ECH 4605 **Product and Process Systems Engineering** *Fall 2011*

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Course Prerequisites: PE1, ChE Thermo, Transport Phenomena, Quantitative Methods

Prerequisite Knowledge:

- **Concepts:** Conservation laws; introductory thermo-physical and transport property estimation; some unit operations
- **Skills:** Ability to solve systems of equations and regression

Class Hours and Place:	**Main Lecture:**	EDU 347	TTh 9:30-10:45
	Tutorials / labs:	ENB 228A	M or W 14:00-16:45

Office Hours: TTh 8:00-9:15 Also by Appointment

COURSE FORMAT

Lectures: 2 times 1:15 lecture/wk-The course is managed using Blackboard portal, active learning is emphasized and references are in three-hour reserve.

Workshops/Tutorials: 3Hrs/wk

GRADING

Workshops, quizzes, mini projects and HW	**450 points**
Exams (2)	**300 points**

During workshops: October 10/12 (closed Book) - November 28/30 (open book)

Comprehensive Final	**250 points**

Recommended/Required Text:

"Analysis, Synthesis, and Design of Chemical Processes", Turton, Baillie, Whiting, Swaeiwitz, Prentice Hall, 2009, 3rd. edition

Policies Regarding Management of the Course and Computer Usage

1. A late penalty of 10 % of the total available points/day will be applied for works turned after due date and hour.

2. You could use any electronic means and machine language to solve the assigned work. I am only interested in the technical quality of the engineering solutions and their efficient communication. However, I will discuss the pros and cons of software/hardware for your benefit.

3. The quality of answers/time you may get from me or your TA will improve significantly through use of electronic means, scheduled meetings, and visits during office hours

4. We will occasionally broadcast news (e.g. hints for solution of HW) through electronic means.

5. We may require you to submit copies of your work/computer programs via electronic means.

6. I will start and the end the class at the scheduled time, late arrivals and early departures distract me and your cohorts are not considered proper professional conduct, except in cases of emergency.

7. No food is allowed during lecture and workshops.

8. Ringing cell phones and less than 75 % attendance is rewarded with a pop-quiz.

Objectives of the Course

Upon completion of this course, you should be able to:

Understand how chemical products enhance our standard of living individually and collectively.

Discuss social (e.g. job) and economic (e.g. profit) impact of a chemical product, enterprise in the chemical business, and a chemical manufacturing facility on the various elements of the society and environment.

Produce a conceptual process design that is economically and technically feasible in addition to satisfying one or more of the following constraints/objectives: environmental, safety, flexibility, reliability, operability, ethics, national security, controllability.

Estimate feasibility of a project, starting from material and energy balances, through equipment sizing, cost estimation, and profitability analysis.

Make the sound decision, faced with a set of alternatives, by employing the appropriate technical and economic feasibility criteria.

Make engineering assumptions.

Learn to make decisions when multiple, possibly conflicting, objectives (criteria) exist.

Learn to make decisions with limited available information.

Use computer aided design tools and sensitivity analysis effectively.

Schedule various synthesis and analysis techniques to solve process systems engineering problems effectively.

Communicate results of a major design project through a written report and oral defense.

Work in a group productively

REFERENCES
(A subset of the List is placed in the library reserve)

See coverage from lecture outline

Popular texts useful for the course

1. "Systematic Methods of Chemical Process Design" Biegler, Grossmann, Westerberg, Prentice Hall, 1997

2. "Strategy of Process Engineering", Rudd and Watson, Wiley, 1968

3. "Plant Design and Economics for Chemical Engineers", Max S. Peters and Klaus D. Timmerhaus, McGraw-Hill, 5th Edition, 2003

4. "A Guide To Chemical Engineering Process Design And Economics", Gael Ulrich, Wiley, 1984

5. "Coulson and Richardson's Chemical Engineering: Volume 6. Design: R.K. Sinnott 2nd edition. Pergamon, 1996

6. "Analysis, Synthesis, and Design of Chemical Processes", Turton, Baillie, Whiting, Swaeiwitz, Prentice Hall, 2009, 3rd edition

7. "Product and Process Design Principles: Synthesis, analysis, and evaluation" Seider, Seader, Levin Wiley, 3rd edition, 2009

8. "The Chemical Process Industries Infrastructure" Couper, Beasley, and Penney, Marcel Dekker, 2001

9. "Jelen's Cost and Optimization Engineering" Humphreys, 3rd ed. McGraw Hill, 1991

10. "Optimization of Chemical Processes" Edgar, Himmelblau, and Lasdon, McGraw Hill, 2001

11. " Chemical Product Design" Cussler and Moggridge, 2nd edition, Cambridge, 2011

General References

G1. "Kirk-Othmer Encyclopedia of Chemical Technology*" 4th edition. Wiley-Interscience, 1991

G2. "Encyclopedia of Chemical Processing and Design*" McKetta ed., Marcel Decker, 1993

G3. "Ullmann's Encyclopedia of Industrial Chemistry*" 5th ed., VCH, 1988

G4. "Perry's Chemical Engineering Handbook", 7th ed. Perry and Green (eds.) McGraw Hill, 1997

G5. "Chemical Process Equipment Selection and Design", Stanley M. Walas, Butterworth, 1988

The data sources for thermo-physical properties

P1. "The Properties of Gases and Liquids", Reid, Prausnitz, Pooling, McGraw-Hill 4th Edition, 1987.

P2. "Vapor-Liquid Equilibrium Data Collection", Gmehling, Onken, Arlt, Grenzeuser, DECHEMA, 1980* several volumes.

Chemical industry, chemical products, employment,

C1. "Structure of Chemical Processing Industry", Wei, Russell, Swartlander, McGraw Hill, 1979

C2. "The Chemical Process Industries Infrastructure" Couper, Beasley, and Penney, Marcel Dekker, 2001

* These multi-volume series are at the library reference section.

Specialized books/manuals

S1. "Pollution Prevention for Chemical Processes" Allen and Rosselot, Wiley, 1997

S2. "Handbook of Chemical Technology and Pollution Control", Hocking, Academic Press, 1998

S3. "User's Guide on Process Integration for the Efficient use of Energy" IChemE, 1994

S4. "Green Engineering" Allen and Shonnard, Prentice Hall, 2002

S5. "Chemical Process Safety: Fundamentals with Applications", Crowl and Louvar, Prentice Hall- 2002 – Second Edition

S6. "National Institute for Occupational Safety and Health, pocket guide to Chemical Hazards", NIOSH, 1987

S7. "Safety, Health, and Loss Prevention in Chemical Processes", AIChE, 1990

S8. "Jelen's Cost and Optimization Engineering" Humphreys, 3rd ed. McGraw Hill, 1991

S9. "The Art of Chemical Process Design", Wells and Rose, Elsevier, 1986

S10. "Chemical Engineering Economics" Garrett, Van Nostrand Reinhold, 1989

Syllabus

Lecture 1. August 23	Introduction to Chemical Engineering Systems: Industry, products and processes Life cycles, design and operation; Objectives and constraints; Properties, data and sources
Lecture 2 August 25	Microeconomics
Lecture 3 Aug 30	Time value of Money
Lecture 4 Sep 1	Feasibility Studies: Capital Cost Estimation
Lecture 5 Sep 6	Feasibility Studies: Operating Cost Estimation
Lecture 6 Sep 8	Feasibility Studies: Cash Flow; Profitability analysis;
Lecture 7 Sep 13	Feasibility Studies: Selection among alternatives
Lecture 8 Sep 15	Chemical Engineering Systems: Material and energy balances, degrees of freedom analysis, selection and specification of decision variables; Solution methods;
Lecture 9 Sep 20	Chemical Engineering Systems: Preliminary Sizing of Continuous Plants
Lecture 10 Sep 22	Chemical Engineering Systems: Computer Aided Methods for Process Design
Lecture 11 Sep 27	Environmental Consideration: Introduction to Green Engineering and Environmental Impact Analysis
Lecture 12 Sep 29	Environmental Consideration: Life Cycle Analysis
Lecture 13 Oct 4	Product Design: Approach
Lecture 14 Oct 6	Product Design: Unit Design

Lecture 15 Oct 11	Process Synthesis: Heuristic and Evolutionary approaches to heat integration
Lecture 16 Oct 13	Process Synthesis: Pinch Method for heat and mass integration
Lecture 17 Oct 18	Process Design: Simple Distillation Sequences
Lecture 18 Oct 20	Optimization: Problem Formulation;
Lecture 19 Oct 25	Optimization: Necessary and sufficiency conditions for extremum and single dimensional search
Lecture 20 Oct 27	Optimization: Multi-Dimensional Search
Lecture 21 Nov 1	Optimization: Linear Programming
Lecture 22 Nov 3	Optimization: Constrained Optimization
Lecture 23 Nov 8	Multi-Objective Decision Making
Lecture 24 Nov 10	Uncertainty and Risk Analysis
Lecture 25 Nov 15	Sensitivity Analysis
Lecture 26 Nov 17	Monte Carlo Simulation
Lecture 27 Nov 22	Introduction to Reliability
Lecture 28 Nov 29	Make-up Exam
Lecture 29. Dec 1	Post Review of the Course

Workshops

Aug 22 week	Syllabus Course Expectations – Process Examples
Aug 29 week	Product Examples
Sep 7	Time Value of Money / Capital Cost Estimation
Sep 14	Cash Flow and Profitability
Sep 21	Alternative Investments
Sep 28	Chemcad / Environmental Impact Analysis
Oct 10	Midterm 1
Oct 17	Product/Equipment Design: Distillation Column Design
Oct 24	Process Synthesis: Pinch Method
Oct 31	Process Synthesis: Simple separation sequences
Nov 7	Optimization: Single dimensional search and multi-dimensional search
Nov 14	Optimization: Linear Programming
Nov 21	Monte Carlo Simulation
Nov 28	Midterm 2