Department of Chemical Engineering
University of Puerto Rico – Mayagüez Campus
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COURSE SYLLABUS AND INSTRUCTOR INFORMATION

1. GENERAL INFORMATION:
   Course Number: INQU4010
   Course Title: Momentum Transfer Operations
   Credit-hours: 4
   Term: Second Semester Spring 2010-2011
   Session: Section 076, Tuesday and Thursday, 1:30-3:20 PM @ IQ-106a
   Course Blog: http://blogs.uprm.edu/inqu4010fluids

2. DESCRIPTION:
   The course introduces chemical engineering undergraduates to the analysis and description of momentum transport. It also applies the principles of conservation of mass, energy, and momentum to the solution of static and dynamic fluid problems.

3. PREREQUISITES:
   INQU4005 (Material and Energy Balances)

4. COREQUISITE:
   MATE4009 (Ordinary Differential Equations)

5. TEXTBOOK, SUPPLIES, AND OTHER RESOURCES:
   B. R. Munson, D. F. Young, and T. H. Okiishi, *Fundamentals of Fluid Mechanics*, Fifth ed., New York, NY: John Wiley & Sons, Inc., 2002.
   R. B. Bird, W. E. Stewart, and E. N. Lightfoot, *Transport Phenomena*, Second ed. New York, NY: Wiley, 2001.

6. REFERENCES:
   G. K. Batchelor, *An Introduction to Fluid Dynamics*. Cambridge, UK: Cambridge University Press, 1967.
   S. Middleman, *An Introduction to Fluid Dynamics*, New York, NY, John Wiley & Sons, 1998.
   N. de Nevers, *Fluid Mechanics for Chemical Engineers*, Second ed. New York, NY: McGraw-Hill, Inc., 1991.
   G. M. Homsy, H. Aref, K. Breuer, S. Hocqreb, and J. R. Koseff, *Multi-Media Fluid Mechanics CD-ROM*. Cambridge, UK: Cambridge University Press, 2000.

R. W. Fox and A. T. McDonald, *Introduction to Fluid Mechanics*. New York, NY: Wiley, 2004.

7. PURPOSE:
This course is open to all chemical engineering undergraduates and is part of their core curricular requirements. It will introduce them to the fundamentals of fluid mechanics with emphasis on chemical engineering applications.

8. GOALS:
The course introduces chemical engineering undergraduates to the field of momentum transport. It also applies the principles of conservation of mass, energy, and momentum to the solution of static and dynamic fluid problems, with particular emphasis on chemical engineering applications. Course objectives are:
   a) To introduce students to the mechanisms of momentum transport.
   b) To make students proficient in the solution of momentum transport problems.
   c) To familiarize students (through problems, discussion, and classroom demonstrations) with fluid dynamics phenomena relevant to Chemical Engineering practice.

9. SPECIFIC TOPICS:
Basic concepts of fluid dynamics; fluid statics; kinematics and deformation; mass balance and continuity; momentum balance and transport; ideal fluids; energy balance and Bernoulli's equation; fluid friction; Newtonian fluids and the Navier Stokes equations; Non-Newtonian fluids, complex fluids, and suspensions.
(For further detail see attached course schedule.)

10. EVALUATION/GRADE REPORTING:
Three partial exams (60%) and a final exam (20%) will be administered. Problem sets will be assigned (10%) and participation in class blog (10%). All students must write four (4) times in the course blog on topics related to fluid mechanics. General rules are found in the blog. Class and exam attendance is compulsory. No make-ups will be given.
Grades (standard curve)
100–90 A
89 – 80 B
79–70 C
69–60 D
60–0 F
The instructor reserves the right to assign additional work or to redistribute evaluation percentages in this case. All class-stipulated deadlines are final.

11. REQUIREMENTS:
All students are expected to have a solid background in Mathematics and Physics. This includes algebra, pre-calculus, calculus (including multivariate), introductory differential equations, basic dynamics, velocity, forces, acceleration, and vectors.

12. LABORATORY/FIELD WORK:
None.

13. DEPARTMENT/CAMPUS POLICIES:

13a. Class attendance: Class attendance is compulsory. The University of Puerto Rico, Mayagüez, PR, reserves the right to deal at any time with individual cases of non-attendance. Professors are expected to record students' absences. The latter will affect the final grade, and may even result in total loss of credit. Arrangements to make up work missed because of a legitimate class absence are the responsibility of the student (Bulletin of Information, Undergraduate Studies, p. 39, 1995-1996).

13b. Absence from examinations: Students are required to attend all examinations. If a student is absent from an examination for a justifiable reason *acceptable to the professor*, he or she *may* be given a special examination at the discretion of the professor. Otherwise, the student will receive a grade of zero or "F" in the examination missed (Bulletin of Information, Undergraduate Studies, p. 39, 1995-1996).

13c. Final examinations: Final written examinations must be given in all courses unless, in the judgment of the Dean, the nature of the subject makes it impracticable. Final examinations scheduled by arrangement must be given during the examination period prescribed in the Academic Calendar, including Saturdays and Sundays (Bulletin of Information, Undergraduate Studies, p. 39, 1995-1996).

13d. Partial withdrawals: A student may withdraw from individual courses at any time during the term, but not later than the deadline established in the Academic Calendar (Bulletin of Information, Undergraduate Studies, p. 37, 1995-1996).

13e. Complete withdrawals: A student may withdraw completely from the University of Puerto Rico, Mayagüez, PR, at any time during the term up to the last day of classes (Bulletin of Information, Undergraduate Studies, p. 37, 1995-1996).

13f. Disabilities: All reasonable accommodations established by the Americans with Disabilities Act (ADA) Law will be coordinated with the Dean of Students to suit the particular needs of the student. After identifying himself or herself with the instructor and the institution, students with disabilities will receive reasonable arrangements in their courses and evaluations. For more information, please contact Disabled Student Services in the Office of the Dean of Students (Q-109) at 787-265-3862 or 787-832-4040 x3250 or x3258.

13g. Ethics: Any academic fraud is subject to the disciplinary sanctions described in articles 14 and 16 of the revised General Student Bylaws of the University of Puerto Rico, contained in Certification 018-1997-98 of the Board of Trustees.

The professor will follow the norms established in articles 1-5 of the Bylaws to deal with such cases.

14. STUDENT ATTENDANCE AND BEHAVIOR

- *Class attendance is compulsory.*
- *Students are expected to dress properly for class.*
- *Smoking, eating, or drinking in the classroom will not be allowed.*
- *Bringing cell phones and beepers to class is not recommended. If you must do so, make sure that they are turned off when you enter the classroom.*
- *Leaving the classroom in the middle of class is disruptive to both the teacher and other students. If you must leave before the scheduled end of class, make sure that it is for a justifiable reason.*

15. INSTRUCTOR INFORMATION

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Ubaldo M. Córdova Figueroa, Ph.D.
Assistant Professor

David Suleiman Rosado, Ph.D.
Professor and Department Chair

January 27, 2011

Table 1: Course Schedule for INQU4010 Momentum Transfer Operations

Class	Topics	Assigned Reading	Suggested Problems
Class 1 Class 2	**Viscosity and the Mechanisms of Momentum Transport:** Newton's law of viscosity, generalization of Newton's law, viscosity of suspensions and emulsions, convective momentum transport	**BSL** 1.1-1.2, 1.6-1.7	**Munson et al.** 1, 2, 4, 6, 8, 14, 24, 30, 42, 48, 54, 56, 58, 61, 65 **BSL** 1A.1-6, 1B.1-2
Class 3 Class 4 Class 5	**Fluid Statics and Pressure Forces:** the concept of pressure, the hydrostatic equation, pressure forces in fluids (buoyant, centroids, projections), manometers, surface tension	**Munson et al.** 2.1-2.12, 1.9	3, 4, 8, 9, 10, 12, 18, 24, 26, 28, 32, 33, 46, 51, 52, 58, 64, 70, 86
Class 6 Class 7 Class 8	**Shell Momentum Balances and Velocity Distributions in Laminar Flow:** shell balances and boundary conditions, flow of a falling film, flow through a circular tube, flow through an annulus, creeping flow around a sphere	**BSL** Chapter 2	2.A.1-4; 2.B.1-12
Class 9	**Exam Review**	-	-
Partial Exam #1 – 3/1/11 6:30-8:30 PM IQ106			
Class 10	**Fluid Kinematics:** Eulerian and Lagrangian viewpoints, types of flows, velocity and acceleration fields, control volumes and systems, the Reynolds Transport Theorem	**Munson et al.** 4.1-4.4	4.1, 4.3-4.5, 4.21, 4.25
Class 11 Class 12	**The Equations of Change for Isothermal Systems:** the equation of continuity, the equation of motion, the equation of mechanical energy, the equation of change in terms of the substantial derivative, use the equations of change to solve flow problems, dimensional analysis of the equations of change	**BSL** 3.1-3.3, 3.5-3.7	3A.1-4, 3B.1-4, 3B.14, 3B.16, 3C.5
Class 13	**Interphase Transport in Isothermal Systems:** definition of friction factors, friction factors for flow in tubes, friction factors for flow around spheres	**BSL** 6.1-6.3	6A.1-3
Class 14 Class 15 Class 16	**Finite Control Volume Analysis (Macroscopic Balances):** the macroscopic mass balance, the macroscopic momentum and angular momentum balance, the macroscopic mechanical energy balance, estimation of the viscous loss, use of the macroscopic balances for steady and unsteady state problems	**BSL** 7.1-7.7	28, 30, 32, 33, 38, 41, 50, 54, 68, 91, 92, 94, 105, 109, 116, 120
Class 17	**Exam Review**	-	-
Partial Exam #2 – 4/5/11 6:30-8:30 PM IQ106			
Class 18 Class 19	**Similitude, Dimensional Analysis, and Modeling**: dimensional analysis, Buckingham Pi theorem, common dimensionless groups in Fluid Mechanics and Chemical Engineering, correlations of experimental data, modeling, and examples	**Munson et al.** 7.1-7.10	9, 10, 14, 16, 17, 46, 48, 50, 52, 58, 59
Class 20	**Viscous Flow in Pipes:** characteristics of pipe flow, fully developed laminar and turbulent flow, dimensional analysis, pipe flow calculations	**Munson et al.** 8.1-8.6	52-54, 56-60, 62, 66, 72-75, 82, 84, 86, 88, 90, 93
Class 21	**Flow in Packed Beds/Porous Media:** fluid friction and pressure drop in packed beds	**BSL** 6.4	
Class 22	**Flow Over Immersed Bodies:** lift and drag concepts, boundary layer characteristics, drag calculations for immersed spheres	**Munson et al.** 9.1-9.3	36, 39, 46, 56, 59, 62, 68
Class 23	**Exam Review**	-	-
Partial Exam #3 – 5/3/11 6:30-8:30 PM IQ106			
Class 24	**Pump Design and Selection**	Handouts	---
Class 25 Class 26	**Polymeric and NonNewtonian Liquids:** behavior of polymeric liquids, rheometry and material functions, generalized Newtonian models, viscoelasticity	Handouts	---
Class 27	**Final Exam Review**	-	-

Notes regarding exams:

- Exams will be given on the specified date from 6:30-8:30PM. All dates are subject to change. Additional lectures will be negotiated with the students a few days in advance.
- All exams are closed book.
- The student will have the **privilege** of bringing one hand-written formula sheet with relevant equations, conversion factors, graphs, and figures. The formula sheet cannot be a photocopy, either regular size or reduction, from the book, notes or notebook. The formula sheet will be revised at the beginning of each exam. If a violation of the rules above exists the formula sheet will be confiscated. After each examination, the sheet has to be attached to the exam. Keep a photocopy of your formula sheet for your record.
- Programmable calculators are allowed but the instructor reserves the right to erase the calculator memory at any time. Bring a spare simple scientific calculator in case you do not wish to erase your calculator memory.

Notes regarding course blog:

- Problem sets will be posted on the course blog.

Notes regarding Videos shown in class:

- The content of these videos counts as material covered in class and is subject to evaluation in problem sets, projects, and examinations.
- Some of the videos will be made available in the UPRM videotheque one week after it is shown in class.

Notes regarding homeworks:

- Homework has to be handed-in at the beginning of the class on the due date or by email if established by the instructor.
- Homework problems will be evaluated as follows: wrong or missing (0 points), partially correct (1/2 total points) and correct (complete points).