook.

Topics Covered
1. Honors Thesis Project. Conduct thesis literature review and undergraduate research and prepare honors thesis.

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	Variable Credit	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
◆	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
◆	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Chambers: March 3, 2004

CHEN 6110: PULP AND PAPER ENGINEERING (3)

Technical Elective Course

2003-2004 Catalog Data Chemical and engineering principles in the manufacturing of pulp and paper.

Prerequisites CHEN 3090, CHEN 3620, CHEN 3700. Coreq. CHEN 4450.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives Study of the chemical and engineering principles involved in the manufacture of pulp and paper. Process engineering calculations as applicable to pulp and paper systems.

Textbooks
Biermann, *Handbook of Pulping and Papermaking*, 2e, Academic Press, 1996.

Topics Covered
1. Reactions of lignin, cellulose and hemicellulose, pulping chemistry, delignification reactions, liquor penetration (3 classes)
2. Kraft pulping process, batch and continuous operations, flow diagrams, process variables, control, chemical recovery, bleaching, engineering and design calculations (24 classes)
3. Stock preparation, consolidation of the web, process calculations (3 classes)
4. Paper machine wet end, approach flow, screening and cleaning, water use and reuse, fiber recovery, dewatering and retention, pressing and drying, process calculations (12 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
	5	Design to meet needs
■	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Krishnagopalan: March 3, 2004

CHEN 6120: SURFACE AND COLLOID SCIENCE OF PAPERMAKING (2)

Technical Elective Course

2003-2004 Catalog Data Fundamentals of surface and colloid science with applications in pulping and papermaking, including sizing, retention and drainage, charge measurements, dry/wet strength additives, fillers, colorants, foams, pitch and deposits.

Prerequisites CHEM 6070, CHEN 3620, CHEN 4100.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to introduce the student to the fundamental principles of surface and colloid science and to apply these concepts to basic problems and applications in pulp manufacturing, papermaking, coating and printing.

Textbooks
Shaw, *Introduction to Colloid and Surface Chemistry*, 4e, Butterworth-Heinemann, 1992.
Scott, *Principles of Wet End Chemistry*, 1e, TAPPI Press, 1996.

Topics Covered
1. Fundamentals (12 classes)
2. Chemical additives (6 classes)
3. Applications (10 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
◆	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
◆	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Neuman: March 3, 2004

CHEN 6400: MOLECULAR ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Introduction to how molecular structure and long range microstructure affect the properties of chemical engineering products and how the knowledge can be used to design chemical engineering products for specific applications.

Prerequisites CHEM 2080, 6070, CHEN 3370. Coreq. CHEN 3700.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide students with a molecular basis for understanding complex chemical and physical systems. The course examines the structure of materials and the molecular interactions between these materials. Methods are suggested to use a molecular approach to design new materials.

Textbooks: No textbook.

Topics Covered

1. Course overview (1 class)
2. Microstructure of materials (4 classes)
3. Properties of materials (3 classes)
4. Bulk *vs*. Surface properties (2 classes)
5. High performance metals (3 classes)
6. Unique ceramics (3 classes)
7. Specialty polymers (3 classes)
8. Electronic and optical materials (3 classes)
9. Biomaterials (3 classes)
10. Futuristic materials (2 classes)

Course Outcomes

Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
☐	8	Effective written communication
☐	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Gupta: March 3, 2004

CHEN 6410: MACROMOLECULAR ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Synthesis and characterization of novel polymers. Physical/chemical properties, molecular modeling, relaxation phenomena, reaction engineering, and macromolecular design applied to chemical engineering polymer systems.

Prerequisites CHEM 2080, 6070, CHEN 3370.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide an overview of synthesis, characterization, and structure/property relationships of polymers. Emphasis is given to applying chemical engineering concepts to polymer science. The current and future applications of polymers are discussed in detail.

Textbooks
Gupta, *Fundamentals of Polymers*, 1e, McGraw-Hill, 1997.

Topics Covered
1. Class overview (1 class)
2. Introduction to polymers (3 classes)
3. Polymerizations (6 classes)
4. Chemical/physical structure (4 classes)
5. Analytical characterization (4 classes)
6. Polymer properties (4 classes)
7. Applications (5 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
◆	5	Design to meet needs
	6	Understand professional ethical responsibility
☐	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Gupta: March 3, 2004

CHEN 6420: POLYMER ENGINEERING (3)

Technical Elective Course

2003-2004 Catalog Data Polymer rheology, transport phenomena, thermodynamics, membranes, conducting polymers, surfaces and interfaces, and processing.

Prerequisites CHEM 2070, 6070, CHEN 3370, 3620. Also, CHEN 6410 or consent of instructor.

Class/Lab Schedule Two one-hour class sessions per week and two ninety-minute lab sessions per week.

Course Objectives This course is designed to provide students with an introduction to transport phenomena, thermodynamics, and processing of polymers. Emphasis is placed on relating molecular properties to processing behavior. Laboratory experiments provide valuable experience and understanding of these complex polymer systems.

Textbooks
Gupta, *Fundamentals of Polymers*, 1e, McGraw-Hill, 1997.

Lecture Topics Covered
1. Class overview (1 class)
2. Overview of polymer science (2 classes)
3. Thermodynamics (4 classes)
4. Transport phenomena (6 classes)
5. Rheology (6 classes)
6. Polymer processing (6 classes)
7. Future directions of polymer engineering (2 classes)

Lab Topics Covered
1. Polymerization (2 labs)
2. Characterization (3 labs)
3. Rheology (3 labs)
4. Diffusion (2 labs)
5. Thermodynamics (2 labs)
6. Extrusion (2 labs)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
◆	5	Design to meet needs

	6	Understand professional ethical responsibility
□	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Gupta: March 3, 2004

CHEN 6430: BUSINESS ASPECTS OF CHEMICAL ENGINEERING (3)

Technical Elective Course

2003-2004 Catalog Data The procession of activities required to successfully commercialize and market new chemical engineering based technologies to the consumer and process industries.

Prerequisites Senior standing in chemical engineering or departmental approval.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives Expand the student's understanding of current and future business practices and strategies not covered in other chemical engineering or business courses. Cultivate essential entrepreneurial, interpersonal, inter-organizational, networking and business skills and awareness required to rapidly and successfully bring chemical products, services and technologies to the global market place using creative alliances and structures with existing companies and organizations which are becoming increasingly more narrow focused on core competency, global competitiveness, environmental, and quality issues.

Textbooks
No Textbook

Topics Covered
1. Elements of a business plan (4 classes)
2. Intellectual property, patent, and confidentiality issues (3 classes)
3. Identification/matching of new technology to markets and opportunities (5 classes)
4. Market surveys, product development, assessment of opportunity and risk (8 classes)
5. Strategic planning, identification and selection of partners (4 classes)
6. Product introduction methodologies and strategies (4 classes)
7. Licensing arrangements and joint ventures (5 classes)
8. Manufacturability, quality, regulatory, safety, and environmental issues (3 classes)
9. Ethical behavior (1 class)
10. Presentations of student projects and business plans (6 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
■	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication

■	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Tatarchuk: March 3, 2004

CHEN 6440: ELECTROCHEMICAL ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Thermodynamics, electrode kinetics, and transport phenomena of electrochemical systems; current and potential distributions, double layer theory; electrochemical processes: power sources, synthesis, corrosion.

Prerequisites CHEM 6070, CHEN 3370, 3620, 3650, 3700.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide an overview of the field of electrochemical engineering. The influence of an electric field on transport, kinetics, and thermodynamics is studied to enable chemical engineers to extend their knowledge to this field. Applications of electrochemical technology and research to create new technology are discussed.

Textbooks
Newman, *Electrochemical Systems*, 2e, Prentice-Hall, 1991.

Topics Covered
1. Course overview (1 class)
2. Electrochemical terminology (2 classes)
3. Thermodynamics (4 classes)
4. Double layers (2 classes)
5. Electrode kinetics (4 classes)
6. Electric potential (2 classes)
7. Transport phenomena (5 classes)
8. Current/potential distributions (2 classes)
9. Applications (5 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 6460: PROCESS SIMULATION SYNTHESIS AND OPTIMIZATION (3)

Required Core Course

2003-2004 Catalog Data Fundamentals of computer-aided simulation and synthesis. Process integration and optimization principles including their applications in design, retrofitting and operation of chemical processes.

Prerequisites Completion of CHEN 3370, 3630, 3650, 3660, 3700 with grades of C or better.

Class/Lab Schedule Two one-hour class session and two ninety-minute lab sessions per week.

Course Objectives This course is intended to introduce students to the fundamentals of computer-aided process synthesis, simulation, analysis and optimization. In particular, the course presents systematic process-integration tools for developing and screening potential process flowsheets. Students use a commercial process simulator (ASPEN PLUS) to aid in evaluating a variety of these process designs. Practical problems are used as examples. These problems include mass integration, heat-integration, separation processes and environmentally-benign designs.

Textbooks
El-Halwagi, *Pollution Prevention Through Process Integration*, 1e, Academic Press, 1997.

Lecture Topics Covered
1. Introduction to process design (4 classes)
2. Global analysis of mass and energy flows (2 classes)
3. Mass integration (10 classes)
4. Energy integration (6 classes)
5. Design of nonideal separation systems (4 classes)

Lab Topics Covered
6. Simulation of individual units (5 labs)
7. Simulation of integrated systems (6 labs)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Understand and explain the need for systematic methods for identifying and screening the infinite number of alternative solutions to a process design problem. (1,2,4)
2. Understand and explain the difference between process synthesis/design and process simulation/analysis. (1,2,4)
3. Formulate and solve the fundamental design equations for stage-wise and continuous mass exchangers. (1,2,5)
4. Perform graphical and algebraic mass pinch analysis to identify optimal mass allocation strategies for pollution prevention as well as conservation of resources. (1,2,4,5)
5. Identify targets and formulate appropriate mass integration strategies for direct recycle, separation and process unit manipulation/substitution to meet the process objectives. (1,2,4,5)
6. Synthesize mass exchanger networks that match specified process constraints and objectives with minimum total annualized cost and choose the best solution from the generated alternatives. (1,2,4,5,6,7)
7. Perform graphical and algebraic thermal pinch analysis to identify optimal heat recovery strategies for minimization of external heating and cooling requirements. (1,2,4,5)
8. Identify targets and formulate appropriate energy integration strategies for stream pairing, routing and process unit manipulation/substitution to meet the process objectives. (1,2,4,5)
9. Synthesize heat exchanger networks that match specified process constraints and objectives with minimum total annualized cost and choose the best solution from the generated alternatives. (1,2,4,5,6,7)

10. Apply state of the art mathematical programming techniques for solving LP, NLP, MILP and MINLP problems encountered in chemical engineering. (1,2,4)
11. Design and sequence distillation columns for azeotropic distillation of binary mixtures through analysis of residue curves and distillation boundaries. (1,2,4)
12. Set up a simulation problem with the appropriate chemical components, unit specifications and choice of thermodynamic model and subsequently perform rigorous steady state simulation, using a commercially available process simulator, of individual process units such as compressors, flash columns, reactors, absorbers, strippers and distillation columns for binary as well as multi-component mixtures. (2,4,5)
13. Optimize the individual units by identifying design variables available for manipulation and thereby evaluate and suggest design changes based on base case simulation results. (1,2,4,5)
14. Perform equipment design using sizing methods provided by a process simulation package and perform cost estimation using computer aided tools as well as empirical correlations. (1,2,4,5)
15. Simulate entire process flowsheets with multiple units and validate design suggestions obtained by performing mass and energy pinch analysis. (1,2,4,5)
16. Perform plant-wide sensitivity analysis to investigate the impact of certain process parameters on the overall performance. (1,2,4,5)
17. Prepare professional reports and simulation memos consisting of concise, well structured and clear language and appropriately placed and constructed tables and graphs, with special emphasis on effective communication, neatness and punctuality. (2,4,8)
18. Identify and utilize traditional as well as novel sources of information such as the World Wide Web, databases, technical journals, and news. (1,4,11)
19. Use computer-based software, such as spreadsheets and numerical solvers, for performing engineering calculations and presenting the results effectively. (1,2,4,8)
20. Understand the inherently dynamic and evolving nature of science and engineering and as a consequence appreciate the need for continuous learning and reeducation. (1,2,4,11)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Eden: March 3, 2004

CHEN 6470: PROCESS DESIGN PRACTICE (2)

Required Core Course

2003-2004 Catalog Data Flow sheet synthesis, simulation and techno-economic analysis applied to complex, open-ended chemical processes. Screening of alternatives and economic optimizations.

Prerequisites Completion of CHEN 6460 with grade of C or better.

Class/Lab Schedule One one-hour class session and two ninety-minute lab sessions per week.

Course Objectives This course is designed to integrate chemical engineering concepts in designing complex industrial facilities.

Textbooks
No text.

Topics Covered
1. Flowsheet synthesis (1 class)
2. Preliminary material balance (1 class)
3. Preliminary energy balance (1 class)
4. Computer-aided process simulation (1 class)
5. Refinement of material and energy balances (1 class)
6. Mass integration (1 class)
7. Energy integration (1 class)
8. Process optimization (1 class)
9. Techno-economic analysis (1 class)
10. Process operability (1 class)
11. Process maintenance (1 class)
12. Process safety (1 class)
13. Individual and final presentations (2 classes)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Formulate and evaluate process and/or product design objectives and constraints for an open-ended problem. (1,2,4)
2. Synthesize a process flowsheet capable of achieving the stated process and/or product objectives subject to a given set of constraints, by employing traditional as well as novel synthesis and design strategies. (1,2,4,5)
3. Obtain the engineering and scientific data required for formulating and solving the fundamental design equations for stage-wise and continuous mass exchangers. (1,2,3,4,5)
4. Develop a rigorous steady state computer simulation of the process flowsheet, using commercially available software packages, capable of representing the process. (1,2,4,5)
5. Validate and report the simulator performance by evaluating the material and energy balances for the process using the simulation results. (1,2,4,9)
6. Evaluate chemical processing equipment alternatives for each processing step and select the appropriate candidates. (1,2,4,5)
7. Perform equipment design using sizing methods provided by a process simulation package and perform cost estimation using computer aided tools as well as empirical correlations. (1,2,4,5)
8. Identify the minimum cost potentials for mass and energy integration with special emphasis on resource conservation, waste minimization and energy recovery. (1,2,4,5)
9. Generate a broad range of feasible alternative designs capable of achieving the process and/or product objectives. (1,2,4,5)
10. Determine capital investment, operating costs, and cash flow estimates for chemical manufacturing processes from process flowsheets, equipment specifications, and material and energy balances. (1,2,4,5,7)

11. Calculate profitability measures including rate of return on investment, net present value, payback period, and discounted cash flow rate of return. (1,2,4,5,7)
12. Perform economic sensitivity analysis in order to identify the primary process parameters affecting the economics of the process plant. (1,2,4,7)
13. Identify, evaluate and minimize the environmental impact of a process and/or product design by using empirical correlations as well as computer-aided tools. (1,2,4,6,7)
14. Utilize the understanding of process engineering, economics, environmental concerns as well as health and safety issues to select the optimum solution to a design problem from the generated alternatives. (1,2,4,6,7)
15. Work in a team on solving an open-ended design project and exhibiting proficiency in developing effective task breakdowns and project plans, time management skills, task delegation and punctuality. (10)
16. Prepare professional reports and simulation memos consisting of concise, well structured and clear language and appropriately placed and constructed tables and graphs, with special emphasis on effective communication, neatness and punctuality. (2,4,6,8)
17. Prepare and deliver a professional oral presentation with appropriate visual aids. (1,2,4,6,7,9)
18. Identify and utilize traditional as well as novel sources of information such as the World Wide Web, databases, technical journals, and news. (1,4,11)
19. Use computer-based software, such as spreadsheets and numerical solvers, for performing engineering calculations and presenting the results effectively. (1,2,4,8)
20. Understand the inherently dynamic and evolving nature of science and engineering and therefore appreciate the need for continuous learning and reeducation. (1,2,4,11)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
◆	5	Design to meet needs
◆	6	Understand professional ethical responsibility
◆	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
◆	9	Effective oral communication
◆	10	Function successfully on a multidisciplinary team
◆	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Eden: March 3, 2004

CHEN 6630: INTRODUCTORY TRANSPORT PHENOMENA (2)

Technical Elective Course

2003-2004 Catalog Data Applications of chemical engineering analysis to momentum, heat and mass transport problems for advanced undergraduate and beginning graduate students.

Prerequisites CHEN 3620, 3650, 4160.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide advanced undergraduate and beginning graduate students with the knowledge required to undertake more advanced study of heat mass and momentum transport operations.

Textbooks
Bird, *Transport Phenomena*, 2e, Wiley, 2001.

Topics Covered
1. Momentum transport (11 classes)
2. Heat transfer (8 classes)
3. Mass transfer (9 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
☐	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
	6	Understand professional ethical responsibility
☐	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Guin: March 3, 2004

CHEN 6650: HAZARDOUS MATERIALS MANAGEMENT AND ENGINEERING (2)

Required Core Course

2003-2004 Catalog Data Fundamental principles and regulatory information related to hazardous material and process safety management and engineering, dispersion of chemicals, hazard and operability analysis, chemical engineering principles for risk reduction.

Prerequisites CHEM 2030 or 2080, CHEN 3820.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to cover the fundamental principles, regulatory information, and management practices that an engineer who is engaged in hazardous materials handling needs to know in order to function effectively and to be certified as a hazardous materials manager.

Textbooks
Carson, *Hazardous Materials Management*, 5e, Institute of Hazardous Materials Management, 1995.

Topics Covered
1. Introduction to federal statutes and the control of toxic substances (1 class)
2. RCRA Overview (3 classes)
3. Toxic air pollution control through the Clean Air Act (2 classes)
4. Clean Water Act (2 classes)
5. Regulations pertaining to discharges (3 classes)
6. Liability and compliance (1 class)
7. OSHA Standards (3 classes)
8. Emergency Planning and Community Right-to-Know Act (4 classes)
9. Toxic Substance Control Act (TSCA) (1/2 class)
10. Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) (1/2 class)
11. Hazardous materials transportation act (2 classes)
12. Chemistry of hazardous materials (3 classes)
13. Radiation principles (1 class)

Course Outcomes
Upon successful completion of this course, students should be able to:
1. Students will have a general understanding of the general procedures used to develop regulations pertaining to the control of toxic substances and how to maintain an awareness of proposed changes to be made in and the development of regulations pertinent to hazardous material managers functioning in chemical and related industries.
2. Students will have an awareness of the goals of major regulations pertinent to the chemical and related industries: RCRA, OSHA, CERCLA, FIFRA, SARA, CWA, HMTA and CAA.
3. Students will have a general knowledge of the procedures used in the regulations to control the management of toxic substances: some specific examples are (a) Chemical and Physical Analysis and Waste Analysis Plan; (b) Hazardous Waste Storage; (c) Treatment and Disposal of Hazardous Waste; (d) Regulation and Disposal of Mixed Waste; (e) Managing Underground Storage Tanks; (f) Waste Minimization; (g) Spill Prevention and Countermeasure Plan (SPCC); (h) Spill Reporting; (i) Stormwater Discharge Permitting; (j) Hazard Communication Program; Process Safety Management Requirements (PSM); (k) Personal Protective Equipment Training; (l) Emergency Response Issues; (m) Emergency Contingency Plan; (n) Accident Scenario Training; (o) Fire Code Requirements (NFPA).
4. Students will have a general knowledge of the basic science and technology pertinent to the handling of toxic chemicals in chemical and related industries. Specifically: Chemistry of Hazardous Materials and Radiation Principles.

5. Students will be aware of the general legal aspects pertinent to the handling of hazardous chemicals: Sources of the Laws; Branches of the Law (Criminal Law and Civil Law & Equity); The American Judicial System; Contracts and Torts (Toxic Torts and Classical Torts); State Environmental Laws; Associated Liabilities.
6. Students will have an appreciation of the importance of public perception of a company's competence to safely handle toxic and hazardous chemicals.
7. Students will have an awareness of the role that different governmental agencies and private groups have in assuring the safe handling and management of hazardous materials.
8. Students will have an awareness of the controversy that exists among the different factions in society in regard to regulations pertaining to the management of hazardous materials.
9. Students will be able to pass the national tests for becoming a hazardous materials manager in training and will understand the importance of participating in the national society of hazardous materials managers.
10. Students will gain insight about the importance of public relations in regard to establishing good perception among the local public as to hazardous materials handling by their employer.
11. Students will appreciate the different views among working professionals with regard to the regulations confronted by hazardous materials managers.
12. Students will appreciate the liabilities and legal aspects associated with various duties performed by hazardous materials managers.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
■	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Tarrer: March 3, 2004

CHEN 6651: PROCESS SAFETY MANAGEMENT AND ENGINEERING (1)

Required Core Course

2003-2004 Catalog Data Application of chemical process safety, risk assessment and management, hazard and operability analysis, chemical engineering principles for risk reduction. Case studies.

Prerequisites CHEN 3820. Coreq. CHEN 4450.

Class/Lab Schedule Two ninety-minute lab sessions per week.

Course Objectives This course teaches chemical engineering students the important technical fundamentals of chemical process safety with practical applications.

Textbooks
Crowl, *Chemical Process Safety: Fundamentals with Applications*, 2e, Prentice Hall, 2002.

Topics Covered
1. Accident process and statistics (2 labs)
2. Toxicology (2 labs)
3. Source models (2 labs)
4. Toxic release and dispersion models (2 labs)
5. Industrial hygiene (2 labs)
6. Fire and explosion (2 labs)
7. Relief sizing (2 labs)

Course Outcomes *(Numbers in parentheses refer to PEO's)*
Upon successful completion of this course, students should be able to:
1. Analyze the accident process (6,7)
2. Calculate the effect of toxicants on animals and humans (1,2)
3. Calculate the permissible exposure limits for chemical mixtures (1,2)
4. Analyze chemical exposure pathways for workers and communities (1,2,6)
5. Calculate release rate of liquids and gases in the case of accidental discharge (1,2)
6. Calculate the concentrations of airborne chemicals as functions of distance, time and weather conditions (1,2,4)
7. Use both puff and plume models of chemical dispersion (1,2,4)
8. Calculate flammability limits for given mixtures (1,2,4)
9. Devise ways to reduce fire hazard (1,2)
10. Calculate the impact of explosions as a function of distance, for people, animals and property (1,2,6)
11. Design equipment and process (purging, electrical bonding, ventilation) to prevent fire and explosion (1,2,5,6)
12. Design sprinkler system for chemical plants (1,2,5,6)
13. Design relief valves for process equipment (1,2,5)
14. Identify hazard by surveying the process (2,6)
15. Analyze case histories of past accidents (6,7,11)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	1 Credit	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering

◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
■	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
■	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Neuman: March 3, 2004

CHEN 6660: MULTIMEDIA WASTE REDUCTION (2)

Technical Elective Course

2003-2004 Catalog Data Integrated air, wastewater and solid-waste reduction. In plant modifications and source reduction, recycle reuse and benign chemistry.

Prerequisites CHEN 6460. Coreq. CHEN 6650.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide students with the chemical engineering fundamentals of cost-effective waste reduction.

Textbooks
El-Halwagi, *Pollution Prevention through Process Integration*, 1e, Academic Press, 1997.

Topics Covered
1. Overview of waste reduction (3 classes)
2. Mutlimedia assessment of waste fate and transport (3 classes)
3. Modeling of mass-exchange systems for waste reduction (5 classes)
4. Separation systems for waste reduction (6 classes)
5. Systems approach to waste reduction (5 classes)
6. Benign chemistry (3 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 6670: POLLUTION PREVENTION ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Chemical and engineering principles applied to pollution prevention. Theory and practice of flotation, coalescence, micro- and ultra-filtration, de-emulsification, polymer coagulation and other methods. Case studies.

Prerequisites CHEM 2080, CHEN 3370, 3620, 3660, 3700.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide intensive quantitative and qualitative training in the practical applications of the principals of chemical engineering to pollution prevention. These principals are integrated into procedures for pollution prevention system design and analysis with the objective of arriving at optimum economic results from a minimum of pilot-plant or test data.

Textbooks
No text. Handouts prepared by the instructor.

Topics Covered
1. Background (8 classes)
2. Process integration strategies (10 classes)
3. Separation methodologies (10 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 6680: ENERGY CONVERSION IN CHEMICAL PROCESSES (2)

Technical Elective Course

2003-2004 Catalog Data Sources of energy. Energy utilization. Integration of fuel, electric power and heating/cooling in chemical processes, energy integration.

Prerequisites CHEN 6460.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide students with chemical engineering principles and applications of advanced energy systems in the process industries.

Textbooks
No Textbook.

Topics Covered
1. Process requirement of heats (3 classes)
2. Thermal pinch analysis (6 classes)
3. Heat exchange networks (3 classes)
4. Heat pumping (2 classes)
5. Combined heat and power (4 classes)
6. Environmental issues of energy systems (2 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
■	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Placek: March 3, 2004

CHEN 6700: ADVANCED SEPARATION PROCESSES (2)

Technical Elective Course

2003-2004 Catalog Data Advanced treatment of modern chemical engineering separation processes. Theory and practice of staged multi-component mass transfer operations, non-ideal multiphase separations and continuous rate processes.

Prerequisites CHEN 3370, 3620, 3660.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide an advanced treatment of separation fundamentals and principles as applied to a variety of chemical engineering separation problems.

Textbooks
King, *Separation Processes*, 2e, McGraw-Hill, 1981.

Topics Covered
1. Characteristics of separation processes (5 classes)
2. Simple equilibrium processes (5 classes)
3. Additional factors influencing product purities (5 classes)
4. Multistage separation processes (5 classes)
5. Binary and multi-component multistage separations (6 classes)
6. Group methods (3 classes)
7. Mass-transfer rates (6 classes)
8. Energy requirements of separation processes (3 classes)
9. Selection of separation processes (5 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
◆	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
■	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
◆	5	Design to meet needs
☐	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
■	9	Effective oral communication
■	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Gupta: March 3, 2004

CHEN 6800: BIOCHEMICAL ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Bioreactor design. Analysis of enzyme and microbial processes.

Prerequisites CHEN 3700.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives This course is designed to provide graduate and advanced undergraduate chemical engineering students with an understanding of and the ability to apply the engineering and biological principles to problems involving microbial and enzymatic processes.

Textbooks
Shuler, *Bioprocess Engineering: Basic Concepts*, 2e, Prentice Hall, 2002.

Topics Covered
1. Introduction (1 class)
2. Basic microbiology and chemistry of cells (4 classes)
3. Kinetics of enzymatic reactions (6 classes)
4. Industrial enzymes (3 classes)
5. Cellular genetics and metabolic pathways (4 classes)
6. Microbial growth kinetics (4 classes)
7. Design and analysis of biological reactors (6 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
◆	4	Use technical skills and modern engineering tools
◆	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
◆	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Lee: March 3, 2004

CHEN 6810: BIOMEDICAL ENGINEERING (2)

Technical Elective Course

2003-2004 Catalog Data Application of chemical engineering principles to the study of medical physiology: blood flow in the cardiovascular system, mass transfer in the kidneys, lungs and circulatory system, thermal and proton regulation, pharmacodynamic simulation, metabolic engineering, artificial organs.

Prerequisites CHEM 2080, CHEM 6070, CHEN 3630, CHEN 3700.

Class/Lab Schedule Two one-hour class sessions per week.

Course Objectives To provide a course that meets the students demand for knowledge of biomedical engineering - in particular the application of chemical engineering principles to the study of medical physiology. Provides preparation for future graduate work in biomedical engineering.

Textbooks
Fournier, *Basic Transport Phenomena in Biomedical Engineering*, 1e, Taylor & Francis, 1999.

Topics Covered
1. Introduction to biomedical engineering (2 classes)
2. Fluid mechanics in biological systems (11 classes)
3. Heat transfer in biological systems (3 classes)
4. Mass transfer in biological systems (5 classes)
5. Organs and artificial systems (5 classes)
6. Hemodialysis (3 classes)
7. Tissue and cellular engineering (5 classes)
8. Metabolic processes and pharmcokinetic models (5 classes)
9. Biointerfacial phenomena (3 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
◆	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
	5	Design to meet needs
■	6	Understand professional ethical responsibility
◆	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
◆	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Byrne: March 3, 2004

CHEN 6820: ADVANCED TOPICS IN ENVIRONMENTAL BIOTECHNOLOGY (3)

Technical Elective Course

2003-2004 Catalog Data Application of biotechnology to environmental process treatment, bioremediation, and bioreactor development.

Prerequisites Departmental approval.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives This course provides a discussion of advanced topics in environmental biotechnology with specific application to the use of immobilized microorganisms for bioreactor development. Advanced bioreactors are applied to both bioremediation and environmental process treatment.

Textbooks
No textbook.

Topics Covered
1. Bioreactor development (14 classes)
2. Applications in environmental process treatment (15 classes)
3. Applications in bioremediation (15 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
■	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
■	7	Contemporary issues, business practices, environmental, health, safety issues
■	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Lee: March 3, 2004

ENGR 1110 - INTRODUCTION TO CHEMICAL ENGINEERING (2)

Required Core Course

2003-2004 Catalog Data Introduction to engineering design, engineering teams, graphical presentation, technical writing, oral presentation.

Prerequisites High school chemistry.

Class/Lab Schedule One one-hour class session and two ninety-minute lab sessions per week.

Course Objectives Introduce engineering design, teaming, problem solving, ethics, graphical presentation, technical writing, oral presentation, engineering software and simulation tools. Reinforce engineering elementary principles, calculations, units, and notation.

Textbooks
Felder, *Elementary Principles of Chemical Engineering*, 3e, Wiley, 2000.

Lecture Topics Covered
1. Introduction to course, introduction to engineering (1 class)
2. Chemical engineering basics: processes, flowsheets (1 class)
3. Chemical engineering basics: synthesis and design (1 class)
4. Problem solving (1 class)
5. Technical communication: writing and visuals (1 class)
6. Technical writing: tables, spreadsheets, Excel (1 class)
7. Technical presentations (1 class)
8. Safety and risk issues (1 class)
9. Use of computer-aided tools in engineering (1 class)
10. Engineering ethics (1 class)
11. Environmental issues (1 class)
12. Engineering economics (1 class)
13. Teaming (1 class)

Lab Topics Covered
1. Problem solving workshop (2 classes)
2. Technical presentation workshops (4 classes)
3. Engineering fundamentals reviews (8 classes)
4. Design project discussions (4 classes)
5. Engineering economics Excel workshop (2 classes)
6. Industry and faculty guest speakers/tours/demos (8 classes)

Course Outcomes
Course outcomes for this elective course will be developed in the future.

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	2 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
☐	1	Apply math, chemistry, science and engineering
☐	2	Identify, formulate and solve engineering problems

	3	Design conduct experiments, analyze and interpret data
☐	4	Use technical skills and modern engineering tools
☐	5	Design to meet needs
☐	6	Understand professional ethical responsibility
☐	7	Contemporary issues, business practices, environmental, health, safety issues
☐	8	Effective written communication
☐	9	Effective oral communication
☐	10	Function successfully on a multidisciplinary team
☐	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Duke: March 3, 2004

ENGR 2010 - THERMODYNAMICS (3)

Required Core Course

2003-2004 Catalog Data Laws of thermodynamics; energy transformations; properties and relationship among properties; equations of state and single processes and cycles.

Prerequisites CHEM 1030 or CHEM 1110, MATH 1620 or MATH 1720. Coreq. PHYS 1600, CHEN 2100 and CHEN 2101.

Class/Lab Schedule Two one-hour class session and two ninety-minute lab sessions per week.

Course Objectives This is the first engineering-wide course in thermodynamics for providing a comprehensive treatment of thermodynamics including the first and second laws of thermodynamics, equations of state, simple processes and cycles, and their applications throughout engineering. The primary emphasis is the application of thermodynamic fundamentals to the analysis of processes and engineering equipment.

Textbooks

Moran, *Fundamentals of Engineering Thermodynamics,*5e, Wiley, 2004.

Topics Covered

1. Concepts and definitions (1 class)
2. Pure substances (3 classes)
3. First Law - closed system (work and heat) (4 classes)
4. First Law of Thermodynamics - open systems (7 classes)
5. Second Law of Thermodynamics (4 classes)
6. Entropy (6 classes)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
☐	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
☐	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Maples: March 3, 2004

ENGR 2200: INTRODUCTION TO THERMODYNAMICS, FLUIDS & HEAT TRANSFER (3)

Service Course Administered by CHEN and MECH

2003-2004 Catalog Data Principles and applications of thermodynamics, fluids and heat transfer.

Prerequisites CHEM 1030, PHYS 1610. Coreg, MATH 2650.

Class/Lab Schedule Three one-hour class sessions per week.

Course Objectives This course teaches engineering students the fundamentals of thermodynamics, fluid mechanics, and heat transfer and how to apply these fundamentals to real problems.

Textbooks

Cengel, *Fundamentals of Thermal-Fluid Sciences*, 1e, McGraw-Hill, 2001.

Topics Covered

1. Basic concepts of thermodynamics (2 classes)
2. Properties of pure substances (2 classes)
3. The First Law of Thermodynamics for closed and open systems (5 classes)
4. The Second Law of Thermodynamics (3 classes)
5. Entropy and the Second Law of Thermodynamics (3 classes)
6. Fluid statics (3 classes)
7. Bernoulli, energy and momentum equations applied to incompressible fluids (3 classes)
8. Flow in pipes (3 classes)
9. Mechanisms of heat transfer (1 class)
10. Steady state conduction in one dimension (3 classes)
11. Transient heat conduction (2 classes)
12. Forced convection heat transfer (2 classes)
13. Radiation heat transfer (2 classes)
14. Heat exchangers (4 classes)

Contribution of Course to Meeting the Professional Component

Mathematics and Basic Sciences	Engineering Topics	General Education
0 Credits	3 Credits	0 Credits

Relationship of Course to Program Educational Outcomes (PEO's)

Coverage	PEO	☐Coverage Is Introductory or Preparatory ■Strong Coverage to Develop Outcome ◆Significant Coverage to Reinforce or Employ Outcome
■	1	Apply math, chemistry, science and engineering
■	2	Identify, formulate and solve engineering problems
	3	Design conduct experiments, analyze and interpret data
	4	Use technical skills and modern engineering tools
	5	Design to meet needs
	6	Understand professional ethical responsibility
	7	Contemporary issues, business practices, environmental, health, safety issues
	8	Effective written communication
	9	Effective oral communication
	10	Function successfully on a multidisciplinary team
	11	Engage in life-long learning

Person(s) Who Prepared This Description and Date of Preparation: Maples: March 3, 2004