# 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 physics, mathematics, and 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 processes pharmaceutical and chemical technologies.

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**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 and Chemical Engineering MS programs 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 and Chemical Engineering MS programs.

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

**Required textbook**: James Welty, Gregory L. Rorrer, David G. Foster ,Fundamentals of Momentum, Heat, and Mass Transfer, Revised 6th Edition , http://www.wiley.com/WileyCDA/WileyTitle/productCd-EHEP003299.html


**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)**

| Topic | Week | Outline | Book Chapter |
|---|---|---|---|
| *Fluid Mechanics* | 1 | Concept of continuum, fluid properties, fluid statics, fluid in motion, examples of fluid flow | 1, 2, 3, 4, 5, 6, 7 |
|  | 2 | Conservation of mass and energy, Newton's second law of motion | 4, 5, 6, 7 |
|  | 3 | Shear stress, Newtonian and non-Newtonian fluids, examples of laminar flow, | 7, 8, 9, 10 |

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|---|---|---|---|
| | | Navier-Stokes equations | |
| | 4 | Dimensional analysis and similitude boundary-layer concept, drag coefficients, description of turbulence, turbulent flow | 11, 12 |
| | 5, 6 | Flow in closed conduits, friction factors, pipe-flow analysis | 12, 13 |
| | 7 | Fluid machinery, scaling laws for pumps and fans, combined pump and system performance | 14 |
| *Midterm exam 1* | 8 | | |
| *Heat Transfer* | 9 | Heat transfer processes, conduction, radiation, natural and forced convection, boiling and condensation | 15, 16, 17, 18, 19, 20, 21 |
| | 10 | Heat exchangers, analysis and design, radiation heat transfer | 22, 23 |
| *Midterm exam 2* | 11 | | |
| *Mass Transfer* | 12 | Molecular diffusion, diffusion associated with chemical reaction, mass-transfer operations | 24, 25, 26, 27 |
| | 13 | Convective mass transfer, basic dimensionless parameters, boundary layer | 28, 29, 30 |
| | 14 | Mass-transfer transfer processes and equipment | 30, 31 |
| *Final exam* | 15 | | |

**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 or should be emailed (in Word or PDF or image file format) to Teaching Assistant with Cc to Instructor before the 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