

CHEMICAL ENGINEERING

SCHOOL OF ENGINEERING & APPLIED SCIENCE MIAMI UNIVERSITY 2006-2007

The program leads to the degree, Bachelor of Science in Applied Science, with a major in Chemical Engineering

The chemical engineering students learn to apply the concepts of chemistry, biochemistry and biological science, and mathematics to solve problems in process engineering, product development, and research and development.

Within the chemical engineering curriculum, students choose among various areas of concentrations by judicious selection of required and elective courses. Areas of concentration include Biochemical Engineering, Environmental Engineering, and Paper Science and Engineering. A partial list of examples of industries that employ chemical engineers are biotechnology and biomedicine, electronics, food processing, environmental protection, paper, petroleum refining, and synthetic fibers. Chemical engineers are amongst the highest paid engineers.

Opportunities are available to obtain valuable work experience and financial assistance in the co-op or internship programs. The professional work experience before graduation enables students more valuable to prospective employers. Students may also choose to work with their professors on research projects (REU – Research Experience for Undergraduates). This program provides for financial assistance to conduct research.

The Bachelor of Science in Applied Science, with a major in Chemical Engineering curriculum is arranged similarly to traditional engineering programs where foundation courses are taken during the first two years, engineering science courses occupy the second and third years, and chemical engineering and the capstone engineering design courses are concentrated in the final year. A suggested 4-year curriculum is described in the following pages.

**CHEMICAL ENGINEERING CURRICULUM
2006-2007**

English (9 hours)

ENG 111 College Composition
ENG 112 Composition and Literature
ENG 313 Introduction to Technical Writing

Mathematics & Statistics (16 hours)

MTH 151 Calculus I
MTH 251 Calculus II
MTH 252 Calculus III
MTH 245 Differential Equations for Engineers

Fine Arts, Humanities, & Social Science (12 hours)

ECO 201 Principles of Microeconomics
Miami Plan Humanities
Miami Plan Fine Arts
Miami Plan Fine Arts, Humanities, or Social Science

U.S. & World Cultures (6 hours)

Miami Plan U.S. Cultures
Miami Plan World Cultures

Natural Science (36 hours)

PHY 181 The Physical World
PHY 182 The Physical World
PHY 183 Physics Lab
PHY 184 Physics Lab
CHM 141,144 College Chemistry and Lab
CHM 142,145 College Chemistry and Lab
CHM 251,252 Organic Chemistry and Lab
CHM 244 Organic Chemistry Laboratory
CHM 332 Outlines of Biochemistry
CHM 351 Physical Chemistry
Miami Plan Biological Science (MPF IVA)

Thematic Sequence (9 hours)

Liberal Education sequence outside your major focused around a theme. The required chemistry courses fulfill the CHM thematic sequence.

**Chemical Engineering & Engineering Science Courses
(56 hours)**

1. Engineering Science (13 hours)

EAS 101 Computing, Engineering & Society
EAS 102 Problem Solving & Design
PSE 219 Statics and Mechanics of Materials
MME/PSE 314 Engineering Thermodynamics
MME/PSE 341 Engineering Economics

2. Chemical Engineering Courses (31 hours)

PSE 204 Material and Energy Balances
PSE 311 Unit Operations Laboratory I
PSE 312 Unit Operations Laboratory II
MME/PSE 313 Fluid Mechanics
PSE 403 Heat Transfer
PSE 412 Chemical Engineering Thermodynamics
PSE 414 Mass Transfer
PSE 415 Chemical Kinetics & Reactor Design
PSE 471 Engineering Design I
PSE 472 Engineering Design II
PSE 473 Chemical Process Design
PSE 482 Process Control

3. Technical Specialty (12-13): Choose one

Paper Science

PSE 201 Principles of Paper Science & Engineering
PSE 202 Pulp, Paper and Products
PSE 301 Pulping
PSE 404 Papermaking
PSE 411 Advanced Paper Manufacturing

Biochemical Engineering

MME 223 Engineering Materials
PSE 416 Biochemical Engineering
PSE 417 Biomedical Engineering
CHM MPT 433 Biochemistry

Environmental Engineering

MME 223 Engineering Materials
PSE 405 Industrial Environmental Control
PSE 441 Pollution Prevention in Environmental Management
PSE 442 Air Pollution Control

SAMPLE CURRICULUM
Chemical Engineering
(Paper Science Concentration)
SCHOOL OF ENGINEERING & APPLIED SCIENCE - MIAMI UNIVERSITY
2006-07

Please consult your adviser before scheduling classes. Actual course offerings may vary.

Freshman Year

First Semester

CHM 141 College Chemistry (MPF IVB)	3
CHM 144 College Chemistry Laboratory (MPF IVB)	2
ENG 111 College Composition (MPF I)	3
MTH 151 Calculus I or 153 Calculus I (MPF V)	5
EAS 101 Computing, Engineering & Society	1
Miami Plan Biological Science (MPF IVA)	<u>3</u>
	17

Second Semester

CHM 142 College Chemistry	3
CHM 145 College Chemistry Laboratory	2
ENG 112 Composition and Literature (MPF I)	3
MTH 251 Calculus II	4
EAS 102 Problem Solving & Design	<u>3</u>
	15

Summer Semester

PHY 181 The Physical World (MPF IVB)	4
PHY 183 Physics Lab	1
ECO 201 Principles of Microeconomics (MPF IIC)	<u>3</u>
	8

Sophomore Year

First Semester

PSE 201 Principles of Paper Science & Engineering	2
PSE 204 Materials and Energy Balances	3
PSE 219 Statics and Mechanics of Materials	3
MTH 252 Calculus III	4
PHY 182 The Physical World (MPF IVB)	4
PHY 184 Physics Lab	<u>1</u>
	17

Second Semester

ENG 313 Introduction to Technical Writing	3
PSE 202 Pulp, Paper and Products	2
MME/PSE 313 Fluid Mechanics	3
MME/PSE 314 Engineering Thermodynamics	3
MTH 245 Differential Equations/Engineers	3
Miami Plan Fine Arts Course (MPF IIA)	<u>3</u>
	17

Junior Year

First Semester

Miami Plan Fine Arts, Humanities, or Social Science Course (MPF II A, B, or C)	3
CHM 251 Organic Chemistry	3
CHM 244 Organic Chemistry Laboratory	2
PSE 403 Heat Transfer	3
PSE 311 Unit Operations Laboratory I	2
CHM 351 Physical Chemistry	<u>3</u>
	16

Second Semester

CHM 252 Organic Chemistry	3
MME/PSE 341 Engineering Economics	3
PSE 412 Chemical Engineering Thermodynamics	3
PSE 312 Unit Operations Laboratory II	2
PSE 414 Mass Transfer	3
PSE 415 Chemical Kinetics & Reactor Design	<u>3</u>
	17

Senior Year

First Semester

Miami Plan Humanities Course (MPF IIB)	3
PSE 301 Pulping	3
PSE 404 Papermaking	3
PSE 471 Engineering Design I (MPC)	1
Miami Plan U.S. Cultures Course (MPF IIIA)	3
Miami Plan World Culture Course (MPF IIIB)+	<u>3</u>
	16

Second Semester

CHM 332 Outlines of Biochemistry	4
PSE 411 Advanced Paper Manufacturing (MPC)	3
PSE 472 Engineering Design II (MPC)	2
PSE 473 Chemical Engineering Design	3
PSE 482 Process Control	<u>3</u>
	15

The Miami Plan for Liberal Education Foundation (MPF) requirement includes 6 hours of English Composition (ENG 111-112 fulfills this requirement); 12 hours in Fine Arts, Humanities, and Social Science (ECO 201 fulfills 3 hours of Social Science) with a minimum of 3 hours in each; 6 hours in U.S. and World Cultures; 9 hours of Natural Science, including one laboratory course with a minimum of 3 hours in Biological Science and 3 hours in Physical Science (PHY 181-182, and CHM 141-144 more than fulfills the Physical Science requirement); 3 hours of Mathematics, Formal Reasoning or Technology (MTH 151 fulfills this requirement). **At least one of these foundation courses must provide a historical perspective (H).** The actual order in which you take these courses is up to you. The outline above is just one sample of how the courses might be arranged. You must also complete 12 hours of Focus: Advanced Liberal Learning courses, including 9 hours in an approved Thematic Sequence (MPT) and a 3 hour Senior Capstone Experience (MPC) (PSE 471/472 fulfill this requirement). This sample curriculum assumes the 9-hour Miami Plan Thematic Sequence requirement will be met by CHM 142/145, CHM 251/244, and CHM 332.

SAMPLE CURRICULUM
Chemical Engineering
(Biochemical and Environmental Concentration)
SCHOOL OF ENGINEERING & APPLIED SCIENCE - MIAMI UNIVERSITY
2006-07

Please consult your adviser before scheduling classes. Actual course offerings may vary.

Freshman Year

First Semester

CHM 141	College Chemistry (MPF IVB)	3
CHM 144	College Chemistry Laboratory (MPF IVB)	2
ENG 111	College Composition (MPF I)	3
MTH 151	Calculus I or 153 Calculus I (MPF V)	5
EAS 101	Computing, Engineering & Society	1
Miami Plan Biological Science (MPF IVA)		<u>3</u>
		17

Second Semester

CHM 142	College Chemistry	3
CHM 145	College Chemistry Laboratory	2
ENG 112	Composition and Literature (MPF I)	3
MTH 251	Calculus II	4
EAS 102	Problem Solving & Design	<u>3</u>
		15

Summer Semester

PHY 181	The Physical World (MPF IVB)	4
PHY 183	Physics Lab	1
ECO 201	Principles of Microeconomics (MPF IIC)	<u>3</u>
		8

Sophomore Year

First Semester

CHM 251	Organic Chemistry	3
CHM 244	Organic Chemistry Laboratory	2
PSE 219	Statics and Mechanics of Materials	3
MTH 252	Calculus III	4
PHY 182	The Physical World (MPF IVB)	4
PHY 184	Physics Lab	<u>1</u>
		17

Second Semester

CHM 252	Organic Chemistry	3
ENG 313	Introduction to Technical Writing	3
PSE 204	Materials and Energy Balances	3
MME/PSE 313	Fluid Mechanics	3
MME/PSE 314	Engineering Thermodynamics	<u>3</u>
		15

17

Junior Year

First Semester

MME/PSE 341	Engineering Economics	3
PSE 403	Heat Transfer	3
PSE 311	Unit Operations Laboratory I	2
CHM 351	Physical Chemistry	3
MTH 245	Differential Equations/Engineers	3
Miami Plan Humanities Course (MPF IIB)		<u>3</u>
		17

Second Semester

CHM 332	Outlines of Biochemistry	4
PSE 412	Chemical Engineering Thermodynamics	3
PSE 312	Unit Operations Laboratory II	2
PSE 414	Mass Transfer	3
PSE 415	Chemical Kinetics & Reactor Design	<u>3</u>
		15

Senior Year

First Semester

Miami Plan Fine Arts, Humanities, or Social Science Course (MPF II A, B, or C)	3	
MME 223	Engineering Materials	3
PSE 471	Engineering Design I (MPC)	1
Concentration Area		3
Concentration Area		3
Miami Plan World Culture Course (MPF IIIB)+		<u>3</u>
		16

Second Semester

Miami Plan Fine Arts Course (MPF IIA)	3	
Concentration Area	3	
PSE 472	Engineering Design II (MPC)	2
PSE 482	Process Control	3
PSE 473	Chemical Process Design	3
Miami Plan U.S. Cultures Course (MPF IIIA)		<u>3</u>
		17

Environmental Engineering*(choose any three)

PSE 405	Industrial Environmental Control
PSE 441	Pollution Prevention
PSE 442	Air Pollution Control

Biochemical Engineering*

PSE 416	Biochemical Engineering
PSE 417	Biomedical Engineering
CHM MPT 433	Biochemistry

*Consult your advisor as the course selection is subject to change.

The Miami Plan for Liberal Education Foundation (MPF) requirement includes 6 hours of English Composition (ENG 111-112 fulfills this requirement); 12 hours in Fine Arts, Humanities, and Social Science (ECO 201 fulfills 3 hours of Social Science) with a minimum of 3 hours in each; 6 hours in U.S. and World Cultures; 9 hours of Natural Science, including one laboratory course with a minimum of 3 hours in Biological Science and 3 hours in Physical Science (PHY 181-182, and CHM 141-144 more than fulfills the Physical Science requirement); 3 hours of Mathematics, Formal Reasoning or Technology (MTH 151 fulfills this requirement). **At least one of these foundation courses must provide a historical perspective (H).** The actual order in which you take these courses is up to you. The outline above is just one sample of how the courses might be arranged. You must also complete 12 hours of Focus: Advanced Liberal Learning courses, including 9 hours in an approved Thematic Sequence (MPT) and a 3 hour Senior Capstone Experience (MPC) (PSE 471/472 fulfill this requirement). This sample curriculum assumes the 9-hour Miami Plan Thematic Sequence requirement will be met by CHM 142/145, CHM 251/244, and CHM 332.

* The suggested curriculum is in transition and under development

PAPER AND CHEMICAL ENGINEERING - COURSE DESCRIPTIONS - 2006-07
SCHOOL OF ENGINEERING & APPLIED SCIENCE - MIAMI UNIVERSITY

EAS 101 COMPUTING, ENGINEERING & SOCIETY (1)

Introduces computing and engineering professions and their role in society. Explores different engineering and computing disciplines, examines ethical and societal issues related to the disciplines and their impact on the world. An active forum for discussion of ideas and issues.

EAS 102 PROBLEM SOLVING AND DESIGN (3) This course introduces an approach to problem solving for computing and engineering students. The students will learn systematic approaches to problem solving. Topics covered include: problem identification, analyzing requirements, research existing and alternative solutions, analyzing solutions quantitatively, synthesizing and evaluating data, prototyping, and testing. Students will also develop their oral and written skills for technical communications. Co-requisite: EAS 101, MTH 151.

PCE 201 PRINCIPLES OF PAPER SCIENCE AND

ENGINEERING (2) Introduction to the pulping and papermaking. Carry out experiments in paper science. Apply engineering skills to problem solving related to paper and allied industries. Prerequisite: EAS 101, 102 or instructor approval.

PCE 202 PULP, PAPER, AND PRODUCTS (2) Discovery of how pulping, papermaking, and converting are utilized to develop the required performance properties of products from paper. Conduct laboratory investigations to determine properties of paper, conduct a paper machine run, and carry out a handsheet study. Prerequisite: PCE 201, or instructor approval.

PCE 204 MATERIAL AND ENERGY BALANCE (3) Techniques used to calculate material and energy balances with special emphasis on paper industry applications. Prerequisite: grade of C- or better in CHM 141, 142, and MTH 151, 251. Co-requisite: PHY 181.

PCE 219 STATICS AND MECHANICS OF MATERIALS (3)

This course provides an introduction to the fundamentals of the mechanics of materials for engineering students in Electrical, Chemical, and Paper Engineering. The course stresses statics, mechanics of deformable media, and material behavior. Elements of dynamics, elasticity, and viscoelasticity will be covered. The central theme of the course that binds these subjects together is proper problem formulation in terms of kinematics, constitutive behavior, equilibrium, and compatibility. Prerequisites: PHY 181, EAS 102.

PCE 244 INTRODUCTION TO ENVIRONMENTAL

ENGINEERING (3) Introductory design concepts for the control of water pollution, air pollution, and solid waste will be covered. Environmental legislation will be discussed. Solutions to environmental problems will be investigated, considering technical, economic and ethical aspects of engineering. Prerequisite: CHM 141 or equivalent, MTH 151 or equivalent.

PCE 301 PULPING (3) Detailed discussion of mechanical and chemical pulping processes and chemical and engineering principles involved. Prerequisite: CHM 252 or a grade of C- or better in CHM 231 or CHM 251.

PCE 311 UNIT OPERATIONS LABORATORY I (2) Laboratory course; students conduct experiments and do computer simulations in the areas of material and energy balances and fluid dynamics. Emphasizes acquisition of knowledge about instrumentation commonly used in paper industry. Both oral and written laboratory reports required. Prerequisite: A grade of C- or better in PCE 204. Co-requisite: PCE/MME 313.

PCE 312 UNIT OPERATIONS LABORATORY II (2) Laboratory course consisting of experiments and computer simulations in areas of advanced material and energy balances, heat transfer, pulping, and paper coating. Emphasis on the process control practices of paper industry. Both written and oral laboratory reports required. Prerequisites: a grade of C- or better in PCE 313. Co-requisite: PCE 301, 403.

PCE 313 FLUID MECHANICS (3) Fundamentals and application of the mechanics of fluids including properties, statics and dynamics of fluids, dimensional analysis and similitude, steady state flow, and topics in compressible flow. Prerequisites: MTH 251, PHY 181, PCE 219 or MME 211 or permission of instructor. Cross-listed with MME 313

PCE 314 ENGINEERING THERMODYNAMICS (3) Study of the fundamental principles of thermodynamics. Emphasis placed on engineering applications such as power cycles, refrigeration, and heat transfer systems. Prerequisite: MTH 251, PHY 181. Cross-listed with MME 314

PCE 341 ENGINEERING ECONOMICS (3) Engineering economic decisions; break-even and minimum cost analysis; engineering methods of resource allocation; concepts of interest; time evaluation of tactical and strategic alternatives. Prerequisite: ECO 201, MTH 151 or PCE 204. Co-requisite: STA 368. Cross-listed with MME 341.

PCE 403/503 HEAT TRANSFER (3) Continued study of unit operations with emphasis on heat transfer. Study of steady and unsteady conduction, and laminar, turbulent, boiling, and condensing convective heat transfer. Radiation heat transfer, heat exchangers, evaporators, and transfer units. Prerequisites: grade of C- or better in PCE/MME 313, MTH 245, PCE/MME 314.

PCE404 PAPERMAKING (3) Papermaking process with emphasis on chemical engineering principles involved. Prerequisite: grade of C- or better in PCE 313 and credit for PCE 202. Co-requisite: PCE 341.

PCE 405/505 INDUSTRIAL ENVIRONMENTAL CONTROL (3)

Survey of environmental issues facing industry and how the industry addresses these issues. In-plant pollution abatement alternatives discussed as well as external treatment. Computer-based modeling applications introduced and applied to problems. Design considerations involved in selecting among alternative pollution control strategies are presented and applied to examples. Prerequisite: A grade of C- or better in PCE 204, PCE/MME 313. Co-requisite: PCE 311.

PCE 411 ADVANCED PAPER MANUFACTURING (3)

Provides students with the opportunity to synthesize their accumulated knowledge and skills in paper science, paper engineering, economics, statistical methods, environmental technology, writing, oral presentations, safety, ethical standards, and teamwork fundamentals. Student teams determine the raw materials and processing conditions required to produce paper that matches a sample of "unknown paper." Prerequisite: senior standing and PCE 404, or by permission of the instructor.

PCE 412/512 CHEMICAL ENGINEERING

THERMODYNAMICS (3) Advanced thermodynamics with emphasis in phase and chemical equilibrium; Thermodynamic relations and application, Properties of ideal and non-ideal one-component and multi-component systems; ideal and non-ideal phase equilibria; phase diagrams; design of equilibrium flash separators; phase equilibria using equation of state; chemical equilibrium;

optimum conditions for feasible reaction equilibria. Prerequisite: PCE 314.

PCE414/514 MASS TRANSFER (3) Continued study of unit operations, with emphasis on mass transfer and special problems. Steady and unsteady diffusion, convective mass transfer, absorption, scrubbing, and stripping. Humidification, psychrometry, and drying. Multiple effect evaporators, cooling towers, packed towers, screening, showering, and pump sizing. Prerequisite: grade of C- or better in PCE 403 and MME/PCE 341.

PCE 415/515 (3) CHEMICAL KINETICS & REACTOR DESIGN Chemical Kinetics of homogeneous and heterogeneous reactions, kinetic theories, mechanism and modeling, reactor design, design of multiple reactions; temperature and pressure effects. Non-ideal reactors, survey of catalytic and biochemical reaction systems. Prerequisites: PCE 204, 313, 314, MTH 245.

PCE 416 BIOCHEMICAL ENGINEERING (3) This course is an introduction to the fundamental concepts concerning biochemical kinetics and bioreactors. In particular, this course will focus on enzymatic reactions and fermentations using genetically engineered organisms. Biochemical topics include overviews of cell structure, enzyme kinetics and cell growth kinetics. Engineering topics include: immobilization, fermentor design and sterilization processes. Prerequisites: PCE 204, MTH 245, CHM 332 or by permission of the instructor

PCE 417 BIOMEDICAL ENGINEERING (3) This course is an introduction to the fundamental concepts in biomedical engineering with a special focus on chemical engineering applications. In particular, this course will focus on transport phenomena in biological systems, pharmacokinetics and tissue engineering. Engineering topics will also include discussions concerning the design of equipment and materials for, dialysis, oxygenation, artificial organs, and tissue engineering. Prerequisites: PCE 204, MTH 245, PCE 414 or by permission of the instructor

PCE 425/525 SURFACE AND COLLOID SCIENCE OF PAPER MAKING (3) Covers basic concepts associated with papermaking process and properties of paper. Includes descriptions of basic colloid properties of fibers, fines, and other papermaking materials. Prerequisite: grade of C- or better in CHM 231 or CHM 251.

PCE 441/551 POLLUTION PREVENTION IN ENVIRONMENTAL MANAGEMENT (3) Provides understanding of how corporations respond to governmental regulation by setting up environmental management systems which employ the principles of pollution prevention. Engineering concepts such as material balances, energy balances, risk assessment, and life cycle assessment have impacted new process designs. In this course a basis for evolution and maturation of pollution prevention as a fundamental methodology to ensure compliance and economic sustainability of industrial processes will be provided. The understanding of the concepts of pollution will be demonstrated by participation in a class project sponsored by industry at one of their facilities. Prerequisites: PCE 204 and Junior standing Co requisite: PCE/MME 341 is recommended.

PCE 442/552 AIR POLLUTION CONTROL (3) This course will introduce students to the formation and control of air pollutants, engineering theories and principles pertaining to the design of air pollution control operations, and environmental legislation. Solutions to environmental problems will be investigated, considering technical, economical and ethical aspects of engineering. Prerequisites: PCE 204, 313, 314, and 341.

PCE 461/561 COATING TECHNOLOGY (3) Methods used in coating paper and properties of coating formulation. Prerequisite: PCE 202, PCE 313.

PCE 471, 472 ENGINEERING DESIGN I & II (2,2) Involves application and synthesis of accumulated knowledge in a major, open-ended, industrial research/design project. Critical elements of the design process and real world constraints (environmental impact, economical and social factors, marketability, ergonomics, safety, aesthetics, and ethics) are considered. Emphasis is placed on oral and written communication skills. Students from different academic backgrounds are assigned to multidisciplinary project teams in order to utilize their varied experiences, knowledge, learning styles, and skills to achieve a successful conclusion to each project. Prerequisite: senior standing, or permission of instructor.

PCE 473 CHEMICAL PROCESS DESIGN (3) This is a project-based course in which chemical engineering technology, process simulation, and economic analysis are used to design chemical processes. The technical and economic aspects of equipment selection and design and alternative methods of operation will be covered. Prerequisites: PCE 313, 314, 341, 403.

PCE 482/582 PROCESS CONTROL (3) Study of system dynamics and control schemes used for continuous processes. Block diagrams, steady-state and dynamic response, Laplace transforms, computer simulations and closed loop control. Stability, tuning, and controller synthesis. Prerequisite: PCE 312 and grade of C- or better in PCE/MME 313, 314 and MTH 245.

PCE 600 GRADUATE SEMINAR (1: maximum 6) Required of all graduate students in the Department of Paper and Chemical Engineering. Student preparation and presentation of lectures on scientific and engineering topics related to thesis research areas. Prerequisite: graduate standing.

PCE 612 CHEMICAL ENGINEERING ANALYSIS (3) Analytical considerations involving the construction and solutions of mathematical models of heat and mass transfer diffusions and convection, mass and energy balance, and simultaneous mass and heat transfer mechanisms relevant to catalysis and chemical reactor design. The analytical methods will cover the modeling of unsteady state engineering problems. Prerequisite: PCE 403, 414 415 (or equivalent) and graduate standing or instructor approval.

PCE 613 FLUID MECHANICS (3) Introduction to unit operations as applied to paper industry with emphasis on fluid mechanics. Designed for graduate student with non-engineering background. Prerequisite: graduate standing.

PCE 620 PAPERMAKING (1-4) Study of papermaking process with emphasis on chemical and engineering principles involved. Students expected to study pertinent technical literature in addition to completing class assignments. Prerequisite: graduate standing and permission of chair.

PCE 621 PAPER PHYSICS (3) Study of the fundamental factors that govern the physical, mechanical, transport, and optical properties of paper. Explore how materials, the papermaking process, and converting impact the performance of paper. Prerequisite: PCE 620, equivalent, or permission of the instructor.

PCE 630 PULPING (1-4) Study of mechanical and chemical pulping processes with emphasis on chemical and engineering principles involved. Prerequisite: graduate standing and permission of chair.

PCE 690 GRADUATE RESEARCH (1-12) Prerequisite: graduate standing and permission of chair.

PCE 700 RESEARCH FOR MASTER'S THESIS (1-16)

PCE 710 INDUSTRIAL PRACTICUM (1-12) Analysis and solution of an industrial problem.