CHEMICAL ENGINEERING
BACCALAUREATE PROGRAM

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

SCHOOL OF ENGINEERING & APPLIED SCIENCE
MIAMI UNIVERSITY
2009-2010

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 Engineering, 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.

Each student is required to take the Fundamentals of Engineering exam prior to graduation, preferably in the senior year. It is expected that the student will make a "good faith" effort to pass the exam in part because the success at this exam has implications regarding gaining license as a professional engineer. The exam is administrated by the National Council of Examiners for Engineering and Surveying.

CHEMICAL ENGINEERING CURRICULUM *
2009-2010

English (9 hours)
ENG 111 College Composition
ENG 112 Composition and Literature
ENG 313 Introduction to Technical Writing

Mathematics (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 241 & 242 or CHM 251 & 252 Organic Chemistry
CHM 244 Organic Chemistry Laboratory
CHM 351 Physical Chemistry
Miami Plan Biological Science (MPF IVA)
Select one of the following:
(i) CHM 332 or 432 for General, Paper and Environmental Technical Specialty
(ii) CHM 432 or CHM 433 for Biochemical Technical Specialty

Thematic Sequence (9 hours)
Liberal Education sequence outside your major focused around a theme. The required chemistry courses fulfill the CHM thematic sequence.

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Chemical Engineering & Engineering Science Courses (56 hours)

1. Engineering Science (13 hours)
EAS 101 Computing, Engineering & Society
EAS 102 Problem Solving & Design
PCE/MME 314 Engineering Thermodynamics
PCE/MME 341 Engineering Economics
Select one of the following:
(i) PCE 219 Statics and Mechanics of Materials
(ii) MME 211 Static Modeling of Mechanical Systems

2. Chemical Engineering Courses (31 hours)
PCE 204 Material and Energy Balances
PCE 311 Unit Operations Laboratory I
PCE/MME 313 Fluid Mechanics
PCE/MME 403 Heat Transfer
PCE 412 Chemical Engineering Thermodynamics
PCE 414 Mass Transfer
PCE 415 Chemical Kinetics & Reactor Design
PCE 451 Unit Operations Laboratory II
PCE 471 Engineering Design I
PCE 472 Engineering Design II
PCE 473 Chemical Process Design
PCE 482 Process Control

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

a) Paper Science
PCE 201 Principles of Pulp and Paper
PCE 202 Pulp and Paper Physics
PCE 301 Pulp and Paper Chemistry
PCE 404 Papermaking
PCE 490 Special Topics

b) Biochemical Engineering
MME 223 Engineering Materials
PCE 416 Biochemical Engineering
PCE 417 Biomedical Engineering
Select one of the following:
(i) CHM MPT 432 (Biochemistry) and CHM 472 (Physical Chemistry)
(ii) CHM 433 (Biochemistry) and CHM 434 (Biochemistry)
Note: CHM 432 and 433 also satisfy the Natural Science requirement

c) Environmental Engineering
MME 223 Engineering Materials
PCE 405 Industrial Environmental Control
PCE 441 Pollution Prevention in Environmental Management
PCE 442 Air Pollution Control

d) General Chemical Engineering
MME 223 Engineering Materials
Choose 3 courses in PCE of which at least 2 must be at 400 level

SAMPLE CURRICULUM

CHEMICAL ENGINEERING

PAPER SCIENCE CONCENTRATION *

SCHOOL OF ENGINEERING & APPLIED SCIENCE - MIAMI UNIVERSITY

2009-2010

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

Freshman Year

First Semester		*Second Semester*	
CHM 141 College Chemistry (MPF IVB)	3	CHM 142 College Chemistry	3
CHM 144 College Chemistry Laboratory (MPF IVB)	2	CHM 145 College Chemistry Laboratory	2
ENG 111 College Composition (MPF I)	3	ENG 112 Composition and Literature (MPF I)	3
MTH 151 Calculus I or 153 Calculus I (MPF V)	5	MTH 251 Calculus II	4
EAS 101 Computing, Engineering & Society	1	EAS 102 Problem Solving & Design	3
Miami Plan Biological Science (MPF IVA)	3		15
	17		

Summer Semester

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

Sophomore Year

First Semester		*Second Semester*	
PCE 201 Principles of Pulp and Paper	3	ENG 313 Introduction to Technical Writing	3
PCE 204 Materials and Energy Balances	3	PCE 202 Pulp and Paper Physics	3
PCE 219 Statics and Mechanics of Materials **or**		PCE/MME 313 Fluid Mechanics	3
MME 211Static Modeling of Mechanical Systems	3	PCE/MME 314 Engineering Thermodynamics	3
MTH 252 Calculus III	4	MTH 245 Differential Equations/Engineers	3
PHY 182 The Physical World (MPF IVB)	4	PHY 184 Physics Lab	1
	17		16

Junior Year

First Semester		*Second Semester*	
PCE/MME 341 Engineering Economics	3	CHM 242 or 252 Organic Chemistry (see sequence below)[1]	3
CHM 241 or 251 Organic Chemistry (see sequence below)[1]	3	PCE 301 Pulp and Paper Chemistry	3
CHM 244 Organic Chemistry Laboratory	2	PCE 311 Unit Operations Laboratory I	2
PCE/MME 403 Heat Transfer	3	PCE 412 Chemical Engineering Thermodynamics	3
CHM 351 Physical Chemistry	3	PCE 414 Mass Transfer	3
Miami Plan Fine Arts, Humanities, or Social Science Course (MPF II A, B, or C)	3	PCE 415 Chemical Kinetics & Reactor Design	3
	17		17

Senior Year *

First Semester		*Second Semester*	
PCE 451 Unit Operations Laboratory II	2	Miami Plan Humanities Course (MPF IIB)	3
CHM 332 or 432 Outlines of Biochemistry	4	Miami Plan Fine Arts Course (MPF IIA)	3
PCE 404 Papermaking	3	PCE 472 Engineering Design II (MPC)	2
PCE 471 Engineering Design I (MPC)	1	PCE 473 Chemical Engineering Design	3
Miami Plan U.S. Cultures Course (MPF IIIA)	3	Miami Plan World Culture Course (MPF IIIB)+	3
PCE 482 Process Control	3	PCE 490 Special Topics	1
	16		15

[1] Consult your advisor and either take CHM 241 & 242 or CHM 251 & 252 sequentially.

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) (PCE 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.

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SAMPLE CURRICULUM

Chemical Engineering

BIOCHEMICAL CONCENTRATION *

SCHOOL OF ENGINEERING & APPLIED SCIENCE - MIAMI UNIVERSITY

2009-2010

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)		3
		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	3
		15

Summer Semester		
PHY 181	The Physical World (MPF IVB)	4
PHY 183	Physics Lab	1
ECO 201	Principles of Microeconomics (MPF IIC)	3
		8

Sophomore Year

First Semester		
CHM 241 or 251 Organic Chemistry (see sequence below)[1]		3
CHM 244	Organic Chemistry Laboratory	2
PCE 219	Statics and Mechanics of Materials **or** MME 211Static Modeling of Mechanical Systems	3
MTH 252	Calculus III	4
PHY 182	The Physical World (MPF IVB)	4
PHY 184	Physics Lab	1
		17

Second Semester		
CHM 242 or 252 Organic Chemistry (see sequence below)[1]		3
MTH 245	Differential Equations/Engineers	3
PCE 204	Materials and Energy Balances	3
PCE/MME 313	Fluid Mechanics	3
PCE/MME 314	Engineering Thermodynamics	3
		15

Junior Year

First Semester		
PCE/MME 403	Heat Transfer	3
CHM 351	Physical Chemistry	3
ENG 313	Introduction to Technical Writing	3
MME 223	Engineering Materials	3
CHM 432 or 433 Biochemistry[2] (see sequence below)		4/3
		15 or 16

Second Semester		
PCE 311	Unit Operations Laboratory I	2
PCE 412	Chemical Engineering Thermodynamics	3
PCE 414	Mass Transfer	3
PCE 415	Chemical Kinetics & Reactor Design	3
CHM 472 or 434 Biochemistry[2] (see sequence below)		3
Miami Plan World Culture Course (MPF IIIB)+		3
		17

Senior Year*

First Semester		
PCE/MME 341	Engineering Economics	3
Miami Plan Humanities Course (MPF IIB)		3
PCE 451	Unit Operations Laboratory II	2
PCE 471	Engineering Design I (MPC)	1
PCE 416	Biochemical Engineering	3
PCE 482	Process Control	3
		15

Second Semester		
Miami Plan Fine Arts Course (MPF IIA)		3
Miami Plan Fine Arts, Humanities, or Social Science Course (MPF II A, B, or C)		3
PCE 417	Biomedical Engineering	3
PCE 472	Engineering Design II (MPC)	2
PCE 473	Chemical Process Design	3
Miami Plan U.S. Cultures Course (MPF IIIA)		3
		17

[2] Choose one of the following:
(1) CHM 432 and 472
(2) CHM 433 and 434

[1] Consult your advisor and either take CHM 241 & 242, or CHM 251 & 252 sequentially

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) (PCE 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.

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SAMPLE CURRICULUM

Chemical Engineering

ENVIRONMENTAL CONCENTRATION *

SCHOOL OF ENGINEERING & APPLIED SCIENCE - MIAMI UNIVERSITY

2009-2010

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)	3
		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	3
		15

Summer Semester		
PHY 181	The Physical World (MPF IVB)	4
PHY 183	Physics Lab	1
ECO 201	Principles of Microeconomics (MPF IIC)	3
		8

Sophomore Year

First Semester		
CHM 241 or 251	Organic Chemistry (see sequence below) [1]	3
CHM 244	Organic Chemistry Laboratory	2
PCE 219	Statics and Mechanics of Materials **or** MME 211Static Modeling of Mechanical Systems	3
MTH 252	Calculus III	4
PHY 182	The Physical World (MPF IVB)	4
PHY 184	Physics Lab	1
		17

Second Semester		
CHM 242 or 252	Organic Chemistry (see sequence below)[1]	3
MTH 245	Differential Equations/Engineers	3
PCE 204	Materials and Energy Balances	3
PCE/MME 313	Fluid Mechanics	3
PCE/MME 314	Engineering Thermodynamics	3
		15

Junior Year

First Semester		
PCE/MME 341	Engineering Economics	3
PCE/MME 403	Heat Transfer	3
ENG 313	Introduction to Technical Writing	3
MME 223	Engineering Materials	3
CHM 351	Physical Chemistry	3
		15

Second Semester		
CHM 332 OR 432	Outlines of Biochemistry	4
PCE 311	Unit Operations Laboratory I	2
PCE 412	Chemical Engineering Thermodynamics	3
PCE 414	Mass Transfer	3
PCE 415	Chemical Kinetics & Reactor Design	3
		15

Senior Year*

First Semester		
Miami Plan	Fine Arts, Humanities, or Social Science Course (MPF II A, B, or C)	3
Miami Plan	Humanities Course (MPF IIB)	3
PCE 451	Unit Operations Laboratory II	2
PCE 471	Engineering Design I (MPC)	1
Concentration Area[2]		3
PCE 482	Process Control	3
Miami Plan	World Culture Course (MPF IIIB)+	3
		18

Second Semester		
Miami Plan	Fine Arts Course (MPF IIA)	3
Concentration Area[2]		3
PCE 472	Engineering Design II (MPC)	2
Concentration Area[2]		3
PCE 473	Chemical Process Design	3
Miami Plan	U.S. Cultures Course (MPF IIIA)	3
		17

[1] Consult your advisor and either take CHM 241 & 242, or CHM 251 & 252 sequentially

[2] Environmental Engineering

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

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) (PCE 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.

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[2] Consult your advisor as the course selection is subject to change.

PAPER AND CHEMICAL ENGINEERING - COURSE DESCRIPTIONS - 2009-2010
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 PULP AND PAPER(3) 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: CHM 141 or instructor approval.

PCE 202 PULP AND PAPER PHYSICS (3) Discovery of how pulping, papermaking and converting are utilized to develop required performance properties of products from paper. Conduct laboratory investigations to determine properties of paper made in the laboratory and from the pilot paper machine. Prerequisite: PCE 201 and a grade of C or better in PHY 181 and one of the following: i) PCE 219 or ii) MME 211.

PCE 204 MATERIAL AND ENERGY BALANCES (3) Techniques used to calculate material and energy balances with special emphasis on paper industry applications. Prerequisite: grade of C or better in CHM 142. 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. Prerequisite: EAS 102. Co-requisite: PHY 181.

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, economical and ethical aspects of engineering. Prerequisite: CHM 141 or equivalent, MTH 151 or equivalent.

PCE 301 PULP AND PAPER CHEMISTRY (3) Wood chemistry, chemical pulping chemistry and processes, and wet end chemistry. Chemical composition and structure of lignocellulosic wood fibers The unit processes used in chemical pulping and bleaching. Kraft Recovery. Colloidal science of retention, sizing, process and functional additives. Prerequisite: PCE 201 and one of the following: CHM241, or CHM 251, or CHM 231.

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 process industries. Both oral and written laboratory reports required. Prerequisite: A grade of C or better in PHY 181 and PCE 204. Co-requisite: PCE/MME 313.

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 and PCE 219 or MME 211. Cross-listed with MME 313.

PCE 314 ENGINEERING THERMODYNAMCIS (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 320 PROFESSIONAL PRACTICE (0) Students participating in paper science and engineering co-op program register for this course during semesters when they are away from Oxford on work assignment. This enables students to remain in good standing with the university registrar.

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. Co-requisite: STA 368 or PCE 204. 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: PCE/MME 313, PCE/MME 314 and MTH 245. Cross-listed with MME 403

PCE404 PAPERMAKING (3) Contemporary paper manufacturing processes with emphasis on the chemical engineering principles. Prerequisite: PCE 313 and PCE 202. Co-requisite: PCE/MME 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. Prerequisites: PCE/MME 313 and a grade of C or better in PCE 204. Co-requisite: PCE 311.

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/MME 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, psychometry, and drying. Multiple effect evaporators, cooling towers, packed towers, and distillation. Prerequisite: PCE/MME 313, PCE/MME 314 and MTH 245, and a grade of C or better in PCE 204.

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/MME 313, 314, MTH 245, and a grade of C or better in PCE 204.

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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: MTH 245, CHM 332 or CHM 432, PCE 415 and a grade of C or better in PCE 204 or by permission of the instructor

PCE/MPC 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: MTH 245, PCE 414, and a grade of C or better in PCE 204, or by permission of the instructor.

PCE 441/541 POLLUTION PREVENTION IN ENVIRONEMENTAL 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. Prerequisite: A grade of C or better in PCE 204 and Junior Standing. Co-requisite: PCE/MME 341.

PCE 442/542 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/MME 313, 314, 341, and a grade of C or better in PCE 204.

PCE 450/550 SPECIAL TOPICS (**1-5**; maximum 20)

PCE 451/551 UNIT OPERATIONS LABORATORY II (2) Laboratory course consisting of experiments and computer simulations in topic from the process industries involving heat, mass and momentum transfer, and process control. Both written and oral laboratory reports are required. Prerequisites: PCE/MME 4 03, PCE 414. Co-requisite: PCE 482.

PCE 471, 472 ENGINEERING DESIGN I AND II (1,2) 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 (economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability) 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 473/573 CHEMCIAL 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/MME 341, PCE/MME 403, and a grade of C or better in PCE 204. Co-requisites: PCE 414 and 415.

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. Prerequisites: PCE/MME 313, 314 and MTH 245.

PCE 490/590A PAPER COATING (1). The course provides an introduction to the coating and surface treatments applied to paper and paperboards to improve functional performance. The materials, processes and equipment used in surface sizing, aqueous pigmented coating and polymer coating/lamination will be covered. Prerequisites: PCE 202 or graduate standing.

PCE 490/590B PRINTING AND CONVERTING PROCESSES (1). The course provides an introduction to conventional and digital printing processes used on paper, films and foils. Converting operations including winding, supercalendering, corrugating and box assembly. Prerequisites: PCE 202 or graduate standing.

PCE 490/590C PAPER MANUFACTURING (1). Provides students with the opportunity to synthesize their accumulated knowledge and skills in paper science, paper engineering, economics, statistical methods, environmental technology, writing, and teamwork fundamentals. Student teams determined the raw materials and processing conditions required to produce paper that matches a sample of "unknown paper". They develop strategies for monitoring and improving team effectiveness continuously. They carry out the engineering, environmental impact, and economic analyses required for a global product development project. And, they lean how to apply high ethical standards to such projects. Prerequisites: PCE 202, PCE 404, or permission of instructor.

PCE 490/590 D FUNDAMENTALS OF CORROSION (1). Principles, mechanisms, and characteristics of corrosion. Corrosion behavior of metals, alloys, plastics and ceramics. Methods of corrosion prevention. Prerequisites: CHM 351 or CHM 361 or graduate standing

PCE 491 INTRODUCTION TO RESEARCH (1-3). Research problems in chemical engineering and paper science selected in consultation with a faculty advisor. Research methodology; design of laboratory experiments and computer simulations; critical analysis of results; technical reports; oral presentations. For grade only. Prerequisites: Permission of instructor, subject to approval of the department chair.