New Jersey Institute of Technology
Otto H. York Department of Chemical Engineering

Course: PhEn 501 Pharmaceutical Engineering Fundamentals II (3 credits)

Prerequisites: Undergraduate courses in chemistry and mathematics and, if needed, PhEn 500 that can also be taken concurrently with this course.

Reason for course prerequisites: Undergraduate courses in chemistry covers states and properties of matter, chemical equilibrium, thermodynamics and its application to chemical and biochemical systems. Undergraduate courses in mathematics and PhEn 500, if needed, provide a mathematical background, including differential equations, required for quantification of chemical and pharmaceutical processes.

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Course description: This bridge course is required for students who are admitted to MS programs in Pharmaceutical Engineering or Chemical Engineering without an undergraduate engineering degree or with an engineering background that did not include the topics covered by this course. The course covers the fundamentals of chemical engineering calculations based on material and energy balances on chemical processes; estimation of physical properties of substances, phase and reaction equilibrium in multi-component systems; and chemical kinetics in reactive processes. It provides the foundation for subsequent courses in pharmaceutical and chemical engineering and is not counted toward degree credit related to MS programs in Pharmaceutical Engineering and Chemical Engineering.

The course combines lectures & problem-solving to provide students with the ability to do the following:

- Formulate and solve material and energy balance equations for basic processes in chemical and pharmaceutical industry
- Communicate effectively the acquired knowledge in written & verbal form

Required textbook: Elementary Principles of Chemical Processes, 4th Ed., Richard M. Felder, Ronald W. Rousseau, Lisa G. Bullard July 2015 © 2016, John Wiley & Sons
http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP003498.html

Course objectives: Use material and energy balance theory to design and analyze basic chemical and pharmaceutical processes:

- Material Balances: Process flowchart, law of conservation of mass, degree-of-freedom analysis, estimation of physical properties of substances, material balance calculations
- Energy Balances: Law of conservation of energy, closed and open process systems, estimation of thermodynamic properties of substances, energy balance calculations
- Reactive Processes: Material and energy balances on reactive processes, exothermic and endothermic reactions, extent of reaction

Measurable outcomes:

- Proficiency in using the basic principles of material and energy balance theory to analyze processes designed to transform raw materials into desired products

Course outline and tentative weekly listing (15-week schedule)

Topic	Week	Outline	Book Chapter
Engineering Calculations and Processes Variables	1	Units and dimensions; sample mean, range, sample variance and sample standard deviation, method of least squares; process variables: temperature, pressure, chemical composition	2, 3
Fundamentals of Material Balances	2	Process classification, flowchart, general differential and integral balances, material balance calculations	4
Fundamentals of Material Balances	3	Material balances on single-unit processes, degree-of-freedom analysis	4
Fundamentals of Material Balances	4	Material balances on multiple-unit processes, recycle and bypass processes, degree-of-freedom analysis	4
Fundamentals of Material Balances	5	Chemical reaction stoichiometry, limiting and excess reactants, multiple reactions, material balances on reactive processes	4
Single-Phase Systems	6	Liquids, ideal gases, equations of state for non-ideal gases, gas mixtures	5
Multiphase Systems	7	Phase-change processes, the Gibbs phase rules, gas-liquid systems	6
Midterm Exam 1	8		
Multiphase Systems	9	Multi-component gas-liquid systems, liquid-liquid systems, liquid-solid systems	6
Energy Balances	10	Forms of energy, energy balances on open systems, thermodynamic data	7
Balances on Non-reactive Processes	11	Energy balance calculations for open and closed systems, processes involving phase changes	8
Midterm Exam 2	12		
Balances on Reactive Processes	13	Heats of reaction, heats of combustion, energy balances on reactive systems	9
Balances on Transient Processes	14	Differential material and energy balances, single-phase nonreactive processes	11
Final Exam	15		

Homework assignment, format guidelines, and grading

- Homework is collected at the beginning of each lecture
- Late homework will not be accepted for grading
- Feedback on the homework will be provided during lectures, solutions will be discussed, and graded homework will be returned
- Each problem will be graded individually
- Structure the solution into the following sections:

  Known - The problem is posed
  Find - The quantities to be found are stated
  Sketch - The flowchart and process variables are presented
  Properties The physical properties/data needed to solve the problem are listed

Analysis - The problem is solved in a systematic manner, showing all steps, the fundamental equations from which the calculation begins are included, and all numerical values (including units) are shown

Discussion - Comments are made on the results, as appropriate

- Arrange problems in numerical order
- Print your name at the top of each page
- Write only on 8½" x 11" paper; start each problem on a new page
- Staple all pages together and bring a hard copy to class or email scanned sheets or files in *.doc* or *.pdf* formats to Instructor with Cc to Teaching Assistant.

Midterm and final exams

- There will be open-book and open-lecture notes midterm exams. Exact date of midterm exams will be announced a week before.
- An open-book and open- lecture notes comprehensive final exam will cover all material in the course.
- The midterm and final exams must be completed individually, in accordance with the NJIT Honor Code.
- Each problem on the midterm and final exams will be graded individually.

A missed midterm exam will be averaged into the final grade as *zero*, unless permission is obtained from the instructor prior to the exam. Permissions are granted only for very serious circumstances attested to by the NJIT administration, verifiable and significant medical problems, religious holidays, and also serious personal situations, such as deaths in the family. A student who has been excused will be required to take a makeup exam.

Assessment criteria and grading

The course has been designed so that lectures, homework assignments, midterm and final exams are integral and essential parts of the learning process. Final grades will be determined from scores as follows:

Midterm exam 1: 25% Midterm exam 2: 25% Homework: 20% Final Exam: 30%

The final grade will be assigned on the basis of "*a curve*".

Course materials

Textbook, lecture notes, relevant publications and websites