CHE 525-Introduction to Biochemical Engineering

Instructor: Dr. John A. Morgan
Office: FRNY 1053
Office Phone: 494-4088
Email: jamorgan@purdue.edu

Course Meeting Time: 10:30-11:45 AM TR

Place: FRNY 1043

Office Hours: by appointment.

Summary: Biochemical engineering is the field of study concerned with production or remediation of compounds using biological molecules and organisms. The purification of biomolecules is also an important area for biochemical engineers. This course will present a quantitative and mechanistic understanding of biological processes based on the core areas of chemical engineering; thermodynamics, kinetics, and transport phenomena. Topics that will be covered are enzyme kinetics coupled with mass transfer, modeling of microbial growth and mass balances, bioreactor design and operation, genetic and metabolic engineering, plant and animal cell culture and purification of bioproducts.

Text: Bioprocess Engineering, Basic Concepts *Second edition* (2002) M. Shuler and F. Kargi

Supplemental notes and articles will be posted on Blackboard or handed out during class.

Requirements: Assigned readings from the text and handouts are required. Problem sets will be assigned and are due one-week later at the beginning of class. No late homework will be accepted unless arranged with instructor prior to due date. An individual literature review project will be assigned on a topic of your choosing and will be due on the second day of the finals period.

Examinations: There will be two in class exams and no final exam. No make-up exams allowed.

Grading:
Exams (2): 60%
Homework: 20%
Final Project: 20%

CHE 525 Syllabus

Week	T	R
01/08/2018	Introduction	Metabolism overview
1/15	Amino acids / Proteins	Enzymes
1/22	Enzyme Kinetics	
1/29	Biocatalysis	Immobilized Enzymes
2/5	Microbial Growth	
2/12	Batch reactors	Fed-batch
2/19	Chemostat Modeling	
2/26		Exam I
3/5	Bioreactor Selection	Gas-Liquid Mass Transfer
3/12	SPRING BREAK (no class)	
3/19	Instrumentation and Control	Scale-Up
3/26	Solid State Fermentation	Sterilization
4/2	Bioseparations	
4/9	Physical methods	Chromatographic Separations
4/16	Animal Cell Culture	Exam II
4/23	Protein Engineering	Biotechnology Ethics

Literature Review Paper due: 5PM in my office on Tuesday of Finals Week

Statement of Academic Integrity

The commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, use of illegal cribs, plagiarism and copying during homework, projects, or examinations is dishonest and will not be tolerated.

Definition of Academic Dishonesty

Purdue University prohibits dishonesty in connection with any University activity. Cheating, plagiarism or knowingly furnishing false information to the University are all examples of dishonesty. Knowingly aided or abetting cheating is also a dishonest act.

Students caught cheating will receive a zero for the assignment or exam for the first offense. Those caught a second time will automatically receive a failing grade for the course. Individual cases may be referred to the Dean of Students office for review and record keeping.

EMERGENCY PREPAREDNESS

EMERGENCY NOTIFICATION PROCEDURES are based on a simple concept – if you hear a fire alarm inside, proceed outside. If you hear a siren outside, proceed inside.

- **Indoor Fire Alarms** mean to stop class or research and immediately **evacuate** the building. o Proceed to your Emergency Assembly Area away from building doors. **Remain outside** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.

- **All Hazards Outdoor Emergency Warning Sirens** mean to immediately seek shelter (**Shelter in Place**) in a safe location within the closest building. o "Shelter in place" means seeking immediate shelter inside a building or University residence. This course of action may need to be taken during a tornado, a civil disturbance including a shooting or release of hazardous materials in the outside air. Once safely inside, find out more details about the emergency*. **Remain in place** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.

**In both cases, you should seek additional clarifying information by all means possible…Purdue Home page, email alert, TV, radio, etc…review the Purdue Emergency Warning Notification System multi-communication layers at http://www.purdue.edu/ehps/emergency_preparedness/warning-system.html*

EMERGENCY RESPONSE PROCEDURES:

- Review the **Emergency Procedures Guidelines** https://www.purdue.edu/emergency_preparedness/flipchart/index.html
  - Review the **Building Emergency Plan** (available from the building deputy) for: o evacuation routes, exit points, and emergency assembly area
  - o when and how to evacuate the building.
  - o shelter in place procedures and locations
  - o additional building specific procedures and requirements.

EMERGENCY PREPAREDNESS AWARENESS VIDEOS

- "Shots Fired on Campus: When Lightning Strikes," is a 20-minute active shooter awareness video that illustrates what to look for and how to prepare and react to this type of incident. See: http://www.purdue.edu/securePurdue/news/2010/emergency-preparedness-shots-fired-on-campus-video.cfm (Link is also located on the EP website)

MORE INFORMATION

Reference the Emergency Preparedness web site for additional information: http://www.purdue.edu/emergency_preparedness

CHE 53600 Particulate Systems

Instructors: Jim Litster
Forney Hall, Room 1053
E-Mails: jlitster@purdue.edu

Class Hours: Tuesday and Thursday 9:00 - 10:15 am FRNY G124

Office Hours: To be scheduled in the first week of semester.

Textbooks: Introduction to Particle Technology (2nd Edition)
Martin Rhodes
Wiley, 2008
ISBN 978-0-470-01428-8
(Chapters 1 to 11 will be covered in this course)

Other Resources: A set of course notes is available on the blackboard site for the course**.** The notes consist of outlines for each module, powerpoint slides for lectures, and some written text book style notes. It is **essential** that student print out copies of the notes and bring to class. If there is sufficient interest, I can organize for a complete set of printed notes to be purchased as a package from the PMU. Additional resource and links, homework problems and solutions will be posted on the blackboard website throughout the semester.

Course Goals: Processing of particulate solids is ubiquitous in the chemical, food, pharmaceutical, consumer goods and mineral processing industries. However, many engineering programs focus mainly on fluids processing. Particulate systems offer some unique challenges to scientists and engineers and often present the most interesting (and difficult) problems to be solved. This course will provide to the student a broad overview of the fundamentals of particle technology, with an emphasis on concepts and practical applications related to powder flow, particle fluid interactions, and solid-fluid separation processes.

At the completion of this course, students will be able to:

1. Articulate the unique difficulties associated with the design and operation of particulate processes and the reasons for the difficulties;
2. Know the definition of important particle properties and techniques of measurement and be able to manipulate property data;
3. Know the various flow regimes for particle-fluid contacting and apply basic fluid mechanics to calculate settling velocities, pressure drops and solids hold up;
4. Do basic calculations to design and analyze systems for the storage, flow and mixing of solids;
5. Analyze and design important solid-fluid separation processes;
6. Apply their knowledge in an open ended project and communicate results to the instructor and their peers.

Teaching and learning methods

A variety of teaching and learning approaches will be used in this course. Each unit will be introduced with a problem or case study. Classes will vary to suit the topic under study and will include a mix of lectures, structured tutorials, demonstrations and group based workshops. All classes will be organized to maximize interaction between the instructor and the students. The emphasis will be on developing a strong understanding of scientific basics and tools for analysis, rather than a descriptive presentation of equipment and processes.

Grading

Assessment Item	Date	Weighting
Unit problems	Continuous	20%
Mid Term Exam 1	TBA (about week 5)	20%
Mid Term Exam 2	TBA (about week 10)	20%
Team project	Due in the final week of classes	20%
Final Exam	Exam week	20%

Unit problems: A set of tutorial problems will accompany each unit. These are to be done as homework. Class problem solving sessions are timetabled to help students with these tasks. Worked solutions will be provided. ***The tutorial problems are good preparation for the three exams.***

Exams: The exams will be open book. Questions will predominantly test students' ability to solve engineering problems using the concepts covered in the course. The first two exams will be on Unit 1 and Unit 2 respectively. The final two hour exam will assess the whole course, but will be weighted heavily towards units 3, 4 and 5.

Team project: Students will work in teams of three or four students on a realistic and open ended problem on some aspect of particle design and processing. The project will involve problem definition, planning, request for laboratory data (but no laboratory work by the student team), calculations, an oral presentation and written report. Full details of assessment criteria and timetable will be handed out with the project description in October.

Campus emergency plan

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Information about changes in this course will be provided by the instructor.

Academic Integrity

It is, as always, a fundamental principle for your success in this class. **Academic dishonesty** will not be tolerated and will result in failure of the course.

Syllabus and Schedule

Unit Titles

1. Particle characterization and sampling
    - Particle size and shape
    - Density and porosity
    - Sampling
2. Fluid and particle mechanics
    - Regimes for particle-fluid contacting
    - Settling velocity of single particles
    - Packed beds

- Fluidized beds
- Colloidal particle systems

3. Storage, transport and mixing of solids
    - Bulk solids flow and storage
    - Pneumatic conveying
    - Hydraulic conveying
    - Powder mixing and segregation
4. Particle-fluid separation
    - Gravity settling and sedimentation
    - Centrifugal separation (cyclones and centrifuges)
    - Filtration
5. Other topics to be announced

A more detailed scheduled will be available by the start of the Fall Semester.

CHE 540 Fall 2018

INTRODUCTORY TRANSPORT PHENOMENA

Instructor: Professor You-Yeon Won, Room 2031, Forney Hall (FRNY)
Telephone: 765-494-4077, Email: yywon@ecn.purdue.edu
Office Hour: T, 16:30 – 17:30

Classes: M, W, F, 13:30 – 14:20, FRNY G124

Teaching Assistants: Han Zhao, Room 1122, Forney;
Telephone: 765-701-8269, Email: zhao826@purdue.edu
TA Hours: T, Th, 14:00 – 15:00, FRNY 1122

(Plus another TA to be assigned)

Textbook: R. B. Bird, W. E. Stewart, E. N. Lightfoot, and D. J. Klingenberg
Introductory Transport Phenomena,
1st Edition, Wiley, 2014.

Course Objectives:

1. Develop a unified understanding of momentum, heat and mass transport phenomena, and apply this understanding to solve problems of practical importance in chemical engineering and allied fields.
2. Learn about current topics in the field of transport phenomena (see the guidelines for a term project for details).

Course Organization: There will be 38 lectures, two evening exams, and a final exam. Part of the lecture may be devoted to help session and problem solving.

Course Prerequisites: Passing grades in CHE 377 (Momentum Transfer) and CHE 378 (Heat & Mass Transfer) or equivalents.

Attendance: Attendance is required. Unexcused absences may be detrimental to your performance and grade. Missing more than eight (8) lectures without advance permission or a valid excuse will yield a failing grade (F) in the course. Absences must be excused in advance, for documented family, medical, or professional reasons.

Homework: There will be 7 homework sets, typically due (one to) two weeks after assigned. Homework problems will mostly be due every other Wednesdays before class. On each homework assignment, students are required to do all problems, and the assigned problems will be graded and returned. Answers will be handed out. Homework must be submitted on time. Please mark your name, date, homework set number, page numbers, and total number of pages submitted. Please write neatly in black and on one side of the page only. The grade will be determined by correctness, precision, and styles. In problem solutions, be sure to identify by numbers any figures or equations taken from the text. Be sure to put all the assumptions in one place so that they can be reviewed. Use schematics for describing the physical systems being considered, and label important variables. Indicate the control volumes in the schematics if appropriate, and be sure to identify relevant processes associated with control volumes.

Professional ethics mandates that you work your answers independently, unless directed otherwise. Names of all coauthors must be disclosed. Requests for re-grading must be made in writing and within a week after the homeworks are handed back.

Examinations: There will be no make-up exams. Every exam will be comprehensive, with some possible emphasis on the more recent material. Exams will be in two parts: (A) closed-book-and–notes, and (B) open-book-and-closed-notes. Exams will cover comprehension questions (definitions, derivations, concepts, etc.) and problems requiring derivations and numerical answers.

Quizzes: There might be unannounced quizzes. No make-up quizzes will be given.

Grades: Grades will be determined from homework, 10%; quizzes/class participation/oral presentation 15%; Exam #1, 20%; Exam #2, 20%; and Final Exam, 35%. The final grades will be assigned based primarily on absolute performance criteria. For every unexcused absence, grade will be reduced by 2% of the total grade. This course will use a +/- grading system.

Unethical Conduct: Any activity in which a student seeks credit for work performed in the unjust manner (or helps another student to do so) constitutes cheating. This includes falsifying class attendance records, using aides during exams and quizzes, and working together (or doing work in the name of another student) on exams, quizzes and homework submissions. Students caught cheating will be prosecuted to the maximum extent possible under Purdue University guidelines. Punitive actions will include at minimum reduction of course grade but may include expulsion from the University.

Campus Emergency: In the event of a major campus emergency (e.g., an influenza epidemic), course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. During such a disruption, information about changes in this course will be communicated by e-mail.

Suggestions for Succeeding in This Course: Come to class, and come to class prepared. Read the assigned chapter of the textbook before class. Review your lecture notes within 24 hours after the class; this is the most important step toward enhancing your course performance. Without review, you will forget most of what you heard by the next day. Identify points that you have difficulty with. Discuss these points with your classmates, and ask the professor or TA for an explanation. If you have done all these things, you should already find it easier (and more fun) to do homework. As far as exams are concerned, understanding the material is essential but not sufficient for success. Practicing with problems is the key; do as many problems as possible.

Oral Presentation:

All students are required to give an oral presentation in front of the class on a recent paper published in the literature since 2008. The presentations will be given in teams of three students. Each talk will be composed of a 10-minute presentation and 2 – 3 minutes of question and answer afterwards; questions will be asked by the audience. A PowerPoint presentation is the suggested format of presentation. Students should submit their paper selection to the instructor for approval via e-mail; in the e-mail, please include the title, author names, journal information (name, volume/issue/page numbers, year of publication) and abstract of the paper. The choice of paper should be approved by the instructor no later than Friday 11/09/2018. The main subject of the paper should be relevant to the topics of this course. The following are some of the examples of recommended journals from which you choose an article: Science, Nature, Nature Physics, Langmuir, Soft Matter, Physical Review Letters, AIChE Journal, Journal of Fluid Mechanics, Journal of Rheology, Proceedings of the National Academy of Sciences, etc. You are required to submit an electronic copy (in the PowerPoint format) of your presentation in its FINAL form by 11:59 PM on the night before the scheduled date of your presentation. When you submit your presentation file, please use the following format for the filename: "CHE 540 Presentation [Your Last Name, e.g., Won].pptx". The presentations will be scheduled in the weeks of 11/26 and 12/3. The grades will be given based on the choice of paper (i.e., relevance, quality, and potential impact), clarity of presentation, depth of understanding, and ability to answer questions.

Tentative Outline: (Subject to changes)

Lecture #	**Date**	**Topics**	**Reading assignments from the textbook (homework dues)**
1	08/20/18	Introduction	Ch. 0 (hw1 assigned)
2	08/22/18	Viscosity, momentum flux vector	Ch. 1
3	08/24/18	Viscosity, momentum flux vector	Ch. 1
4	08/27/18	Shell momentum balances, velocity distributions	Ch. 2
5	08/29/18	Shell momentum balances, velocity distributions	Ch. 2 (hw1 due; hw2 assigned)
6	08/31/18	Equations of change (isothermal)	Ch. 3
	09/03/18	No class (Labor Day)	
7	09/05/18	Equations of change (isothermal)	Ch. 3
8	09/07/18	Equations of change (isothermal)	Ch. 3

9	09/10/18	Turbulent momentum transport	Ch. 4
10	09/12/18	Turbulent momentum transport	Ch. 4 (hw3 assigned; hw2 due)
11	09/14/18	Dimensional analysis of momentum transport	Ch. 5
12	09/17/18	Dimensional analysis of momentum transport	Ch. 5
13	09/19/18	Friction factors, use of empirical correlations	Ch. 6
14	09/21/18	Friction factors, use of empirical correlations	Ch. 6 (hw3 due)
15	09/24/18	Review	
	09/25/18	**Exam #1** (6:30 – 7:30 PM, WTHR 104)	
16	09/26/18	Macroscopic isothermal energy balances	Ch. 7 (hw4 assigned)
17	09/28/18	Thermal conductivity, heat flux vector	Ch. 9
18	10/01/18	Shell energy balances, temperature distributions	Ch. 10
19	10/03/18	Shell energy balances, temperature distributions	Ch. 10
20	10/05/18	Shell energy balances, temperature distributions	Ch. 10
	10/08/18	No class (October Break)	
21	10/10/18	Equations of change (non-isothermal)	Ch. 11 (hw4 due; hw5 assigned)
22	10/12/18	Equations of change (non-isothermal)	Ch. 11
23	10/15/18	Turbulent energy transport	Ch. 12
	10/17/18	No class (Walther Embedding Project presentation)	
24	10/19/18	Turbulent energy transport	Ch. 12
25	10/22/18	Dimensional analysis of energy transport	Ch. 13 (hw5 due)
26	10/24/18	Review	
	10/25/18	**Exam #2** (8:00 – 9:00 PM, WTHR 104)	
27	10/26/18	Dimensional analysis of energy transport	Ch. 13 (hw6 assigned)
	10/29/18	No class (AIChE Annual Meeting)	
	10/31/18	No class (AIChE Annual Meeting)	
28	11/02/18	Heat transfer coefficients, use of empirical correlations	Ch. 14
29	11/05/18	Heat transfer coefficients, use of empirical correlations	Ch. 14
30	11/07/18	Macroscopic non-isothermal energy balances	Ch. 15
31	11/09/18	Diffusivity, mass flux vector	Ch. 17 (paper selection due)
32	11/12/18	Diffusivity, mass flux vector	Ch. 17

33	11/14/18	Shell mass balances, concentration distributions	Ch. 18 (hw6 due; hw7 assigned)
34	11/16/18	Shell mass balances, concentration distributions	Ch. 18
35	11/19/18	Equations of change (binary mixtures)	Ch. 19
	11/21/18	No class (Thanksgiving Vacation)	
	11/23/18	No class (Thanksgiving Vacation)	
36	11/26/18	Equations of change (binary mixtures)	Ch. 19
37	11/28/18	Turbulent mass transport	Ch. 20
38	11/30/18	Mass transfer coefficients, use of empirical correlations	Ch. 22
	12/03/18	Student presentations	
	12/05/18	Student presentations	(hw7 due)
	12/07/18	Student presentations	
		Final exam (comprehensive, schedule TBA)	

08/18/2018

ChE 55300
Pharmaceutical API Process Development and Design
Course Information

Spring 2017

Objective

The development and design of processes for the production of pharmaceutical products involves three important tasks: (1) translation of the recipe for the drug substance (or active pharmaceutical ingredient (API)) that was developed at the laboratory stage to a recipe usable in production; (2) selection, preliminary design, and scale-up of the equipment used to carry out the steps of the recipe; and (3) selection, preliminary design, and scale-up of the equipment used to make the formulation (e.g., tablet or capsule) that is the vehicle for delivery of the API to the patient. In this course the engineering methodology which underlies the first two tasks will be covered using references from the process systems engineering and pharmaceutical manufacturing literature. The basic features of batch operations will be discussed. The features of common unit operations used in the pharmaceutical industry will reviewed, including batch reaction, solid-liquid separation, crystallization, drying, batch distillation and other separation systems. Both dedicated and multi-product production system design and batch and semi-continuous operating modes will be covered. Software for simulation unit operations (Dynochem) and process trains (BATCHES) will be introduced and used to solve industrially relevant applications. The FDA current good manufacturing practices (cGMP) and Design Space concepts will also be reviewed. Case studies will be used to demonstrate the overall design strategy and its operational implementation and to integrate the course material.

Course Requirements

1. *Attendance* at all lectures and meetings is required. The instructors will allocate 10% of the grade on the basis of student's level of attendance, participation, presentations and engagement in the class and class discussions

2. *Exams:* There will be a written mid-term exam covering the lecture material. There will be no written final exam; however, the fifth project report will be due at the end of exam week.

3. *Projects*: Five assigned projects will be required that are executed in pairs by student teams. Several of these projects will require the use of appropriate process engineering software. Projects will require both written reports and oral presentations in class. Reports should be structured as formal documents, written in good technical English and using figures and tables to present results. Late report submissions can not be accepted without prior arrangement with the instructors.

Course Grading:	Mid-term exam	30%
	Projects	60%

Participation	10%

Course Staff:

Faculty member
Prof. G.V. Reklaitis
FRNY 1019
Phone 49662
reklaiti@purdue.edu

Prof Reklaitis will be principal lecturer. Additional guest lecturers from Purdue faculty and research staff and from pharmaceutical companies will be invited as appropriate.

Office hours will be immediately following class, 2:45 to 3:30, as well as by prior arrangement via email.

Course materials

There is no required text for this course. Lecture notes and copies of papers from the literature will be made available in pdf form via the course Blackboard site. The web site will also contain the most up to date lecture schedule, homework assignments, and course news. Office hours will also be posted after consultation with the class. Appointment for additional consultations can be made via email.

List of Topics to be covered (typical)

Overview of Pharmaceutical Process Development & Design
Status of relevant engineering software
Batch reactor design & operation
Reaction calorimetry & reactor safety
Mixing
Solid-liquid separations
Crystallization
Drying
Batch distillation
Solvent Extraction
Impact of API on solid dosage form design
Simulation & Optimization of Process Trains
Process control issues
Process analytical technology
Process planning and scheduling
Industrial case studies

ChE 59700-Energy Storage Systems Laboratory - *Syllabus*

INSTRUCTOR: Prof. Vilas G. Pol, 765-494-0044, vpol@purdue.edu

Theory: Hampton Hall of Civil Engnrng 2108 (Class 12:00pm -1:15pm TR)

Experimental: FRNY 2184 (Class 12:00pm -1:15pm TR)

PROF. OFFICE HOURS: Friday, 11:00 am to 12 pm.

TYPE OF COURSE: Elective

COURSE DESCRIPTION: Fundamental understanding of rechargeable lithium ion batteries, hands on experience on their assembly, testing, analysis and safety aspects. Students will be fabricating and testing high energy density batteries utilizing engineered electrodes, electrolytes and separators. Broader perspectives on sustainable battery manufacturing will be provided.

This course is designed to introduce undergraduate and graduate students to the current challenges and recent developments in the field of rechargeable batteries. Strong emphasis will be on Li ion battery technology, nanotechnology implementation and the materials design for such batteries. Part of the course will cover sustainable issues and manufacturing aspects of batteries. Beyond Li-ion systems, Li-S, Na-ion batteries and K-ion batteries will be designed and discussed.

MAJOR TOPICS COVERED:

- Introduction to Energy Storage Systems: Overview, history, market, theory, thermodynamics, kinetics, definitions, and safety.
- Challenges of Li-ion Battery Technology, Selection criteria for commercial batteries
- Experimental techniques, Promising Cathode Materials, Anode Materials, Electrolytes, current distribution and related issues
- Electrode slurry preparation, lamination, drying, pressing, manufacturing of batteries and testing
- Battery types and Chemistry: Cell charging, Cell discharge testing, Electrochemical impedance spectroscopy (EIS)
- Kinetics and thermodynamics of electrochemical reactions
- Beyond Li-ion Battery Technologies, next generation Li-S batteries, Sodium ion batteries, K-ion batteries will be reviewed.

ChE 597 - 3 credit hours

Financial Analysis and Management of Projects

Spring 2017, Module 1

Class meets in FRNY 1043 on Tuesdays and Thursdays
3.30 to 6.30 pm from January 10 to March 2, 2017

Final Exam: March 2, 2016

Instructors

Dan Sajkowski

Office: FRNY G051 Phone: 815 412 5616 (cell)

Email: dsajkows@purdue.edu; dsajkowski@yahoo.com

Office Hours: by appointment

Dan is the former Business Unit Leader at BP's Whiting Refinery. As a stand-alone business the Whiting Refinery ranks among the top 3 in Indiana and easily within the Fortune 500. Dan has held various research, engineering, management and executive roles in the energy industry for the past 30 years. In addition to leading the Whiting Refinery, he has been the Vice President of Refining Technology for BP and has led the Supply and Trading Group for BP's US Refining operations. He has also played lead roles in projects up to and over $4 billion in size. He is currently on the Board of Directors of Calumet Specialty Products (CLMT). He has consulted for Sapphire Energy, a San Diego based start-up company that is working to develop fuels from microalgae, Virent, Valdes Engineering, Cabot Corporation and The Heritage Group. He has a PhD in Chemical Engineering from Stanford University and an MS and BS from the University of Michigan. He is a graduate of The General Manager Program at Harvard.

Cristina Farmus

Office: FRNY 1060 Phone: 765-494-0027 Email: cfarmus@purdue.edu

Office Hours:
Tue –Thu 1.00 -2.00 pm in FRNY 1060 or by arrangement of another time through email

Cristina Farmus is the Managing Director for Purdue Chemical Engineering. She has been with the School in positions of progressive responsibility for over ten years. Cristina handles multiple projects ranging from launching new programs, such as the ChE Professional MS Program, to multi-million dollar capital renovations. Cristina serves on the Board of Directors for Purdue Federal Credit Union and is active with Toastmasters at Purdue, which she founded in 2015. She has a BS in Commerce and Marketing from Transilvania University, Romania, and an MBA from Purdue's Krannert School of Management, US.

Course Description

Projects are the fundamental building block for “getting things done”. At the most rudimentary level, projects are a series of tasks with a designed outcome. More broadly projects can be concerned with the allocation of resources, including capital, among alternatives and then executing the project plan to create value within an existing business. A project may also even consist of even starting the business itself from the very beginning. This course will cover quantitative and qualitative aspects of the financial analysis of projects with a view toward decision-making. It will also cover the management and execution of projects. The perspective will be from that of an engineer in a business context.

Prerequisites

None

Learning Outcomes

Students will learn to:

- Think of projects in an expansive way where projects can be new business lines, improvements in existing businesses, start-ups, partnerships and capital expenditures of any size
- Do project analysis including economic evaluations
- Balance quantitative analysis with business judgment
- Distinguish between project management practices that have a good chance of success from those that are less likely to succeed
- How to assess and manage risks

Required Texts

- “Finance for Executives,” Hawawini and Viallet 4th edition, South Western 2011 – it is important to note that we will use the 4th edition. Later editions are much different.

- “Sources of Value, A Practical Guide to the Science and Art of Valuation,” Woolley, Cambridge, 2009 – selected chapters from this book will be used, they are all uploaded into the Course Content/Reading Packet folder in Blackboard.

Policies

General Course Policies

The highest standards of professionalism and ethics are expected in this course. Each student is expected to come to class on time and not disrupt the class. Each student is also expected to follow Purdue’s codes of student conduct (http://www.purdue.edu/studentregulations/student_conduct/regulations.html) and behave in a professional manner. The rights of students in violation of the code of conduct are outlined. Each student is expected to exhibit consideration and respect towards the other students, the graders, the teaching assistants (TAs), and the faculty members. Each student is expected to exhibit a positive attitude. Expectations for each student include (but are not limited to):

- Attending all class sessions.
- Coming to on time and prepared by reading assigned material beforehand.
- Refraining from disrupting class (e.g., turning off or silencing cell phones, refraining from cell phone or laptop use during class, and carrying on a loud conversation during class).
- Maintaining the highest standards of academic honesty and integrity.
- Being knowledgeable about the policies and information described in the syllabus.

Grading

The final grade will be based on:

- Homework assignments 50%
- Exam 40%
- Course participation 10% (attendance and active participation in class discussion)

Home work will be collected/uploaded to Blackboard as instructed. Exam will be open book in the classroom during the last class session.

A range: 100 – 85% of the weighted points
B range: 84.9 – 75% of the weighted points
C range: 74.9 – 65% of the weighted points
D range: 64.9 – 55% of the weighted points
F: Less than 55% of the weighted points

If an exam or homework was too difficult (as judged by the faculty instructors) the final grade may be scaled to a higher value. Grades will never be scaled downward. As a rule, scaling will not be applied. There is no preset distribution of final grades. The grading will reflect demonstrated student capability relative to an absolute performance standard that is expected of all Purdue chemical engineering students, rather than a scale that compares students to a mean performance metric on any evaluation vehicle. In practice, this means the entire class could receive A marks.

Academic Dishonesty

Academic dishonesty will not be tolerated in any form in this course. Specifically, Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Section B-2-a, Code of Student Conduct] Furthermore, the University Senate has stipulated that "the commitment of acts of cheating, lying, and deceit in any of their diverse forms (such as the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest." [University Senate Document 72-18, December 15, 1972] All incidents of academic dishonesty will be reported to the Dean of Students. Such incidents include:

(i) possessing or accessing, in hardcopy or electronic form, the solution manual to the course text, or to the exams;
(ii) claiming credit for work that is not your own original work;

(iii) enabling other students to create work that is not their original work.

The punishment for the first offense is a grade of zero for the entire work (exam or homework), and the punishment for a second offense is an F mark for the class.

You may also want to refer students to Purdue's student guide for academic integrity: https://www.purdue.edu/odos/academic-integrity/

Use of Copyrighted Materials

Students are expected, within the context of the Regulations Governing Student Conduct and other applicable University policies, to act responsibly and ethically by applying the appropriate exception under the Copyright Act to the use of copyrighted works in their activities and studies. The University does not assume legal responsibility for violations of copyright law by students who are not employees of the University.

A Copyrightable Work created by any person subject to this policy primarily to express and preserve scholarship as evidence of academic advancement or academic accomplishment. Such works may include, but are not limited to, scholarly publications, journal articles, research bulletins, monographs, books, plays, poems, musical compositions and other works of artistic imagination, and works of students created in the course of their education, such as exams, projects, theses or dissertations, papers and articles.

You may want to refer students to the University Regulations on policies: http://www.purdue.edu/policies/academic-research-affairs/ia3.html

Attendance

Students are expected to be present for every meeting of the classes in which they are enrolled. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts or absences can be anticipated, such as for many University sponsored activities, an interview or religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency absences when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email.. When the student is unable to make direct contact with the instructor and is unable to leave word with the instructor's department because of circumstances beyond the student's control, and in cases of bereavement, the student or the student's representative should contact the Office of the Dean of Students.

The link to the complete policy and implications can be found at: http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

Missed or Late Work

All homework is expected to be completed and submitted on time. Late submissions will not receive credit. Homework is to be submitted through Blackboard by 5 pm Eastern on the day it is due.
The final exam will take place on Thursday, March 2, 2017, from 3.30 to 6.30 pm. If a student has a valid reason for missing the exam, arrangements should be made in advance to reschedule the exam at the earliest possible time.

Grief Absence Policy for Students

Purdue University recognizes that a time of bereavement is very difficult for a student. The University therefore provides the following rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS). GAPS Policy: Students will be excused for funeral leave and given the opportunity to earn equivalent credit and to demonstrate evidence of meeting the learning outcomes for misses assignments or assessments in the event of the death of a member of the student's family.

See the University's website for additional information: http://www.purdue.edu/studentregulations/regulations_procedures/classes.html

Violent Behavior Policy

Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university act*ivity.*

See the University's website for additional information:
http://www.purdue.edu/policies/facilities-safety/iva3.html

Emergencies

In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances beyond the instructor's control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

See the University's website for additional information: https://www.purdue.edu/ehps/emergency_preparedness/

Students with Disabilities

Any academic accommodation must be arranged for by the student through Purdue's Disability Resource Center. Instructors cannot make academic accommodations without a DRC accommodation letter. Below is Purdue's policy statement for supporting students with disabilities.

Purdue University is committed to maintaining an inclusive community that recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, Purdue University seeks to develop and nurture its diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas and enriches campus life.

Purdue University views, evaluates and treats all persons in any university-related activity or circumstance in which they may be involved solely as individuals on the basis of their own personal abilities, qualifications and other relevant characteristics.

Purdue University does not condone and will not tolerate Discrimination against any individual on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, disability, status as a veteran, marital status, parental status, sexual orientation, gender identity or gender expression. Purdue University promulgates policies and programs to ensure that all persons have equal access to its employment opportunities and educational programs, services and activities. The principal objective of this policy is to provide fair and consistent treatment for all students and employees of the University. Purdue is committed to increasing the recruitment, selection and promotion of faculty and staff at the University who are racial or ethnic minorities, women, persons with disabilities and veterans. The University also is committed to policies and programs that increase the diversity of the student body.

Here are some links that may be relevant:
http://www.purdue.edu/policies/ethics/iiic2.html
http://www.purdue.edu/studentregulations/equal_opportunity/studentgrievance.html
https://www.purdue.edu/studentsuccess/specialized/drc/faculty/index.html

Nondiscrimination
Purdue University is committed to maintaining a community which recognizes and values the inherent worth and dignity of every person; fosters tolerance, sensitivity, understanding, and mutual respect among its members; and encourages each individual to strive to reach his or her own potential. In pursuit of its goal of academic excellence, the University seeks to develop and nurture diversity. The University believes that diversity among its many members strengthens the institution, stimulates creativity, promotes the exchange of ideas, and enriches campus life.

Purdue University prohibits discrimination against any member of the University community on the basis of race, religion, color, sex, age, national origin or ancestry, genetic information, marital status, parental status, sexual orientation, gender identity and expression, disability, or status as a veteran. The University will conduct its programs, services and activities consistent with applicable federal, state and local laws, regulations and orders and in conformance with the procedures and limitations as set forth in Executive Memorandum No. D-1, which provides specific contractual rights and remedies. Any student who believes they have been discriminated against may visit www.purdue.edu/report-hate to submit a complaint to the Office of Institutional Equity. Information may be reported anonymously.

You may want to refer students to Purdue's nondiscrimination statement: http://www.purdue.edu/purdue/ea_eou_statement.html

Class Schedule

Date	Lecture	Lecture Topic	Assigned Reading	HW Assignment
1/10/2017	1	Introduction to the Course	FfE Ch 1	
1/12/2017	2	Interest rates,equivalence of cash flows. How to work problems	FfE Ch 1	1
1/17/2017	3	Financial calculations (continued)		
1/19/2017	4	Net present value/Valuation	FfE Ch 6	2
1/24/2017	5	Decision criteria/ after tax cash flow	FfE Ch 7	
1/26/2017	6	Depreciation and working capital	FfE Ch 7 & 8	3
1/31/2017	7	Cash flows/Putting it all together	FfE Ch 7 & 8	
2/2/2017	8	Technoeconomics/Breakeven and sensitivity analysis	FfE Ch 7 & 8, SoV Ch7	4
2/7/2017	9	Leverage, Balance Sheets	FfE Ch 2 & 4	5
2/9/2017	10	Income and cash flow statements	FfE Ch 2 & 4	
2/14/2017	11	Sources of value, Risk Management	SoV Ch 5 &8	
2/16/2017	12	Strategy/Value chain/5 Forces	SoV Ch 4 pp 115-124	6
2/21/2017	13	Project Management (Critical path/Scheduling)/FEL/Benchmarking	SoV Ch 4 pp 113-4	
2/23/2017	14	System constraints		7
2/28/2017	15	Systems Thinking, Real options, Case Studies: Macondo, Texas City, KIOR, Sapphire	SoV Ch12	
3/2/2017	16	Exam		

FfE = Finance for Executives, Hawawini and Viallet, 4th ed

SoV = Sources of Value, Woolley

Disclaimer

This syllabus is subject to change. Changes will be communicated through Blackboard.

EMERGENCY PREPAREDNESS SYLLABUS ATTACHMENT

EMERGENCY NOTIFICATION PROCEDURES are based on a simple concept – if you hear a fire alarm inside, proceed outside. If you hear a siren outside, proceed inside.

- **Indoor Fire Alarms** mean to stop class or research and immediately **evacuate** the building.
  - Proceed to your Emergency Assembly Area away from building doors. **Remain outside** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.
- **All Hazards Outdoor Emergency Warning Sirens** mean to immediately seek shelter (**Shelter in Place**) in a safe location within the closest building.
  - "Shelter in place" means seeking immediate shelter inside a building or University residence. This course of action may need to be taken during a tornado, a civil disturbance including a shooting or release of hazardous materials in the outside air. Once safely inside, find out more details about the emergency*. **Remain in place** until police, fire, or other emergency response personnel provide additional guidance or tell you it is safe to leave.

**In both cases, you should seek additional clarifying information by all means possible…Purdue Emergency Status page, text message, Twitter, Desktop Alert, Albertus Beacon, digital signs, email alert, TV, radio, etc.…review the Purdue Emergency Warning Notification System multi-communication layers at http://www.purdue.edu/ehps/emergency_preparedness/warning-system.html*

EMERGENCY RESPONSE PROCEDURES:

- Review the **Emergency Procedures Guidelines** https://www.purdue.edu/emergency_preparedness/flipchart/index.html
- Review the **Building Emergency Plan** (available on the Emergency Preparedness website or from the building deputy) for:
  - evacuation routes, exit points, and emergency assembly area
  - when and how to evacuate the building.
  - shelter in place procedures and locations
  - additional building specific procedures and requirements.

EMERGENCY PREPAREDNESS AWARENESS VIDEOS

- "Shots Fired on Campus: When Lightning Strikes," is a 20-minute active shooter awareness video that illustrates what to look for and how to prepare and react to this type of incident. See: http://www.purdue.edu/securePurdue/news/2010/emergency-preparedness-shots-fired-on-campus-video.cfm (Link is also located on the EP website)

MORE INFORMATION

Reference the Emergency Preparedness web site for additional information: https://www.purdue.edu/ehps/emergency_preparedness/

CHE 59700/BME 59500: Principles of Tissue Engineering
Spring 2016

Instructor:	Prof. Julie C. Liu	julieliu@purdue.edu	FRNY 1160
Class Hours:	TR 9:00 – 10:15 a.m.		FRNY 1043
Office Hours:	Instructor	Tues 2-3, Wed 1-2 or by appointment	FRNY 1160

Course Description: This course will address the design strategies for engineering tissues and organs. In particular, we will focus on the underlying biological and engineering principles that are used for the design of an appropriate scaffold, selection and comparison of cell sources, and the use of exogenous (growth) factors. Examples from primary literature will be used. Topics include cell-material interactions, examples of scaffolds, and degradation kinetics of the materials. At the end of the course, each student should have:

- A basic knowledge of challenges and current strategies employed in tissue engineering
- An understanding of cell-material interactions and experimental techniques used to assess them

Website for Course Information: https://mycourses.purdue.edu/
The website is limited to enrolled students and will have the syllabus, handouts, supplemental reading, and other course materials. Please check the website regularly for assignments as paper copies will not be handed out in class. Generally, homework is due on Thursdays, and homework will be posted a week before it is due.

Textbook:
Clemens van Blitterswijk *et al.*, *Tissue Engineering*, Academic Press Series in Biomedical Engineering. Either the 2008 or 2014 edition is fine. The 2008 edition is on reserve in the Engineering Library. Both the 2008 and 2014 editions are **available for free as an electronic resource** through the Purdue library.

Supplemental Texts (on reserve in Engineering Library):
Bernhard O. Palsson and Sangeeta N. Bhatia, *Tissue Engineering*, Prentice Hall, 2004.

W. Mark Saltzman, *Tissue Engineering: Engineering Principles for the Design of Replacement Organs and Tissues*, Oxford University Press, 2004. **Available for free as an electronic resource** through the Purdue library**.**

Prerequisites: This class is open to advanced undergraduate students and graduate students. Courses in organic chemistry, molecular biology, and mass transfer are preferred but not required. Because of the interdisciplinary nature of these topics, supplementary reading materials will be suggested for those students who may feel they are deficient in certain areas.

Attendance: You are expected to attend all lectures, and your attendance/participation will contribute to your class participation portion of your grade. If you will be absent during the semester (e.g. attending a conference), you must communicate with the instructor *in writing* at least two weeks before the absence is to occur. Failure to do so will indicate an unexcused absence. Any unexcused absence will result in a grade of zero for any presentation scheduled for that class period. If an emergency exists such that a student is not present for a class period, the instructor will determine if the student will be allowed to make up any homework or presentation.

Procedures and Policies:

- Students are required to read all assigned materials *before* coming to class.
- Before class begins, please turn off or silence all cell phones, pagers, etc.

E-mail: Occasionally, important class announcements will be disseminated through the class e-mail list. It is your responsibility to regularly check your e-mail every day and to read the e-mails regarding this class to receive important class information. If you e-mail Prof. Liu with questions or a request to make an appointment, please allow at least 24 hours for a response during the week (or a response by Monday at 5 p.m. if the e-mail is sent on the weekend).

Homework: Homework will be assigned throughout the course and must be submitted <u>before</u> lecture begins by the due date stated. These assignments will include problem-solving, conceptual questions, and written assignments. *No late submissions will be accepted*, except if excused by the instructor in advance. Please include on the first page your name, assignment number, the date, and the names of the people with whom you worked on the homework. You may work in groups; the sharing of ideas is an excellent way to learn. Individual solutions, however, have to be turned in by each student. Thus, students should not copy others' homework assignments or assist others by making homework answers available. Requests for regrading must be made in writing and within a week after the homework is handed back.

Group Presentations: The field of tissue engineering is constantly changing. Throughout the semester, we will discuss recent advances in the area. Student groups will create a Powerpoint presentation discussing these recent advances. Further details will be provided in class.

Final Project: A final project will be assigned that will require you to delve more deeply into one of the topics of the course. More information on the project will be given during the semester.

Course Evaluation Policy: At the end of the semester, you will be asked to fill out an online course evaluation. It is important that you give honest and critical feedback for future course improvement. To encourage participation, <u>extra credit</u> will be provided to each student who prints a confirmation that he/she has filled out the survey.

Grades:
Grades will be determined as such:

5%	Class Participation/Attendance and Professionalism
25%	Group Presentation
25%	Homework/Written Assignments
45%	Final Project

For group activities, I will collect from each group member a peer evaluation on the degree of participation of all group members, the results of which will be used to adjust the grade you actually receive for that group activity.

The final grades will be assigned based primarily on the absolute performance and secondarily on the relative performance. The following grading scale is guaranteed but may be modified based on relative student performance:

A+	98%-100%	C	74-76%
A	94-97%	C-	70-73%
A-	90-93%	D+	67-69%
B+	87-89%	D	64-66%
B	84-86%	D-	60-63%
B-	80-83%	F	<60%
C+	77-79%		

Professionalism: The highest standards of professionalism and ethics are expected. Expectations include:

- Showing up on time and attending lectures.
- Maintaining the highest standards of academic honesty (e.g., no copying of homework).
- Being an active contributor to group assignments and completing your portion of the assignment in a timely manner
- Being knowledgeable about the policies and information described in the syllabus.

Any student who does not meet the professionalism standards will not receive full points for this portion of the grade.

Academic Honesty: The highest standards of academic honesty are expected in this class. Purdue University's policy on academic dishonesty states that "the commitment of the acts of cheating, lying, stealing, and deceit in any of their diverse forms (such as the use of ghost-written papers, the use of substitutes for taking examinations, the use of illegal cribs, plagiarism, and copying during examinations) is dishonest and must not be tolerated. Moreover, knowingly to aid and abet, directly or indirectly, other parties in committing dishonest acts is in itself dishonest" (University Senate Document 72-18, December 15, 1972). Furthermore, plagiarism means "to use and to pass off someone else's ideas, inventions, writings, etc. as one's own" (New Webster's Dictionary and Thesaurus, 1992). In this course, cheating, plagiarism, or any act of dishonesty will not be tolerated.

This course will use SafeAssign to check for plagiarism. In this course, it is expected that you generate new ideas and new writing for the homework, writing assignments, and final project. This course will consider it academically dishonest to submit work that has been submitted for a grade in another course. In addition, this course will consider it academically dishonest to submit work that has been used previously in a manuscript or for a graduate exam (e.g., qualifying or preliminary exam, qualifying literature assessment). Any participation in an academically dishonest practice such as plagiarism may result in an F on the pertinent homework assignment or group assignment.

Campus Emergency: In the event of a major campus emergency, course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. Here are ways to get information about changes in this course: Blackboard Learn web page, my email address: julieliu@purdue.edu, and my office phone: 494-1935.

Students with Disabilities: Any student who feels s/he may need an accommodation based on the impact of a disability should contact me privately to discuss specific needs. Please contact the Disability Resource Center in room 830 Young Hall to coordinate reasonable accommodations for students with documented disabilities.

Use of Copyrighted Materials: Among the materials that may be protected by copyright law are the lectures, notes, and other material presented in class or as part of the course. Always assume the materials presented by an instructor are protected by copyright unless the instructor has stated otherwise. Students enrolled in, and authorized visitors to, Purdue University courses are permitted to take notes, which they may use for individual/group study or for other non-commercial purposes reasonably arising from enrollment in the course or the University generally.

Notes taken in class are, however, generally considered to be “derivative works” of the instructor’s presentations and materials, and they are thus subject to the instructor’s copyright in such presentations and materials. No individual is permitted to sell or otherwise barter notes, either to other students or to any commercial concern, for a course without the express written permission of the course instructor. To obtain permission to sell or barter notes, the individual wishing to sell or barter the notes must be registered in the course or must be an approved visitor to the class. Course instructors may choose to grant or not grant such permission at their own discretion, and may require a review of the notes prior to their being sold or bartered. If they do grant such permission, they may revoke it at any time, if they so choose.

Violent Behavior Policy: Purdue University is committed to providing a safe and secure campus environment for members of the university community. Purdue strives to create an educational environment for students and a work environment for employees that promote educational and career goals. Violent Behavior impedes such goals. Therefore, Violent Behavior is prohibited in or on any University Facility or while participating in any university activity.

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Tentative List of Topics

Please check the website regularly for added reading materials and changes. Please note that the 1st and 2nd edition refer to the van Blitterswijk textbook.

Topic	**Textbook**
Tissue Engineering and Class Overview: Examples and Challenges *Goals, limitations, current directions*	Introduction (1st ed.) or Ch 1 (2nd ed.)
Morphogenesis: The Process of Tissue Formation *How the body naturally forms tissues, tissue architecture, regeneration potential of various tissues, mass transfer calculations*	Ch 2.1, 3 (1st ed.) or 3.1 (2nd ed.) *Optional: Palsson Ch 2-4*
Cellular Growth *Cell cycle, cellular proliferation*	Saltzman Ch 4
Stem Cells and Cell Source *Stem cells and their plasticity, differentiated cells and their proliferation capacity*	Ch 1, 10 (1st ed.) or 2, 13 (2nd ed.)
Cellular Differentiation *Receptor binding kinetics, ligand diffusion and binding, factor degradation and formation of local gradients*	Saltzman Ch 4
Cellular Adhesion and Spreading *ECM, cell receptors, peptide grafting, quantitative measurements, cell shape*	Ch 4 (1st ed.) or 4, 7 (2nd ed.) Saltzman Ch 7
Cellular Migration *Cell migration model, quantitative techniques, random walk model*	Saltzman Ch 7
Mechanical Properties of Tissues *Solid mechanics, fluid mechanics, viscoelastic models*	Saltzman Ch 5
Mechanical Properties and Cell Response *Mechanical effects on differentiation*	Ch 7 (2nd ed.) Engler *et al.* 2006
Scaffold Design and Fabrication *Examples of polymers, polymer degradation, pore connectivity, fabrication techniques*	Ch 7, 14 (1st ed.) or 6, 10 (2nd ed.)
Mass Transport and Vascularization *Limitation of oxygen, bioreactors, vascularization*	Ch 12.4-12.7 (1st ed.) or 12, 14 (2nd ed.)
Controlled Delivery *Controlled release of factors, different delivery strategies*	Ch 15 (1st ed.) or 11 (2nd ed.) *Saltzman Chapter 11*
Natural polymers *Alginate gels, chitin/chitosan*	Ch 6 (1st ed.)
Extracellular matrix scaffolds *Small intestinal submucosa, silk fibroin, Genetically-engineered scaffolds (elastin, silk-based)*	Ch 5,6 (1st ed.) or 5 (2nd ed.)
Biocompatibility	Ch 9
Ethics *Round-table discussion*	Ch 22 (1st ed.) or 23 (2nd ed.)

ChE 662 Catalysis Fall 2010

Primary Reference

Concepts of Modern Catalysis and Kinetics by I. Chorkendorff and J. W. Niemantsverdriet, second edition, Wiley-VCH (2007) ISBN 978-3-527-31672-4

Other References

Catalytic Chemistry, by B. C. Gates, John Wiley & Sons, N.Y. (1992)

Kinetics of Catalytic Reactions, by M. Albert Vannice. Springer Science (2005)

Catalysis: Concepts and Green Applications by Gadi Rothenberg (April 18, 2008)

Green Chemistry and Catalysis by Roger Arthur Sheldon, Isabel Arends, and Ulf Hanefeld (April 20, 2007)

Catalysis for Renewables: From Feedstock to Energy Production (Hardcover) by Gabriele Centi (Editor), Rutger A. van Santen (Editor) (Oct 19, 2007)

Molecular Heterogeneous Catalysis: A Conceptual and Computational Approach (Paperback) by Rutger Van Santen (Author), Matthew Neurock (Author) (Mar 31, 2006)

J.M. Thomas and W.J. Thomas, Principles and Practice of Heterogeneous Catalysis, VCH, Weinheim (1996).

Handbook of Heterogeneous Catalysis, 8 Volumes by Gerhard Ertl, Helmut Knözinger, Ferdi Schüth, and Jens Weitkamp (April 18, 2008) $2,875.00

Michael Bowker, The Basis and Applications of Heterogeneous Catalysis, Oxford Science Pub. (1998).

J.A. Dumesic, D.F. Rudd, L.M. Aparicio, J.E. Rekoske, and A.A. Treviño, The Microkinetics of Heterogeneous Catalysis, American Chemical Society (1993).

M. Boudart and G. Djega-Mariadassou, Kinetics of Heterogeneous Catalystic Reactions, Princeton University Press (1984).

R. I. Masel, Chemical Kinetics and Catalysis, John Wiley and Sons, N. Y. (2001).

J. A. Moulijn, PWNM van Leeuwen, and R. A. van Santen eds, Catalysis: an Integrated Approach to Homogeneous, Heterogeneous and Industrial Catalysis, Elsevier, 1993

R. I. Masel, Principles of Adsorption and Reaction on Solid Surfaces, John Wiley and Sons, N. Y. (1996).

B.C. Gates, J.R. Katzer, and G.C.A. Schuit, Chemistry of Catalytic Processes, McGraw-Hill, New York (1979).

R. J. Farrauto and C. H. Bartholomew, Fundamentals of Industrial Catalytic Processes, Blackie Academic and Professional, Division of Chapman and Hall, London (1997).

A. Clark, The Theory of Adsorption and Catalysis

G.C. Bond, Catalysis by Metals

R.B. Anderson, Experimental Methods in Catalytic Research

D.O. Hayward and B.M.W. Trapnell, Chemisorption

G.A. Somorjai, Principles of Surface Chemistry, Chemistry in Two Dimensions: Surfaces, Surface Chemistry and Catalysis.

E.K. Rideal, Concepts in Catalysis

C.L. Thomas, Catalytic Processes and Proven Catalysts

Gregg and Sing, Adsorption, Surface Area and Porosity

Delgass, Haller, Kellerman, and Lunsford, Spectroscopy in Heterogeneous Catalysis

J.H. Sinfelt, Bimetallic Catalysts

J.R. Anderson and M. Boudart, eds., Catalysis, Science and Technology

J. Catal., Applied Catal., Advances in Catal., Catalyses Reviews, Catalysis Today, Catalysis Letters, J. Mol. Catal., Surf. Sci., Appl. Surf. Sci., J. Vac. Sci. Technol., J.P.C., JACS, Surfaces & Interface Sci., International Congress on Catal., 00, 96, 92, 88, 84,80, 76, 72, 68, 64, 60. 56.

ChE 662 - Catalysis

11:30 MWF FRNY G124

Instructor: W. Nicholas Delgass, FRNY 2164. Office Hour: 1:00 Thursday

The objectives of this course include an overview of the field of catalysis, review of the kinetics of surface catalyzed chemical reactions (including effects of energetic heterogeneity and methods for estimating parameters), examination of the relation between the surface chemical properties of catalysts and the reaction steps they catalyze (i.e. identification of the system descriptors that control catalytic behavior), and discussion of the current state of understanding of several specific catalytic systems. A theme of the presentation will be to examine how the course material fits into a predictive modeling formalism for catalyst design.

Course Outline

I. Overview

II. Kinetics of Catalytic Reactions

We will cover most of Boudart and Djega-Mariadassou and the kinetics in Chorkendorff and Niemantsverdriet and use some parts of Dumesic et al. and the original Boudart book.

III. Properties of Catalytic Materials (Semiconductors, metals, oxides, solid acids, polyfunctional catalysts) – From Chorkendorff and Niemantsverdriet, lectures, original papers, and a number of sections of texts, we will examine effects of:

Structure
Electronic State
Surface Bonding and Chemistry
Physical chemical details of adsorption and surface reactions

IV. Specific Catalytic Processes – Chorkendorff and Niemantsverdriet, Gates, and Gates et al.

Reaction on metals, acid catalysis, hydrodesulfurization, partial oxidation, ammonia synthesis, Fischer-Tropsch synthesis, water gas shift reactionNOx reduction, etc.

Course Credit

Homework	-	20%
Exams (2)	-	50%
Critical analysis of paper	-	10%
Term paper	-	20%

Term Paper

<15 Typed pages, due Dec 6. Topics due October 13. Outlines with major references are due November 10. The term paper should include a one page abstract and an annotated bibliography for distribution to the rest of the class. Objectives of the term papers will be to identify a catalytic system for which detailed data is available and then to analyze that data in light of a focused aspect of a predictive modeling formalism, i.e. try to link catalyst descriptors to performance.

ChE 662 - Some Possible Term Paper Topics

Acid Catalysis
Adsorption and reaction on clean surfaces
ALPOs
Catalyst sintering
Catalytic combustion
Catalytic hydrodesulfurization
Catalytic reforming
Effects of surface heterogeneity on transient or steady state kinetics
Electrocatalysis
Enantioselective catalysis
Fischer-Tropsch synthesis
Homogeneous catalytic reactions
Hydrogen peroxide synthesis
Hydrogen spillover
Membrane catalysis
Metal support interactions including SMSI
Methane activation
NO reduction
Oxide catalysts
Partial oxidation catalysis
Peroxide oxidation
Photocatalysis
Polymerization catalysis
Role of surface diffusion in catalysis
SAPOs
Scaling laws derived from the d-band center theory of Nørskov and coworkers.
Selected works of Goodman, Ertl, Davis, Barteau , Freund, Schlögl, Norskov. Besenbacher, Topsøe, Dumesic, Prins, Neurock, Schmidt
Shape-selective catalysis
Solid base catalysis
Structure sensitive reactions
Sulfated zirconia and other "kinetic" super acids.
Symmetry rules in catalytic reactions
Temperature programmed reaction
Thermodynamics of surfaces or small particles

CHE 668 Spring 2015

Colloidal and Interfacial Phenomena

Instructor: Professor You-Yeon Won; Room 2031 Forney
Tel: 4-4077; e-mail: yywon@ecn.purdue.edu
Office hours: T 10:30 – 11:30 AM

Classes: M, W, F 1:30 – 2:20 PM, Forney G124

Teaching Assistants: No graduate TA has been assigned for this course this year.

Prerequisites: Undergraduate physical chemistry

Text:

D. F. Evans, and H. Wennerström, "The Colloidal Domain: Where Physics, Chemistry, Biology, and Technology Meet", 2nd ed., Wiley-VCH, 1999 (on reserve in Engineering Library).

Supplemental Text:

R. J. Stokes, and D. F. Evans, "Fundamentals of Interfacial Engineering", Wiley-VCH, 1996 (on reserve in Engineering Library).

P. C. Hiemenz, and R. Rajagopalan, "Principles of Colloid and Surface Chemistry", 3rd ed., CRC Press, 1997 (on reserve in Engineering Library).

Additional References:

J. Israelachvili, "Intermolecular & Surface Forces", 2nd ed., Academic Press, 1992.

K. A. Dill, and S. Bromberg, "Molecular Driving Forces: Statistical Thermodynamics in Chemistry and Biology", Garland Science, 2003.

V. A. Parsegian, "Van Der Waals Forces: A Handbook for Biologists, Chemists, Engineers, and Physicists", Cambridge University Press, 2006.

M. Rubinstein, and R. H. Colby, "Polymer Physics", Oxford University Press, 2003.

T. A. Witten, "Structured Fluids: Polymers, Colloids, Surfactants", Oxford University Press, 2004.

P.-G. de Gennes, F. Brochard-Wyart, and D. Quere, "Capillary and Wetting Phenomena: Drops, Bubbles, Pearls, Waves", Springer, 2004.

B. W. Ninham, and P. Lo Nostro, "Molecular Forces and Self-Assembly: In Colloids, Nano Sciences and Biology", Cambridge University Press, 2010.

H. Bechhold, "Colloids in Biology and Medicine", D. Van Nostrand Company, 1919 (translation from the 2nd German edition).

W. Norde, "Colloids and Interfaces in Life Sciences", Marcel Dekker, 2003.

H. C. Berg, "Random Walks in Biology", Princeton University Press, 1993.

W. M. Saltzman, "Drug Delivery: Engineering Principles for Drug Delivery", Oxford University Press, 2001.

B. J. Berne, and R. Pecora, "Dynamic Light Scattering: With Applications to Chemistry, Biology, and Physics", Dover Publications, 2000.
P. C. Hiemenz, and T. P. Lodge, "Polymer Chemistry", 2nd ed., CRC Press, 2007.

Course Objectives:

1. Develop a broad understanding of core principles/concepts, and experimental techniques, relevant to the studies of colloidal and interfacial phenomena (see the course outline below for specific topics that will be covered).
2. Learn about current topics in colloid and interface science (see the guidelines for a term project for details).

Tentative Course Outline: (subject to changes)

Week of	Topics (Reading Assignments)
1/12, 1/19, 1/26, 2/2, 2/9	Forces between molecules, and forces between particles: van der Waals forces; colloid electrostatics; DLVO theory; hydrophobicity; steric (polymeric) forces; solvation effects; adhesion
	(No class on 1/19: Martin Luther King Jr. Day)
2/16, 2/23, 3/2, 3/9	Colloidal and interfacial phenomena involving collections of molecules: fractal aggregates of particles; capillarity; wetting vs. dewetting, insoluble (Langmuir) monolayers, self-assemblies of amphiphiles (lipids, surfactants, block copolymers); problems in biology and medicine
	(Midterm exam on 3/13)
3/16	**(No classes on 3/16, 3/18, 3/20: Spring Vacation)**
3/23, 3/30, 4/6	Dynamics of particles and molecules in colloidal systems: diffusion under external fields; nanoparticles in cells, tissues and body; molecular exchange in self-assembled systems; fluctuations in aggregates and gels
	(Paper selection for oral presentation due on 3/31)
	(No class on 4/1: NIH Review Panel)
4/13, 4/20	Measurements of structures and dynamics of colloids: rheology of suspensions and gels/networks; static/dynamic light scattering
(4/20,)4/27	Student presentations
	(Final exam on 5/1)

Grades:

The course grade will be based on homework (15%), one midterm (25%), one final (30%), and oral presentation/class participation (30%). Attendance is required. For every unexcused absence, your final grade will be reduced by one point (out of 100). This course will use a +/- grading system.

Homework:

There will be about five homework sets, due about 2 – 3 weeks after assigned. *On each homework assignment, students are required to do all problems, but only part of the assigned* *problems will be graded*. General discussion between students is encouraged, but homework should be done independently, unless directed otherwise. Copying will result in heavy penalty for all involved.

Exams:
The midterm exam will take place during the class on **Friday 3/13**. The final exam will also take place during the class on **Friday 5/1**. All exams will be closed book and closed note, but students will be allowed to have one double-sided 3" × 5" note card with information on it. Requests for re-grading must be made within a week after the graded exams are handed back.

Oral Presentation:
Each student is required to give an oral presentation in front of the class on a recent paper published in the literature since 2011. Each talk will be composed of a 12-minute presentation and a few minutes of question and answer afterwards; questions will be asked by the audience. A PowerPoint presentation is the suggested format of presentation. Students should submit their paper selection to the instructor for approval via e-mail; in the e-mail, please include the title, author(s)' name(s) and abstract of the paper. *The choice of paper should be approved by the instructor no later than **3/31/2015**.* The main subject of the paper should be relevant to the topics of this course. The following are some of the examples of recommended journals from which you choose an article: Science, Nature, Nature Materials, Langmuir, Soft Matter, Journal of Colloid and Interface Science, Macromolecules, Physical Review Letters, Advanced Materials, etc. You are required to submit an electronic copy (in the PowerPoint format) of your presentation in its FINAL form by 12:00 AM on the night before the scheduled date of your presentation. When you submit your presentation file, please use the following format for the filename: "CHE 668 Presentation [Your Last Name, e.g., Won].pptx". The presentations will be scheduled in the weeks of 4/20 and 4/27. The grades will be given based on the choice of paper (i.e., quality and potential impact), clarity of presentation, depth of understanding, and ability to answer questions.

Campus Emergency:
In the event of a major campus emergency (e.g., an influenza epidemic), course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other circumstances. During such a disruption, information about changes in this course will be communicated by e-mail.

1/11/2015

COURSE ON NUMERICAL METHODS

<u>FINITE ELEMENT ANALYSIS IN CHEMICAL ENGINEERING:</u>

WITH EMPHASIS ON

SOLUTION OF FREE BOUNDARY PROBLEMS IN FLUID MECHANICS, HEAT/MASS TRANSFER, REACTION ENGINEERING, AND SEPARATIONS

CHEMICAL ENGINEERING 697B
SPRING SEMESTER 2017
Time: MWF 3:30-4:20 ; Location: FRNY 1043

INSTRUCTOR: PROF. OSMAN A. BASARAN
SCHOOL OF CHEMICAL ENGINEERING (OFFICE: FRNY 3060)
765-494-4061 (phone); 765-494-0805 (fax); obasaran@purdue.edu

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<u>Course philosophy and objectives.</u> Over the last several decades, finite element methods have emerged as the numerical method of choice in diverse applications in which the equations that govern the transport of momentum, heat, and species have to be solved and/or free boundaries abound. Some well-known applications of the finite element method to these problems have included free surface flows encountered in coating flows, polymer processing, and drop and bubble dynamics; porous media flows such as ones studied in ground water hydrology and contaminant transport; and solidification and phase change problems such as ones solved in analyses of crystal growth and chemical vapor deposition. This course will emphasize (but not be restricted to) the fundamentals and applications of the finite element method to nonlinear free boundary problems. No prior knowledge of or familiarity with numerical methods will be assumed. Throughout the course, finite difference and analytical methods will be taught side-by-side with finite element methods to enhance the value and applicability of the course to subjects other than those that will be covered during the semester. This course supplements the fine selection of other courses on finite element methods that are offered at Purdue University by focusing on situations in which fluid-fluid and fluid-solid interfaces play a dominant role. The course material is suitable for and should be of interest to students from all engineering disciplines, the sciences (especially physics), and applied mathematics.

<u>Course outline.</u> The course will cover most of the following topics (coverage varies slightly from year to year), beginning with the fundamentals and then quickly moving on to apply the methods to certain problems at the frontiers of research.

Finite elements: one-, two-, and three-dimensional linear and nonlinear, steady and time-dependent problems; basis functions; ordinary and partial differential equations; integral equations; direct and iterative matrix solvers; automatic and adaptive mesh generation, and moving elements.

Stability analysis: turning and bifurcation points.

Applications. Examples from:

- capillary hydrostatics and solutions of the Young-Laplace equation;
- flows governed by the Navier-Stokes and the Euler equations, mixed-interpolation and penalty methods;
- free surface flows and free boundary problems — algebraic and elliptic mesh generation, drop dynamics, film and coating flows, flows with interface rupture, and problems with phase change (e.g. solidification and vaporization);
- flows with heat, mass, and charge transport — surface tension gradient-driven flows, electrohydrodynamics (i.e. coupled solution of the Cauchy momentum and Maxwell's equations), and flows encountered in the processing of electronic materials;
- polymer processing, rheology, and non-Newtonian fluid mechanics;
- separations and reaction engineering.

Other methods: survey of boundary element or boundary integral, finite difference, volume of fluid, level set, boundary collocation, and perturbation methods.

Instructional method. Extensive handouts of lecture notes and supplementary materials, algorithms, and computer programs. Homework (including writing of computer programs), test(s), and project. The latter may be open-ended and lead to publications and/or inclusion in M.S./Ph.D. theses. By the end of the course, participants will be able to read the research literature and use finite elements in their research/work. In past years, a small number of lectures on a hot or specialized topic has also been presented by an expert on that topic. This year, a number of such hot topical areas may once again be covered by several outside experts. These special lectures will be announced during the course of the semester.

Prerequisites. Class participants either should be familiar with or willing to learn during the course of the semester (a) using computers and FORTRAN, C, or some other high-level programming language (MATLAB is also acceptable), (b) vector and tensor analysis at the level of Chapter 6 of Hildebrand's *Advanced Calculus for Applications* and Appendix A of Bird, Stewart, and Lightfoot's *Transport Phenomena* (BSL), and (c) basics of transport phenomena at the level of BSL. A good background in calculus and ordinary and partial differential equations will also be helpful but no previous knowledge of numerical methods will be assumed.

Required and/or supplementary texts. Although there are no required textbooks this year, the following two books were required in recent offerings of this course.

1. M. S. Gockenbach, *Understanding and Implementing the Finite Element Method*, SIAM (2006).

2. W. H. Press, S. A. Teukolsky, W. T. Vetterling, and B. P. Flannery, *Numerical Recipes*, Cambridge U. Press (2007).

Moreover, the following books are highly recommended as general supplementary texts:

(i) G. Strang and G. J. Fix, *An Analysis of the Finite Element Method*, Prentice-Hall (1973). [The second edition of this classic, which was republished in 2008 by Wellesley-Cambridge Press, has a new part II that focuses on implementation issues.]

(ii) J. N. Reddy and D. K. Gartling, *The Finite Element Method in Heat Transfer and Fluid Dynamics*, CRC Press (1994). [The third edition of this book was published in 2010. I do not recommend this book as a textbook from which one can learn finite elements.]

(iii) L. Lapidus and G. F. Pinder, *Numerical Solution of Partial Differential Equations in Science and Engineering*, Wiley-Interscience (1982). [Just because a book is old does not mean it is not good!]

For most of the material to be presented in the course, there are no appropriate texts. Therefore, lecture notes and handouts will be used in lieu of text during the course of the semester. A list of additional supplementary (reference) texts will be given out in class.

Course history. This course has its roots in a one-credit seminar/course taught by the instructor and his colleagues while he was a graduate student in the Department of Chemical Engineering and Materials Science at the University of Minnesota. Since that time, the scope of the course has greatly broadened. In particular, the course being offered is a direct offshoot of a graduate level course which was taught by the instructor biennially over a period of several years at the University of Tennessee and the Oak Ridge National Laboratory. The more recent versions of the course have previously been taught at Purdue University during a number of spring semesters beginning in 1996.

CHE 542: Polymer Engineering (Temporary No. CHE 597000)
Spring Semester 2020
Chemical Engineering
Purdue University

Instructor: Prof. Jim Caruthers caruther@ecn.purdue.edu

Why take the course:
Polymers are one of the two the major output of the chemical industry (the other being gasoline and oil). No one goes to Walmart and buys a gallon of teraphthalic anhydride even though it is a multi-billion dollar per year product; rather, you buy clothes that have polyester fibers that were polymerized from teraphthalic anhydride and propylene glycol. The basic commodity chemicals like ethylene, propylene, styrene, teraphthalic acid, etc. are just internally consumed by the chemical industry, where the major products that leave the chemical industry (and hence make money) are polymers. Chemical engineers make polymers that are then sold to mechanical/industrial engineers that manufacture a variety of products that are then sold to the consumer. The key criteria for selling polymers are their mechanical, electric, optical, environmental, etc. properties. The property requirements for each individual application are different – it is at this point-of-sale that the chemical industry makes its profit. The objective of this course is to (i) introduce the various physical/chemical properties of polymers that are important in industrial and consumer application and (ii) connect these physical properties to the molecular architecture of the polymer.

Course description:
A list of topics include:

1. Description of the different types of polymers
2. Molecular weight and molecular weight distribution
3. Characterization of different physical states: rubber, melt, glass and semi-crystalline
4. A brief description of rheology (i.e. flow behavior) of polymer melts and solutions
5. Engineering properties of polymers:
    a. Mechanical behavior, including nonlinear stress-strain behavior and viscoelasticity
    b. Electrical
    c. Optical
    d. Diffusion
6. Multi-phase polymers: filled polymers, block copolymers, polymer matrix composites

Course perspective and organization:
The course is designed to be an exposure for all students to these technologically important materials. The course will not be a grind of weekly homework. There will be some (but not a lot) homework, one (or maybe two) quizzes and a project. The educational perspective is for student to learn the types of things that are important for polymer products made by chemical engineering without being scared away from this important material because of fear of drowning in weekly homework and exams.

Who can take the course:
Professional MS and PhD students in Chemical Engineering or Materials Engineering and selected undergraduates with permission of instructor.

CHE 597: Recent Developments and Methods for Energy-Efficient Distillation and Membrane Separations

Separations are ubiquitous in all chemical and petrochemical industries. Of the numerous alternatives, distillation is the predominant choice; accounting for 90-95% of all industrial liquid separations. Further, the development of novel materials with increased selectivities led membrane-based separations to receive increasing attention in industry. It is well-known that both the alternatives are energy intensive at industrial scale. To put it in perspective, it is estimated that distillation alone consumes energy equivalent of roughly 4% of total US energy consumption. The growing demand to reduce the carbon footprint is driving the separations field towards the development of novel energy-efficient and cost-effective solutions. This course introduces methods and techniques developed in the last two decades for systematic synthesis and analysis of new distillation designs. Concepts introduced in this course will enable a process engineer to assess the efficiency of existing distillation flowsheets, identify the potential for improvements, and systematically identify solutions that will realize the improvement potential. In addition, the course also introduces the fundamentals of membrane-based separations, and underlying principles behind the synthesis of multistage membrane cascades for high purity and high recovery separations. The course will cover the topics listed below

1. Introduction to separations, and concept of minimum work of separations
2. Review of concepts in binary distillation – VLE, McCabe Thiele method for computing minimum vapor duty (both graphical and algebraic methods), extension to binary nonideal and azeotropic systems
3. Utilization of waste heat stream for distillation to improve the overall efficiency, introduction to exergy (thermodynamic) analysis in the context of separations
4. Optimal feed conditioning, optimal placement of intermediate reboilers and condensers, prefractionator arrangements, and double-effect distillation to reduce heat duty up to 50%
5. Methods for running distillation with electric work rather than heat (heat-pump distillation) along with a brief example of cryogenic separation, introduction to internally Heat-Integrated Distillation Column (HIDiC)
6. Introduction to multicomponent distillation, derivation of Underwood method for computing minimum reflux ratio for a general multicomponent mixture, visualization of results from Underwood method via Vmin diagram
7. Introduction to sloppy splits, thermal couplings and column sequencing, discussion on thermal couplings as an implicit heat integration, concept of *quality of heat* as a function of temperature
8. An easy-to-use method for systematic generation of all possible *distillation configurations* for the separation of a multicomponent mixture, methods for identifying energy efficient configurations
9. Methods for improving the operability of thermally coupled configurations: column-section rearrangement, and liquid-only-transfer arrangement
10. Process intensification in multicomponent distillation: Modeling intermediate heat exchangers, multieffect distillation, and heat and mass integration for reducing heat duty, dividing wall columns for making distillation configurations more compact.

11. Introduction to membrane separations, binary and multicomponent membrane cascade theory and modeling.
12. If time permits, a brief description on methods for multicomponent azeotropic distillation, and multi-feed, multi-product columns.