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

Course: PhEn 502 Pharmaceutical Engineering Fundamentals III (3 credits)

Prerequisites: PhEn 500 and PhEn 501, as well as undergraduate course in physical chemistry.

Reason for course prerequisites: A mathematical background, including differential equations (covered in PhEn500), and a foundation in material and energy balances (covered in PhEn501) is required to understand the basic concepts of fluid mechanics, heat transfer, and mass transfer taught in this course and required for quantification of pharmaceutical technology and processes.

Instructor: Dr. Boris Khusid
Professor, Otto H. York Department of Chemical, Biological & Pharmaceutical Engineering
FMH 215, Tel: 973-596-3316, Fax: 973-596-8436, E-mail: khusid@adm.njit.edu
http://chemicaleng.njit.edu/people/khusid.php

Course description: The course covers the fundamentals of fluid mechanics, heat transfer, mass transfer and the design of unit operations involving these principles. This is a required bridge course for those students who are admitted to the Pharmaceutical Engineering MS program without an undergraduate engineering degree or with an engineering background that did not include the topics covered in this course. The course is not counted toward degree credit related to the Pharmaceutical Engineering MS program.

The course combines lectures and problem-solving to provide students the ability to do the following:
- Fundamentals of fluid mechanics, heat transfer and mass transfer
- Ability to communicate effectively the acquired knowledge in written & verbal form


Course objectives: Identify the basic transport phenomena encountered in pharmaceutical engineering:
- Fluid Mechanics: Fluid statics, mass and momentum transfer, laminar and turbulent flows, fluid machinery
- Heat Transfer: Conservation law, conduction, convection, radiation, boiling and condensation, heat-transfer equipment
- Mass Transfer: Conservation law, molecular diffusion, convective mass transfer, mass-transfer equipment

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

<table>
<thead>
<tr>
<th>Topic</th>
<th>Week</th>
<th>Outline</th>
<th>Book Chapter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid Mechanics</td>
<td>1</td>
<td>Concept of continuum, fluid properties, fluid statics, fluid in motion, examples of fluid flow</td>
<td>1, 2, 3, 4, 5, 6, 7</td>
</tr>
<tr>
<td></td>
<td>2</td>
<td>Conservation of mass and energy, Newton’s second law of motion</td>
<td>4, 5, 6, 7</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>Shear stress, Newtonian and non-Newtonian fluids, examples of laminar flow, Navier-Stokes equations</td>
<td>7, 8, 9, 10</td>
</tr>
</tbody>
</table>
Dimensional analysis and similitude boundary-layer concept, drag coefficients, description of turbulence, turbulent flow

Flow in closed conduits, friction factors, pipe-flow analysis

Fluid machinery, scaling laws for pumps and fans, combined pump and system performance

Flow in closed conduits, friction factors, pipe-flow analysis

Heat transfer processes, conduction, radiation, natural and forced convection, boiling and condensation

Heat exchangers, analysis and design, radiation heat transfer

Molecular diffusion, diffusion associated with chemical reaction, mass-transfer operations

Convective mass transfer, basic dimensionless parameters, boundary layer

Mass-transfer transfer processes and equipment

Measurable outcomes:
- Proficiency in using the basic principles of fluid mechanics, energy and mass transfer to describe transport processes in fluid machinery, heat-transfer and mass-transfer equipment

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 physical situation and/or diagram
  Assumptions - The significant assumptions in solving the problem are stated
  Properties - The materials properties 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
- Staple all pages together
- Print your name at the top of each page
- Write only on of 8½ x11 inch paper; start each problem on a new page
Midterm and final exams

- There will be open book and lecture notes midterm exams. Exact date of midterm exams will be announced a week before.
- An open book and 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