BME 595/CHE 597  
Principles of Tissue Engineering  
(3-Credit)

Instructor:  
Prof. Solorio  
lisolorio@purdue.edu  
496-1956  
Office: MJIS 3019

Prof. Liu  
julieliu@ecn.purdue.edu  
494-1935  
Office: FRNY 1160

Office Hours:  By appointment

Lectures  
Tues, Thurs 10:30 AM – 11:45 AM  
FRNY G124

Objectives  
This course is designed to provide background for the application of engineering principles with the life sciences to facilitate understanding of normal and pathological mammalian tissues. Applications of drug delivery, tissue and cell transplantation, bioartificial organs, tissue regeneration, disease models, and applications in clinical practice will be explored.

Learning Outcomes  
By the end of this course students will:
1. Understand the importance of cell sources, material properties, and mass transport on tissue structure and function
2. Be able to design a rational experiment and have improved understanding for how to characterize and analyze tissue engineered constructs
3. Improve their ability to present new concepts and ideas to a group of students and potential investors

Teaching Philosophy  
Learning is an active process. Learning should not be passive, such as simply listening to lectures, making notes, and taking exams. The most effective learning is through active participation, including asking questions, presenting opinions, and making suggestions. This course is designed to maximize students’ participation in classes with free discussions, debates, and dialogues.

Learning Resources, Technology, and Texts  
All lecture materials will be made available through Blackboard Learn (https://mycourses.purdue.edu/), and Kahoots! will be used in class to evaluate the students understanding of concepts presented in lectures.

Recommended Textbooks:  

Grading

Students are expected to attend class, participate in discussions, read all handout materials, and do homework (due at the beginning of lecture). It is possible that the whole homework assignment may be graded or that only specific problems on a homework assignment may be graded. As part of a 3-4 member team, students will drive the critical review of a primary journal article and will also teach topics related to the article to the class. Articles will be suggested by the instructors, but students may choose their own article as long as it is approved by the instructors. The article presentation is designed to train students how to collect, analyze, and utilize information on a research topic and to improve their presentation skills. Throughout the semester, students will work in teams to prepare an R21-based project proposal or business pitch. Students will turn in a written report and give a presentation at the end of the semester. The proposal will be critiqued by the instructor as well as by other students in the class. The proposal topic will be selected by the students and approved by the instructors. Missed or late work will not be accepted. Any requests for regrade must be made in writing and within a week after the assignment was available to be handed back to students. For group activities, we 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.

<table>
<thead>
<tr>
<th>Assignments</th>
<th>Due</th>
<th>Weighting</th>
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<tbody>
<tr>
<td>Participation in class discussion</td>
<td>Throughout the semester</td>
<td>5%</td>
</tr>
<tr>
<td>Homework assignments</td>
<td>Throughout the semester</td>
<td>15%</td>
</tr>
<tr>
<td>Article Presentation</td>
<td>Throughout the semester</td>
<td>30%</td>
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</table>

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%
Attendance Policy
Students are expected to attend all classes. Sometimes an unavoidable situation may occur and excuse a student from attending the class. In that situation, please consult with the instructors before class or, if due to an emergency, immediately afterwards. Any unexcused absences will negatively impact your class participation grade and result in a zero for scheduled presentations or assignments due during that class period.

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 BME 595/CHE 597 to receive important class information. If you e-mail Profs. Solorio or Liu with questions or a request to make an appointment, please allow a minimum of 24 hours for a response during the week (or a response by Monday evening if the e-mail is sent on the weekend).

Academic Integrity
The highest standards of academic honesty are expected. The Purdue Honor Pledge is: “As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue.” 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). In this course, cheating, plagiarism, or any act of dishonesty will not be tolerated.

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). 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, in class presentations, 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.

Any incidents of academic dishonesty will be reported to the Office of Student Rights and Responsibilities where university penalties, including removal from the university, may be considered. The first offense will result in an F on the pertinent homework assignment, recitation activity, project, exam, or lab report. A second offense will result in an F grade for the course.

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing or by calling 765-494-8778. While the information may be submitted anonymously, the more information that is submitted provides the greatest opportunity for the university to investigate the concern.
Students with Disabilities
Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let us know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at drc@purdue.edu or by phone: 765-494-1247.

In addition to the University policy, the Davidson School of Chemical Engineering has established procedures for students seeking accommodations. These can be found online at the ChE Undergrad Office website. Only those accommodation requests that conform to both University and ChE policy guidelines will be implemented.

Some important points from the CHE policy include: Please give letters of accommodation to Prof. Solorio, Prof. Liu, and your academic advisor. If you have your letter at the start of the term, we strongly recommend you give it to us within the first two weeks of the semester.

Bereavement Policy
Purdue recognizes that a time of bereavement is very difficult for a student. The University therefore provides rights to students facing the loss of a family member through the Grief Absence Policy for Students (GAPS): http://www.purdue.edu/studentregulations/regulations_procedures/classes.html. Students who find themselves in need of assistance in a time of bereavement should contact Profs. Liu and Narsimhan privately to discuss specific needs.

Nondiscrimination Statement
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 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’s nondiscrimination policy can be found at: https://www.purdue.edu/purdue/ea_eou_statement.php

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.
Emergency Preparation
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 instructors’ control. Relevant changes to this course will be posted onto the course website or can be obtained by contacting the instructors. You are expected to read your @purdue.edu email.

Mental Health Statement
• If you find yourself beginning to feel some stress, anxiety, or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.
• If you need support and information about options and resources, please see the Office of the Dean of Students for drop-in hours (M-F, 8 am-5 pm).
• If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

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.

Course Evaluation
During the last two weeks of the course, students will be provided with an opportunity to evaluate this course and your instructor. Purdue uses an online course evaluation system. You will receive an official email from evaluation administrators with a link to the online evaluation site. You will have up to two weeks to complete this evaluation. Your participation is an integral part of this course, and your feedback is vital to improving education at Purdue University. I strongly urge you to participate in the evaluation system.

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. Thus, these materials cannot be posted online. 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.

Emergency Procedures
In the event that the class would need to evacuate FRNY (e.g., in the event of a fire alarm), the class
should proceed to exit the building and meet in front (i.e., on the fountain side of the MSEE
Building) or, in the case of inclement weather, inside of MSEE. Do not leave the area as emergency
responders will need to count to ensure that all persons have made it from the facility. In the event
that we are required to shelter in place (e.g., due to a tornado warning), we will proceed to the
appropriate shelter in place area within the lower levels of FRNY (i.e., immediately outside of
B124).

Disclaimer
This syllabus is subject to change. If any change occurs, it will be announced in the class.
Course Title: Engineering applications of biological molecules

Instructor: Chongli Yuan
Room 1154, Forney Hall
Tel: 45824; email cyuan@purdue.edu
Office Hours: 12:00-1 pm Tuesday or by appointment

Classes: Lectures 1:30 – 2:45 HAMP 2107

Course Description: This course introduces the engineering applications of biological molecules in different scientific fields. We will discuss the state-of-art recombinant DNA technologies and conduct case-study of their applications in disease treatment, biosensing, nanoelectronics, computing and polymer science. The goal of the course is to introduce biotechnology to chemical engineering students and prepare them for research and development work in interdisciplinary environments.

Textbook: Class notes will be disseminated in class.
Prerequisite: Bio230 or equivalent, junior, senior standing and graduate students

Course Objectives: Develop a fundamental understanding of biological molecules and its various applications in different scientific and engineering disciplines.

Course Outcome:
1. Understand the basics concepts of fundamental biological molecules.
2. Understand the basic molecular biology methods to prepare biological molecules.
3. Understand the engineering application of biological molecules.

Course Structure: Lecture The typical weekly schedule will be:
Tuesday and Thursday: two lectures
Since the schedule will sometimes deviate from this pattern, follow your detailed course outline.

Assessment:
Grades for the course will be allocated as following
Course Grading: Class participation (25%), homework (25%), final project (50%)
The class session will contain case studies. The case study will be organized as a mock development process of a specific research subject and students will be constantly asked to “make decisions” based on the “current” progress. Active participation from the students is crucial and therefore constitutes 20% of the final grade.
The topics of the final project can be in the broad area of genetic engineering, biotechnology or nanobiotechnology. The topic of the final project needs to be approved by the instructor. The final project includes a written report (6 pages maximum) and an in-class presentation. The following sections need to be included in the final report: (1) Definition of the theme problem; (2) background and literature review; (3) challenges and outlooks; and (4) References. The grade of the final project will be equally weighted between the written report and the presentation.
The course will be graded as follows. Some cut offs may be adjusted depending on the difficulty of the assessment items

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<thead>
<tr>
<th>Grade</th>
<th>GPA Value</th>
<th>Recommended Range</th>
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<tbody>
<tr>
<td>A</td>
<td>4.0</td>
<td>≥87%</td>
</tr>
<tr>
<td>B</td>
<td>3.0</td>
<td>≥77%</td>
</tr>
<tr>
<td>C</td>
<td>2.0</td>
<td>≥70%</td>
</tr>
<tr>
<td>D</td>
<td>1.0</td>
<td>≥62%</td>
</tr>
<tr>
<td>F</td>
<td>0.0</td>
<td>&lt; 60.0</td>
</tr>
</tbody>
</table>
Lecture Notes: Lecture notes will be posted on the blackboard website. Students are encouraged to go through the notes before the lecture.

**Ethical Conduct:**

Honesty on homework. Your homework answers must reflect your own independent work and thinking. Discussion about homework problems are allowed and encouraged. However, do NOT copy homework and do NOT assist others by making your homework answers available. Any student detected copying or assisting in copying will receive zero credit on the assessment piece.

Honesty on final project. You are expected to work by yourself on your final project. Any usage of published materials needs to be accompanied with proper references. Violations will result in, at least, a failing grade on the assessment piece. Serious cases will result in a failing grade for the course and documentation will be sent to the Dean of Students Office.

No disruption of class. Please turn off cell phones before lecture and recitation sessions. No phone calls and text messaging are allowed in class.

Purdue prohibits "dishonesty in connection with any University activity. Cheating, plagiarism, or knowingly furnishing false information to the University are examples of dishonesty." [Part 5, Section III-B-2-a, Student Regulations] 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]

**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. Please refer to the website below for details

http://www.purdue.edu/policies/academic-research-affairs/ia3.html

**Course Syllabus**

Week 1-2: General overview of common molecular and cell biology techniques, e.g. cell culture, PCR, gel electrophoresis, protein liquid chromatography and etc.

Week 3-6: Case study 1: Cell engineering. The topic will be selected among (1) CRISPR-based cell engineering tools; (2) engineered T-cells (CAR-T); or (3) student suggested topics.

Week 7-10: Case study 2: Biotechnology. The topic will be selected among (1) Next generation DNA sequencing technique; (2) Real-time PCR and transcriptome; or (3) student suggested topics.

Week 11-13: Case study 3: Data-driven biological discoveries. Selected topic between (1) Multi-omics; (2) single cell analysis; or (3) student suggested topics.

Week 14-15: Final project report

**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/

**Accessibility and Accommodations**

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247.
CHE 544  Spring 2021

Structure and Physical Behavior of Polymer Systems

Instructor:  Professor You-Yeon Won; Room 2031 Forney
Tel: 4-4077; e-mail: yywon@purdue.edu
Office hours: T 10:00 – 11:00 AM (subject to occasional changes)
(https://purdue.webex.com/purdue/j.php?MTID=m8bd857ceda0e6b0d4dfcfb0794919b0e)

Classes:  M, W, F 12:30 – 1:20 PM
(https://purdue.webex.com/purdue/j.php?MTID=m0eefaf0884a0d115b04c89b317d71d1f)

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

Prerequisites:  Undergraduate physical chemistry


Course Objectives:
1. Develop a broad understanding of the underlying principles and concepts relating to the structural and physical behavior of polymers (see the course outline below for topics that will be covered).
2. Learn about current topics in polymer science (see the guidelines for oral presentation on your own research or a recent paper for details).

Tentative Course Outline:  (subject to minor changes)
Week of  Topics (Reading Assignments)
1/18 Introduction: history of polymers; basic definitions; classes of polymers; average molecular weights; synthesis; stereochemistry; common polymers (Ch 1; notes) (No class on 1/18: Martin Luther King Jr. Day)

1/25, 2/1 Chain conformations: freely-jointed chain; freely-rotating chain; hindered rotation; characteristic ratio; persistence length; wormlike chain; radius of gyration; Gaussian distribution; excluded volume; solvent quality; expansion parameter (Ch 2 & 3; notes)

2/8, 2/15 Thermodynamics of polymer mixtures: regular solution theory; Flory-Huggins theory; osmotic pressure; second virial coefficient; theta temperature; solubility parameter; concentration regimes in polymer solutions; phase separation (Ch 4 & 5; notes)

2/22, 3/1 Scattering: static light scattering; form factor; Zimm plot; small-angle neutron/X-ray scattering (Ch 1; notes) (No class on 2/22: An NSF review panel meeting)

3/8, 3/15 Characterization based on polymer solution dynamics: intrinsic viscosity; gel permeation chromatography; dynamic light scattering (Ch 1; notes)

3/15 Crystalline polymers: hierarchical structure; crystallography; thermodynamics of crystallization and melting; crystallization kinetics (notes) (No class on 3/17: APS March Meeting)

3/22 Amorphous polymers: Gaussian conformation; glass transition; free volume; α, β-relaxations; thermal analysis of polymers (notes)

3/29, 4/5 Rheology of polymer melts: basic concepts; models for viscoelasticity; dynamic mechanical spectroscopy; time-temperature superposition; entanglement; plateau modulus; relaxation time; reptation model (Ch 7, 8 & 9; notes)

4/12 Rubber elasticity: role of entropy; statistical mechanical theory; swelling in solvent (Ch 7; notes)

4/19, 4/26 Viscoelasticity in polymer solution: Bead-spring model (Ch 8; notes)

4/26 Student presentations (Final exam date: TBA)

Grades:
The course grade will be based on homework (30%), one final (50%), and oral presentation/class participation (20%). 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 3 – 4 homework sets, due about 3 weeks after assigned. Homework problems will be announced through Brightspace. On each homework assignment, students are required to do all problems, but only part of the assigned problems will be graded. All homeworks should be submitted as a PDF via email to me (yywon@purdue.edu) before noon on the due date. Include your homework in the email as an attachment in PDF format. Use the following filename format: "CHE 544 Homework Number Your Last Name.pdf". Homework solutions will be handed out. Homework scores will be announced. However, detailed comments on incorrect approaches will not be provided. 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:**
There will be no midterm exams. The final exam will be a 24-hour take-home exam and will take place during the final exam week (5/3 – 5/8); the exam date will be announced later in the semester. The final exam will be open-book, open-notes, and open-whatever-other-material-you-might-find-useful. The exam paper will be emailed to the class on the exam date. It is recommended to use letter-size, lined notepad paper and also to mark each page with your name and page number at the upper right corner. Email your exam solutions to me as a single PDF file. Use the following format for the filename: "CHE 544 Final Exam Your Last Name.pdf".

**Oral Presentation:**
Each PhD-level graduate student is required to give an oral presentation in front of the class about his/her thesis research project. The talk should discuss the significance/innovation, approach, results, and conclusions of your current research. While doing so, you should also demonstrate how the knowledge learned from this course will be/has been useful for your thesis research. 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 (PPT) presentation is the suggested format of presentation. *Each PhD student should submit the title and abstract of his/her presentation to me via email by Saturday 4/10/2021.*

An undergraduate or non-thesis master’s program student should give an oral presentation on a recent paper (published after 2016). The format and length of this literature review presentation will be the same as the PhD research presentation. Undergraduate and masters students should submit their paper selections via email for my approval; in the email, please include the title, authors’ names and abstract of the paper, journal name, volume number, page numbers, year published. *The choice of paper should be approved by the instructor no later than Saturday 4/10/2021.* The subject of the paper should be relevant to the topics of this course. Review or perspective articles are not allowed; only original research papers are allowed for this presentation. The followings are some of the examples of recommended journals from which I suggest to choose your article: Nature Materials, Macromolecules, Nature, Advanced Materials, Polymer, Journal of Polymer Science B (Polymer Physics Edition), etc.

The presentations will be scheduled in the week of 4/26. The exact dates and presenters will be announced later. Each student should email me an electronic (PPT) copy of his/her slides due by the midnight before the presentation date. The filename should be in the following format: “CHE 544 Presentation Your Last Name.pptx”. The grades will be given based on the quality and potential impact of the work discussed, clarity of presentation, depth of understanding, and ability to answer questions.

**Communication Protocols:**
Please use the professor’s office hours for additional help or for any questions or requests regarding the course. Please use email or phone only in case of personal issues that need to be urgently addressed. Emails that do not follow this protocol will be disregarded without reply. Also, emails that ask questions that are clearly and directly answered by the information in the syllabus will be disregarded without reply.

Course requirements, deadlines and grading percentages are subject to changes that may be necessitated by a revised semester calendar or other unforeseen circumstances. Information about any such changes in this course will be communicated by email.

1/19/2021
Fall 2020 Course Syllabus – ChE 55100, IPPH 59000, ME 59700, ABE 59100, AAE 49000 & 59000 – Principles of Pharmaceutical Engineering

Course Information
Course number and title: ChE 55100, IPPH 59000, ME 59700, ABE 59100, AAE 49000 & 59000 Principles of Pharmaceutical Engineering
CRN: 22181/27876
Meeting time: Tuesdays/Thursdays 4:30-5:45 PM
Meeting location: WANG 2599
Course credit hours: 3.000 CHE55100 also can be taken as a 3-credit special topics 49X/59X in AAE/ABE/CHE/IPPH/ME
Prerequisites: STEM background

Information about Course Instructors
Instructor and Course Co-Coordinator: Professor Gintaras V. Reklaitis (ChE)
Email Address: reklaiti@purdue.edu

Instructor and Course Co-Coordinator: Professor Alina A. Alexeenko (AAE, ChE)
Email Address: alexeenk@purdue.edu

Instructor: Professor Kingsly Ambrose (ABE)
Email Address: rambrose@purdue.edu

Instructor: Professor Marisol Koslowski (ME)
Email Address: marisol@purdue.edu

Instructor: Professor Zoltan Nagy (ChE)
Email Address: znagy@purdue.edu

Instructor: Professor Carl Wassgren (ME)
Email Address: wassgren@purdue.edu
If you need to contact us by email, please include “ChE 55100” in the subject line.

Course Description
The course is designed to provide engineering, science and pharmacy students with an understanding of the structure, economic and regulatory context, product discovery and development pipeline dynamics, intellectual property considerations and common manufacturing technology of the global pharmaceutical industry. Course assessment will be based on team projects, three quizzes and participation.

Learning Resources, Technology & Texts
Required text:
• There is no required textbook for this course

Additional resources:
• Lecture powerpoint files and paper pdfs available on course site
• Course site will also contain:
  o Lecture schedule
  o Project assignments
  o Quiz information
  o Course news
  o Grades
  o Staff office hours
• Additional consultations via email

Software and Computing Resources
• N/A

Learning Outcomes
By the end of the course, you will be able to:
1. Understand the “big picture” view of the Pharmaceutical Industry
   ● Structure and key players
   ● Economic & Regulatory context
   ● Product pipeline dynamics
   ● Current manufacturing technology
2. Working vocabulary of domain concepts
3. Appreciation of technical challenges and opportunities
4. Foundation for specific follow-up courses such as:
   ● API Process Development and Design
   ● Particle Technology and Manufacturing
   ● Pharmaceutical Materials and Dosage Form Design
   ● Parenterals and Sterile Operations
   ● Bioprocessing
Assignments and Grading

Five projects will be assigned over the semester. Projects may involve analysis of the pharmaceutical industry companies and products, critical assessment of the economics of the pharmaceutical business, evaluation of differences between the pharmaceutical industry sector, analysis of processes and products, etc. Each project will require the submission of a written report. Each group will give two oral in-class presentations on projects. Projects will be executed in teams of two students each. Three quizzes will be given during the course of the semester. There is no final examination.

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<tr>
<th>Assignments</th>
<th>Due</th>
<th>Weight</th>
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<tbody>
<tr>
<td>Participation</td>
<td>Throughout the semester</td>
<td>10</td>
</tr>
<tr>
<td>5 Projects</td>
<td>As announced</td>
<td>12 points each</td>
</tr>
<tr>
<td>Quizzes</td>
<td></td>
<td>10 points each</td>
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• Participation grade includes 3 points for each presentation

Course Topics and Tentative Schedule*

Please check the Course Schedule posted on Brightspace for due dates for projects and other assignments.

Topics
• Introduction, course mechanics
• Major Companies, therapeutic categories, leading brand name drugs, generics, orphan, OTC
• Industry overview: world markets, sales, trends
• FDA history, enabling legislation, organization structure & functions, ICH
• Product life cycle & healthcare economics; Cost & risks of pharma business
• FDA Approval Processes: NME, NDA, ANDA, PAI, etc
• Critical Quality Attributes (CQAs), QbD, SUPAC

• Pharmaceutical dosage forms I
• Pharmaceutical dosage forms II (include drug-device combinations)
• Basic Pharmaceutics I: GI Tract physiology; ADME, etc
• Basic Pharmaceutics II; BCS, transporters
• Batch process fundamentals: recipes, dynamics, batch size, cycle time, etc
• Batch process operations (examples of campaigns)
• IP & Patent Strategy

• Process Development
• Solid Unit Operation
• API manufacture – typical unit operations
• Manufacture of solid oral dosage
• Manufacture of biologics
• Vaccines and their Manufacture
• Parenterals sterile processing, lyophilization
• Integrated Computational Materials Engineering Approach to Pharmaceutical Manufacturing
• PAT: Process monitoring & control
• Continuous manufacturing developments; Disruptive innovations in manufacturing
* Schedule and assignments subject to change. Any changes will be posted on the course website.

Please consult Modified Fall 2020 schedule in Purdue Academic Calendar. Key University dates for the Fall 2020 semester:

- Aug. 24 – Classes Begin
- Sep. 4 – Last Day to Drop/Add a Course
- Nov. 24 – Face-to-Face Instruction Ends
- Nov. 25-28 – Thanksgiving Break
  (no classes – 25, 26, 27; University Holidays – 26, 27)
- Dec. 5 – Classes End
- Dec. 7-12 – Final Exams
- Dec. 13 – Commencement
- Dec. 15 – Grades Due

(New!) Attendance Policy during COVID-19

Students should stay home and contact the Protect Purdue Health Center (496-INFO) if they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, but the student still needs to inform the instructor of any conflict that can be anticipated and will affect the submission of an assignment or the ability to take an exam. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, through Brightspace, or by phone. 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, quarantine, or isolation, the student or the student’s representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link on Attendance and Grief Absence policies under the University Policies menu.

(New!) Academic Guidance in the Event a Student is Quarantined/Isolated

If you have any COVID19 health concerns, contact the Protect Purdue Health Center at 765-496-4636. If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.
(New!) Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors on campus include: staying home and contacting the Protect Purdue Health Center (496–INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining appropriate social distancing with peers and instructors (including when entering/ exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

References Supporting Protect Purdue Compliance:
- Office of the Dean of Students Protect Purdue Compliance Plan: Ask, Offer, Leave, Report
- Office of the Dean of Students Managing Classroom Behavior and Expectations

Academic Integrity

Purdue’s Honor Pledge: “As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue."

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

Course notes are “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.” As such, they cannot be sold or bartered without your express written permission.

Nondiscrimination Statement

Purdue’s nondiscrimination policy is included in the Brightspace and can also be found here.

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. More details are available on our course Brightspace table of contents, under University Policies.

Accessibility
Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. More details are available on our course Brightspace under Accessibility Information.

Mental Health Statement
If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.

If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Emergency Preparation
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 or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

1. If you experience any symptoms of COVID-19 or suspect you may have been exposed to someone with COVID-19 stay home and call the Protect Purdue Health Center at 765-496-INFO.
2. Keep your cell phone on to receive a Purdue ALERT text message.
3. Log into a Purdue computer connected to the network to receive any Desktop Popup Alerts.
ChE 55400
Smart Manufacturing in Process Industries

Course Objective

This course surveys the tools and techniques, which are relevant to support the multiple levels of technical decisions that arise in modern integrated operation of manufacturing facilities in the chemical and related process industries. The linkage of these decisions levels and sharing of associated data and knowledge via effective IT methodology is currently termed Smart Manufacturing. The topics covered in the course include the structure of the operations decision hierarchy, role of online process measurements, elements of sensor network design, information systems to support process operations, plant data reconciliation, detection and diagnosis of process faults, plant wide control, real time process optimization, production planning and scheduling, and supply chain management. Each topic will be addressed by first summarizing the basic role and scope of that component, then discussing the structure of the decision problem, and then will outlining some representative tools available to address that decision problem. Each main topic will include a lecture given by an industrial practitioner who will offer a perspective on the state of industrial practice.

Course Organization

Faculty: Professor C. Laird
Professor Z. Nagy
Professor J. Pekny
Professor G V Reklaitis

Guest Lecturers: Dr M. Bassett, Dow Ag Sciences
Dr S. Brown, Invensys
Dr S. Garcia-Munoz, Eli Lilly
Dr A. Giridhar, CSOPS
Dr C. Iles, Evonik
Dr A. Ogden-Swift, Honeywell

Course Coordinator: Professor G.V. Reklaitis
Office: FRNY G027B
reklaiti@purdue.edu
765-494-9662

Course Materials: There are no required textbooks.

Lecture notes will be posted on the course Blackboard site. All supplementary reading and reference materials, consisting of articles from the literature and a selection of book chapters will also be made available on the Blackboard site.
Course Requirements:
There will be five assignments on the following topics: data reconciliation, fault
detection using MSPC, plant-wide control, process optimization, and
planning/scheduling, using software which will be made available. There will be an
in-class midterm and a project in lieu of a final exam.

Course Grading:

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Assignments (5)</td>
<td>50%</td>
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<tr>
<td>Midterm exam:</td>
<td>25%</td>
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<tr>
<td>Final project:</td>
<td>25%</td>
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</tbody>
</table>

The final project will be executed by student teams and will require a formal report
and oral presentation of project results. Student teams may define their own
projects on topics relating to their research or technical interest but must employ
applications of the methodology covered in the course. Project suggestions will be
offered by the faculty and lecturers, if requested by the project team.

Course policies
Attendance is required at all course meetings. A 10% reduction in course grade will
be assigned for any student with more than three unexcused absences. Dishonesty
in the execution of assignments, project or midterm exam constitutes grounds for
failure of the course.

Learning Outcomes
As a result of this course, the student should be able to
- Explain the function, information requirements and main decisions made at each
  level of the operational hierarchy of an integrated processing system.
- Understand the design requirements of a sensor network, that insures that all
  variables which must be managed are observable
- Explain what process data storage requirements are and how these
  requirements are met in integrated process systems
- Know how to use data reconciliation methods to obtain the maximum likelihood
  estimate of the state of a process
- Explain why exceptional events are important to process operations
- Use multivariate statistic methods to determine whether and when an
  exceptional event has occurred
- Explain what fault diagnosis is, why it is needed and what general types of
  methods are available for effective diagnosis
- Understand the role of plant-wide control and how it relates to individual unit
  operations control
- Be able to test, evaluate and improve a specific plant wide control system design
  using a process simulation model
- Explain the role of real time process operations and the differences between
  steady state and dynamic RTO.
• Be able to implement and solve a steady state RTO problem based on material balances
• Explain the differences and relationship between process planning and scheduling
• Represent a process planning problem by formulating a linear programming model and solving it using standard LP tools
• Be able to explain the main decision variables of a process scheduling application and understand the underlying computational complexity of scheduling problems
• Represent a scheduling problem using a state task network and solve it using a commercial solver
• Explain how supply chain management relates to the operational planning of individual processes
• Understand the main components and operational decision variables of a supply chain optimization problem
• Explain the information requirements for effective supply chain management
• Understand where the sources of uncertainty arise in supply chain planning and what strategies can be used to accommodate to these uncertainties.

Tentative Lecture Schedule (to be confirmed)

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Lecturer</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>8/26</td>
<td>Overview &amp; syllabus</td>
<td>Reklaitis</td>
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<tr>
<td>8/28</td>
<td>The operations decision hierarchy</td>
<td>“</td>
<td>Role of each level, differences between batch &amp; continuous</td>
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<tr>
<td>9/2</td>
<td>Information systems &amp; management</td>
<td>Giridhar</td>
<td>ISA architecture, process historians, ERP systems</td>
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<tr>
<td>9/4</td>
<td>Plant data reconciliation</td>
<td>“</td>
<td>Introduction &amp; Linear problem</td>
</tr>
<tr>
<td>9/9</td>
<td>Plant data reconciliation</td>
<td>“</td>
<td>Nonlinear form</td>
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<tr>
<td>9/11</td>
<td>Sensor networks &amp; their design</td>
<td>“</td>
<td>Aspects of observability, reliability, accuracy; cost/benefit</td>
</tr>
<tr>
<td>9/16</td>
<td>Exceptional events and consequences</td>
<td>Garcia</td>
<td>Overview, Statistical basis &amp; tools</td>
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<tr>
<td>9/18</td>
<td>Fault detection: MSPC</td>
<td>Garcia</td>
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<tr>
<td>9/23</td>
<td>Fault diagnosis: MSPC</td>
<td>Garcia</td>
<td></td>
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<tr>
<td>9/25</td>
<td>Model based diagnostic methods</td>
<td>Reklaitis</td>
<td>Overview of qualitative &amp; quantitative approaches</td>
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<tr>
<td>9/30</td>
<td>POTR pilot plant demo</td>
<td>Giridhar</td>
<td>Sensors, EEM, control</td>
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<tr>
<td>10/2</td>
<td>Plant wide control intro</td>
<td>Nagy</td>
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<tr>
<td>10/7</td>
<td>Plant wide control</td>
<td>Nagy</td>
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<tr>
<td>10/9</td>
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<td>Nagy</td>
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<td>10/14</td>
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<td>10/16</td>
<td>Plant wide control</td>
<td>Ogden-Swift</td>
<td>Industrial experience and applications</td>
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<td>10/21</td>
<td>Mid-term exam</td>
<td>Reklaitis</td>
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<tr>
<td>10/23</td>
<td>Real time process optimization : SS</td>
<td>Laird</td>
<td>Objective &amp; components</td>
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<td>10/28</td>
<td>RTO: SS</td>
<td>&quot;</td>
<td>NLP solution methods</td>
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<tr>
<td>10/30</td>
<td>RTO: dynamic</td>
<td>&quot;</td>
<td>Start-up/shut down, grade transition, batch</td>
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<td>11/4</td>
<td>RTO: dynamic</td>
<td>&quot;</td>
<td>Solution approaches</td>
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<td>11/6</td>
<td>RTO</td>
<td>Brown</td>
<td>Software tools and implementation</td>
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<td>11/11</td>
<td>Scheduling &amp; planning overview</td>
<td>Pekny</td>
<td>Objectives &amp; scope, differences, motivating applications</td>
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<td>11/13</td>
<td>Planning methods</td>
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<td>Single/multiperiod LP</td>
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<td>11/18</td>
<td>Scheduling methods</td>
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<td>Problem Representation</td>
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<td>11/20</td>
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<td>Solution approaches: MILP</td>
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<td>11/25</td>
<td>Scheduling Applications</td>
<td>Iles</td>
<td>Industrial experiences and needs</td>
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<td>11/27</td>
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<td>Thanksgiving</td>
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<tr>
<td>12/2</td>
<td>Supply chain management</td>
<td>Reklaitis</td>
<td>Components &amp; roles</td>
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<td>12/4</td>
<td>Supply chain management</td>
<td>Reklaitis</td>
<td>Integration &amp; uncertainty aspects</td>
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<td>Supply chain challenges</td>
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<td>Industrial Applications</td>
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<td>12/11</td>
<td>Class Project reports</td>
<td>Reklaitis</td>
<td>Team presentations</td>
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CHE 558  RATE CONTROLLED SEPARATIONS  
Fall 2020 (On-line CHE 558-001 LEC)  
Revised September 4. 2020

INSTRUCTOR:  Professor N.-H. Linda Wang  
Office:  FRNY 1015, Phone 494-4081  
E mail:  wangn@purdue.edu  
Office Hours:  To be arranged

LECTURE:  MWF 12:30am – 1:20 pm, on-line.

TEXT:  
(1) Wankat, P.C., Rate Controlled Separations,  

Alternative Textbook:  

COURSE OBJECTIVES:

1. To develop in-depth understanding of the fundamental concepts and quantitative theories in three important rate-controlled separation techniques: chromatography, membrane separations, precipitation and crystallization;
2. To develop abilities to learn from reading and discussion and to give presentations and to lead discussion during class;
3. To develop abilities for critical review of key articles in the literature;
4. To develop abilities to use computer simulations to understand complex chromatography processes (optional);
5. To develop abilities in literature search and independent case studies of a separation process with potential applications in producing an important chemical or biochemical; and to present your results in class and in a term paper.

GRADING:

4 Homeworks (5% each)  20%

1 Exam (Take-home)  35%

In-Class Teaching/Discussion  15%

1 Oral Presentation  10%

1 Research Paper  20%

TOTAL  100%

REFERENCE ARTICLES:  Lists of key papers on various topics will be posted for review and discussion.
REFERENCE BOOKS:


<table>
<thead>
<tr>
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<th>Topic</th>
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<td>Introduction of Separations;</td>
<td>W1§1, 6, 14</td>
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<td></td>
<td></td>
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<td>Chromatography</td>
<td>W2§ 18.1</td>
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<td>R1 § 1-4</td>
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<td>2</td>
<td>08/26</td>
<td>W</td>
<td>Applications of Chromatography</td>
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<td>3</td>
<td>08/28</td>
<td>F</td>
<td>Dynamics of Chromatography</td>
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<td>4</td>
<td>08/31</td>
<td>M</td>
<td>Solute Movement Theory</td>
<td>W1§6; W2§18.2</td>
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<td>5</td>
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<td>Linear Theories</td>
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<td>R7 § 1-3, 5-6</td>
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<td>10/21</td>
<td>W</td>
<td>SMB</td>
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<td>36</td>
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<td>11/11</td>
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<td>38</td>
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<td>39</td>
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<td>Precipitation/Crystallization</td>
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<td>40</td>
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<td>M</td>
<td>Precipitation/Crystallization</td>
<td>W § 3</td>
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### Thanksgiving Vacation (Nov. 25-27)

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<tr>
<th>Date</th>
<th>Day</th>
<th>Date</th>
<th>Activity</th>
<th>Notes</th>
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<tbody>
<tr>
<td>41</td>
<td>11/30</td>
<td>M</td>
<td>Crystallization</td>
<td>W § 3</td>
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<tr>
<td>42</td>
<td>12/02</td>
<td>W</td>
<td>Crystallization</td>
<td>Presentation slides due</td>
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<tr>
<td>43</td>
<td>12/04</td>
<td>F</td>
<td>Term Paper Presentation</td>
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<tr>
<td>44</td>
<td>12/07</td>
<td>M</td>
<td>Term Paper Presentations</td>
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<tr>
<td>45</td>
<td>12/9</td>
<td>W</td>
<td>Term Paper Presentations</td>
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### Term Paper Due Dec. 11

*Instead of 2 make-up lectures for the 2020 AIChE meeting, we will have a take-home exam (2 hours). Any additional make up lectures, if needed, will be on evenings or Saturdays.*

**Reading Notation: §: Chapter; W: Text by Wankat; R1: Reference 1; R3: Reference 3; R7: Reference 7.
A. Instructor. William R. Clark, M.D.

B. Course description. This course provides a “real world” overview of healthcare delivery in the United States (US). The major medical technology segments (pharmaceutical compounds and medical devices) are a significant focus, including their research and development processes, regulatory framework, and market approaches. Another highlight of the course is an assessment of a series of critical medical conditions having the highest impact on the US healthcare system. Clinical cases illustrating these conditions along with case studies designed to provide practical examples of healthcare developments and challenges are included. A number of emerging healthcare developments, including precision medicine, artificial intelligence, digital health, and value-based care, are addressed. In addition, the numerous ways in which the COVID-19 pandemic has affected patients and the manner in which they receive healthcare are discussed. In lieu of examinations, a team project consisting of two oral presentations and a final report is an important aspect of the course.

While the course is relevant to a broad spectrum of students, those planning a career in the healthcare industry may find it particularly useful. The course content is geared toward students interested in the pharmaceutical or medical device industry along with those pursuing post-graduate clinical training (e.g., medical school, osteopathic school).

C. Course requirements. The course is open to all undergraduate students and all students enrolled in the Graduate School. BIOL 23000 or equivalent course is recommended but not mandatory.

D. Instructor Biographical Information: Dr. Clark is a nephrologist (kidney specialist) and chemical engineer by training. He received his M.D. degree along with specialty and sub-specialty training in internal medicine and nephrology, respectively, at Indiana University School of Medicine. In addition, he received both his B.S and M.S. degrees in chemical engineering from Purdue University, at which he is now Professor of Engineering Practice in the Davidson School of Chemical Engineering. Before joining the Purdue faculty, Dr. Clark worked in the medical device (dialysis) industry for more than 20 years in a variety of positions. Dr. Clark continues to serve as a consultant in the dialysis industry.

E. Recommended (NOT REQUIRED) Texts.

- *Crowley's An Introduction to Human Disease: Pathology and Pathophysiology Correlations*, Edited by Emily Reisner, Howard Reisner, Jones and Bartlett Learning, 2017, 10th ed, ISBN 978-1284050233

F. Course Learning Outcomes.

- Evaluate the impact of the following conditions, from both a clinical and resource utilization (cost) perspective: coronary artery disease, heart failure, diabetes, cancer, obesity, Alzheimer’s disease, chronic kidney disease, stroke, arthritis, sepsis, and acute kidney injury.
- Analyze the major segments of medical products (pharmaceutical/biotechnology compounds and medical devices) along with the regulatory framework applying to each of these segments.
- For the biopharmaceutical industry, determine the major components of the drug development process and the manner in which drug pricing factors into the risk/reward equation.
• Assess US health economics by identifying the major cost drivers in the healthcare system (hospital care; physician costs; drugs and other medical products).

• Formulate a basic understanding of the sources of health insurance coverage in the US, including the differences between government-based (Medicare/Medicaid) and commercial payers.

• Explain several evolving trends which have the potential to influence healthcare substantially in the future, including precision medicine, artificial intelligence, digital health, and value-based care.

G. Course Meeting Schedule.

Lectures: Tuesday/Thursday 3:00-4:15 PM; HAMP 2102
Presentation 1: TBD
Presentation 2: TBD
Final Report due: TBD

At the approximate mid-point of the semester, students will assemble into groups of 2-3 and choose a high-impact clinical condition to study. Each group will provide two progress updates (Presentations 1 and 2) during the course of the semester in lieu of formal examinations. A complete written summary of each group’s assessment (Final Report) will be due at semester’s end in lieu of a final examination.

H. Instructor Contact Information.

Professor William R. Clark – Email: clarkw@purdue.edu, Telephone: (765) 496-8647 (office); (317) 691-1438 (cell)
Office: FRNY 1055
Office Hours: TBD

I. Assessment of Course Outcomes. A weighted average grade will be calculated as follows.

Homework assignments (4): 20% of total
Presentations (2): 40% total
Final report: 40% of total

The grading scale will be as follows.

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

Note that students with grades within 3 weighted percentage points of either the upper or lower bounds of a grade range listed above will receive a “plus” or “minus” mark, respectively, after his/her score (e.g., scores between 75% and 78% of the total weighted points would earn an B–). Marks of an A– will not be given.

Group projects

Student groups may assess a high-impact clinical condition from the list of those discussed in class or another one (with instructor approval). In either case, each group should plan to meet with Professor Clark before beginning work on the project to set expectations. The assessment will include the clinical characteristics of the disorder along with its causes, demographics, and current treatment – these topics will be presented in Presentation 1. With Professor Clark or another engineering faculty member serving as a mentor, an unmet clinical need for the disorder will be identified along with an engineering-based solution for the problem – these considerations will be the focus of Presentation 2. For a particular disorder, the engineering approach can have a direct clinical effect (e.g., improved medical device treatment) or indirect clinical effect (e.g., novel manufacturing approach for pharmaceuticals).
**J. Course Schedule (subject to change)**

<table>
<thead>
<tr>
<th>Lecture</th>
<th>Topic</th>
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<tbody>
<tr>
<td>Lecture 1</td>
<td>Intro and US healthcare system overview</td>
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<tr>
<td>Lecture 2</td>
<td>Cardiovascular disease</td>
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<tr>
<td>Lecture 3</td>
<td>Obesity</td>
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<td>Lecture 4</td>
<td>Diabetes</td>
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<tr>
<td>Lecture 5</td>
<td>Kidney disease</td>
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<tr>
<td>Lecture 6</td>
<td><strong>Clinical case 1</strong></td>
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<tr>
<td>Lecture 7</td>
<td>Cancer</td>
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<td>Lecture 8</td>
<td>Arthritis and autoimmune disease</td>
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<td>Lecture 9</td>
<td>Neurologic disorders (Alzheimer’s disease and stroke)</td>
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<td>Lecture 10</td>
<td>Chronic liver disease</td>
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<td>Lecture 11</td>
<td>Critical care medicine (acute kidney injury and sepsis)</td>
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<tr>
<td>Lecture 12</td>
<td><strong>Clinical case 2</strong></td>
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<tr>
<td>Lecture 13</td>
<td>Biopharmaceutical industry (1)</td>
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<td>Lecture 14</td>
<td>Biopharmaceutical industry (2)</td>
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<tr>
<td>Lecture 15</td>
<td>Case study: Biopharmaceutical manufacturing*</td>
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<tr>
<td>Lecture 16</td>
<td>Case study: Drug discovery*</td>
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<td>Lecture 17</td>
<td>Medical device industry</td>
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<td>Lecture 18</td>
<td>Healthcare spending/financing</td>
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<td>Lecture 19</td>
<td>Health insurance</td>
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<td>Lecture 20</td>
<td>Case study: technology evolution in healthcare</td>
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<td>Lecture 21</td>
<td>Clinical research</td>
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<td>Lecture 22</td>
<td>Case study: medical device company*</td>
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<td>Lecture 23</td>
<td>Case study: healthcare entrepreneurship*</td>
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<td>Lecture 24</td>
<td>Case study: electronic medical record*</td>
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<td>Lecture 25</td>
<td>Emerging healthcare developments (1)</td>
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<td>Lecture 26</td>
<td>Emerging healthcare developments (2)</td>
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<td>Lecture 27</td>
<td>Health equity and access to care*</td>
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<td>COVID-19</td>
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<td>No class**</td>
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<tr>
<td>Lecture 30</td>
<td>No class**</td>
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*: guest lecturer

**: make-up for evening presentation session
ChE 59700-Energy Storage Systems Laboratory - Syllabus

INSTRUCTOR: Prof. Vilas G. Pol, 765-494-0044, vpol@purdue.edu
Theory: G124 TR / 2184 Experimental/Lab: FRNY 2184
PROF. OFFICE HOURS: Monday 10-11 am
TYPE OF COURSE: Elective

COURSE DESCRIPTION:

Energy Storage Systems Laboratory course is designed to introduce fundamentals of electrochemistry and electrochemical engineering of rechargeable lithium ion batteries (LIBs) to undergraduate and graduate students. The course will be reviewing working principles of LIBs, hands on experience on their assembly, charge-discharge testing, data analysis and related safety aspects. Strong emphasis will be given on the Li-ion battery technology, nanotechnology implementation and the materials design. Beyond conventional Li-ion systems and Pb-acid batteries, next generation Na-ion, K-ion and Li-S batteries will be discussed and designed. Students will be fabricating and testing high energy density batteries utilizing engineered electrodes, electrolytes and separators. Broader perspectives on sustainable, cost effective, longer lasting battery manufacturing will be provided.

MAJOR TOPICS COVERED:

- Introduction to Energy Storage Systems: Overview, definitions, history, market, theory, thermodynamics, kinetics 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 coin cell batteries and testing for rate capabilities and long cycle life
- 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.

This course will provide detailed understanding of battery science, technology and engineering background making next generation researchers ready to handle the upcoming challenges related to LIBs. Such background could provide job opportunities in numerous industries including Apple, Google, Tesla; national labs as well as faculty positions to create next generation scientific and advanced intellect. This course applies to various disciplines including MSE, Chemistry, ChE, ME, AAE, Physics, Technology and EE. Taking this advanced elective course on rechargeable batteries will not only provide theory background but also hands on experience to the undergraduate and graduate students.

The course assessment will be done by weekly homework, mid-term written exam, quizzes on hands on experience, scientific presentation and scientific reports preparation.
Instructor: Jeff Siirola, FRNY 1029A, 6-2125, jsiirola@purdue.edu or jjsiirola@gmail.com

Office Hours: Almost anytime; best to make appointment by email

Course Description:
This course traces the historical development of the chemical and related process industries and describes the principal products that are made and the evolution of the raw materials, chemistries, and processes by which they have been made. The scope includes natural products, inorganics, fuels, and commodity and specialty organics. The course also covers topics of current interest including the impacts of modern catalysis, computation, and systems engineering on process technology, issues of sustainability, resource conservation, environmental responsibility, product stewardship, and carbon management, and the likely impacts of recently more abundant and less expensive shale gas and oil on the chemical industry.

Course Content:
- History and structure of the chemical and allied process industries (1 week)
- Natural Products (animal and vegetable products; wood derivatives) (1 week)
- Inorganics (dehydration (calcining), reduction (smelting), bases and acids, commodities) (2 weeks)
- Fuels (fossil, petroleum refining, synthetic and biofuels) (1.5 weeks)
- Organics (wood and coal derivatives, basic building blocks, commodity intermediates and solvents, commodity monomers and polymers, plastics fibers and coatings, fine chemicals, biotechnology) (4 weeks)
- Technical Impact Factors (catalysis, computers, innovation) (1.5 weeks)
- Current Issues (environmental protection, health and safety, sustainability, carbon dioxide management, shale gas and oil) (3.5 weeks)

Tentative course schedule (subject to change):
- Tue 11 Jan Course introduction; scope of the chemical and allied process industries
- Thu 13 Jan Historical technology development (alchemy, chemistry, processes, unit operations, transport phenomena, process systems); historical milestones (brewing, soap, salt, smelting, soda ash, distillation, electrolysis, high pressure, continuous controlled processes)
- Tue 18 Jan Natural Products 1 - Animal and vegetable fiber, leather, oils, fats, waxes, gelatin, dairy products, food processing
- Thu 20 Jan Natural Products 2 - Pulp and paper, naval stores, resins, turpentine, rosin, rubber (Report 1 Due)
- Tue 25 Jan Inorganics 1 - Chemistry of dehydration/hydration: ceramic pottery, tile, and brick, glass, plaster, cement, mortar, and concrete
- Thu 27 Jan Inorganics 2 - Chemistry of reduction: ore smelting, iron and steel, silicon, copper, brass, bronze, aluminum
Tue 1 Feb  Inorganics 3 - Bases and acids: soda ash, caustic soda, lime, mineral acids (nitric, sulfuric, phosphoric, hydrochloric)
Thu 3 Feb  Inorganics 4 - Commodity inorganics: water, hydrogen, oxygen, nitrogen, chlorine, fertilizers (ammonia, phosphates, potash), titanium dioxide, carbon black, carbon dioxide, phosgene, hydrogen peroxide (Report 2 Due)
Tue 8 Feb  Fuels 1 - Wood, coal, petroleum (gasoline, diesel, jet fuel, fuel oil), LPG, natural gas
Thu 10 Feb  Fuels 2 - Natural gas processing, petroleum refining processes and products
Tue 15 Feb  Fuels 3 - Synthetic fuels: town gas, F-T, SNG, MTG, biofuels
Thu 17 Feb  Organics 1 - Wood and coal chemicals and materials (Report 3 Due)
Tue 22 Feb  Organics 2 - Basic building blocks: acetylene, olefins (ethylene, propylene, butadiene) aromatics (BTX, Styrene), carbon monoxide
Thu 24 Feb  Organics 3 - Commodity intermediates and solvents: alcohols glycols and phenols, aldehydes and ketones, acids, esters, ethers
Tue 1 Mar  Organics 4 - Commodity monomers and polymers (PE, PP, PS, PET, PC, SBR)
Thu 3 Mar  Organics 5 - Adhesives, coatings, films, fibers, plastics (Report 4 Due)
Tue 8 Mar  Possible No Class
Thu 10 Mar  Organics 6 - Fine chemicals: dyes pigments and cosmetics, flavors and fragrances, soap and detergents, explosives, agrichemicals, pharmaceuticals
14-18 Mar  Spring Break
Tue 22  Organics 6 continued
Thu 24 Mar  Organics 7 - Fermentation and biochemical processes; biotechnology (Report 5 Due)
Tue 29 Mar  Technical Impact Factor 1 - Homogeneous and heterogeneous catalysis
Thu 31 Mar  Technical Impact Factor 2 - Engineering and operational digital computation
Tue 5 Apr  Current Issues 1 - Environmental protection: air, wastewater, land; personnel protection: health and safety
Thu 7 Apr  Current Issues 2 - Loss prevention and process safety (Report 6 Due)
Tue 12 Apr  Current Issues 3 - Sustainability: triple bottom line, life cycle analysis, industrial ecology, green chemistry and engineering
Thu 14 Apr  Current Issues 4 - Sustainability: population and economic growth, raw materials; energy and water resources
Tue 19 Apr  No Class
Thu 21 Apr  Current Issues 5 - Climate change
Tue 26 Apr  Current Issues 6 - Carbon dioxide management, capture, and sequestration
Thu 28 Apr  Current Issues 7 - Impact of shale gas and oil (Report 7 Due; Bonus Report Due)

Homework Reports:
Report 1 - Industry Structure and Statistics (Due 20 January)
Report 2 - Reaction Path Synthesis: Solvay Process (Due 3 February)
Report 3 - Block Flow Diagram: Petroleum Refining (Due 17 February)
Report 4 - Process Supply Chain: Polyethylene Terephthalate (Due 3 March)
Report 5 - General Purpose Batch Processing: Fine Chemical Manufacture (Due 24 March)
Report 6 - Safety and Environmental Protection: Methyl Isocyanate (Due 7 April)
Report 7 - Sustainability: Carbon Management (Due 28 April)
Bonus Report: Process Narrative: Major Chemical Intermediate (Due 28 April)

Grading:
20% Attendance and class participation
80% Reports (Report 7 counts double)
Bonus Report: Up to +10 percentage points

Academic Honesty:
Students are individually responsible for each homework report. Cheating will not be tolerated. While discussions of homework among classmates are to be expected, students are responsible for submitting their own work. Copying the work of others, specifically including wholesale copying from electronic sources, is plagiarism and is considered a form of cheating.

Accommodation:
Purdue University strives to make learning experiences as assessable as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let the instructor know so that options may be discussed. You are also encouraged to contact the Disability Resource Center at drc@purdue.edu or by phone at 765-494-1247.

In addition to the University policy, the Davidson School of Chemical Engineering has established procedures for students seeking accommodations. These can be found online at the ChE Undergrad Office website. Only those accommodation requests that conform to both University and ChE policy guidelines will be implemented.

Protect Purdue:
The Protect Purdue Plan, which includes the Protect Purdue Pledge, is a campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center if you feel ill or know you have been exposed to the virus, wearing a mask in classrooms and campus buildings at all times, disinfecting workspace prior to and after use, maintaining proper physical distancing, and maintaining robust personal hygiene. Measures will be taken to provide alternative remote instructional experiences if the course had an on-line delivery option or if on-line delivery becomes mandated during the course of the semester.

References:
Kirk-Othmer Encyclopedia of Chemical Technology (5th Ed and On-line, Wiley)
Ullmann's Encyclopedia of Industrial Chemistry (5th Ed and On-line, Wiley)
Handbook of Chemical Technology and Pollution Control (Robert Myers, 3rd Ed, Elsevier)
Handbook of Petroleum Refining Processes (Martin Hocking, 2nd Ed, McGraw Hill)
**Additional Information:**
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. Here are ways to get information about changes in this course.

- Blackboard Learn website: [http://www.itap.purdue.edu/learning/tools/blackboard/](http://www.itap.purdue.edu/learning/tools/blackboard/) (Melissa – what is the equivalent site on Brightspace?)

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at drc@purdue.edu or by phone: 765-494-1247.

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Syllabus: Catalytic Industrial Processes

Instructor: Jeff Miller (mill1194@purdue.edu)

Short description: A survey course on the process design of major catalytic processes in the refining and petrochemical industries for production of transportation fuels and commodity chemicals.

Rationale: Energy in the form of natural gas, coal and oil are utilized to produce more than 80% of today’s energy. This course will discuss the current supply and demand of global energy production. Catalytic process are used primarily to produce transportation fuels and chemicals from petroleum. This course will discuss the chemical composition and specifications for fuels and chemicals and how these are produced at an industrial scale. The process design, catalyst composition and reaction chemistry of the major refining and petrochemical processes will be emphasized. Additionally, the latest catalyst characterization methods, research innovations and industry trends of these processes will be covered. This course is an elective that will benefit those seeking a chemistry or chemical engineering career in the energy and chemical industries.

Course Content

Energy Overview
- Overview of the major energy sources
- Estimates of the energy demand worldwide and regionally and how are these expected to change in the next 25-50 years
- Discussion of developing changes and opportunities in the energy sector

Transportation Fuels
- Molecular compositions of gasoline, diesel and jet fuels
- Overview of the fuel properties of molecular compounds in fuels
- Overview of the regulatory requirements for fuel compositions

Refining Technology Processes (Transportations Fuels Production)
- Overview of petroleum refinery and how these individual process are interconnected
- Overview of Naphtha Reforming, process, chemistry and catalysts
- Overview of Fluid Catalytic Cracking, process, chemistry and catalysts
  - In-depth discussion of zeolite fundamentals and catalytic properties
- Overview of Hydrotreating, process chemistry and catalysts

Auto-Exhaust and Emission Control Catalysts
- Overview of auto emission three-way catalysts
- Overview of diesel emission three-way catalysts
- Regulatory requirements for vehicle exhaust emissions

Petrochemical Processes (Chemical Feedstock Production)
- Overview of Propylene production, process, chemistry and catalysts
- Overview of Aromatics production, process, chemistry and catalysts
- Overview of Ethylene production, process and chemistry
Emerging Technology Developments
- Production of chemicals from biomass
- Production of fuels and chemicals from shale gas

Additional Topics: Catalyst Synthesis and Fundamentals
- Fundamentals of catalyst synthesis
- Commercial Catalyst manufacturing methods
- Single site alkane dehydrogenation catalysts
- Metal alloy catalysts
- Catalyst characterization by MAS NMR, TEM, X-ray spectroscopy, and others
  - Characterization under reaction conditions
- Invited lectures by leading industrial experts, generally senior managers, in 1-2 process technologies covered in this class

Learning Objectives:

1. Understand and analyze the historical, current and potential future roles that hydrocarbons play in the economy for energy, fuels, and chemicals.
2. Understand and compare the ways that energy is used in society, especially the breakdown between electricity/power and fuels. Understand the basic fuel properties of liquid transportation fuels (LPG/LNG, gasoline, diesel and jet).
3. Understand the regulatory requirements, technical specifications and molecular composition of fuels and chemicals.
4. Understand the major refining and petrochemical processes by which hydrocarbons are produced. Additionally, understand the reaction chemistry and role of the catalyst in these chemical transformations.
5. Understand the chemical principles and industrial processes for catalyst manufacture.
6. Understand the structure of the catalytically active site and methods for its determination.
7. Understand the future demands for fuels and chemicals and potential opportunities for changes to the current processes.
CHE 69700 Statistics Methods and Modeling for Chemical Engineers

Fall 2019

Class Times: Lectures Tues and Thurs 12:00-1:15, PHAR 164

Instructors: Kendall Thomson (Instructor)
Room 1152 Forney Hall
Tel: 496-6706
Office Hours: TBA
thomsonk@purdue.edu

Graduate Teaching Assistant:
Yah-Shu Huang, graduate student
huan1289@purdue.edu

Course Objective
Introduce the mathematical basis for statistical analysis and develop and apply statistical methods, including designing experiments and building models from experimental data for use in engineering and science research. This course is offered as part of the required graduate chemical engineering curriculum.


Software: During this class, students will utilize mathematical tools (Mat Lab, Mathematica, etc.)

Grading Policy: Homework Assignments 70 pts
Two 1 hour Exams 200 pts
Final Exam (Take home) 150 pts

Total 420 pts

Course Grading

Final grades for this class will be assigned using the +/- system (A+, A, A-, B+, B, etc...)
Homework:

Assignments will be handed out most Thursdays during lecture and are due in completed form in two weeks, on Thursday, beginning of lecture. Late homework will not be accepted. While you may find it helpful to discuss problem sets with one another, what you turn in must be your own work.

Course Topics (tentative):

- Measure theory, set theory, and probability theory
- Discrete and continuous random variable probability distributions
- Multivariate and joint probability distributions
- Elementary statistical inferences
- Single and multivariable analysis of variance
- Correlation, linear, non-linear, and multiple regression
- Maximum likelihood methods
- Sufficiency and optimal tests of hypotheses
- Bayesian statistics
  - Belief, probability and exchangeability
  - One-parameter models
  - Multi-parameter models
  - The normal model
  - Posterior approximation with the Gibbs sampler
  - The multivariate normal model
- Advanced Bayesian methods
Purdue University  
School of Chemical Engineering  

ChE 59700: Introduction to Chemical Engineering Mathematics  
Fall 2021

Instructors: Jim Caruthers (FRNY 2043C, caruther@ecn.purdue.edu)  
Administrative Assistant – Jason Thorp – FRNY 2043  
Virtual Office Hrs. Wednesday 2:30 via WebEx at 
purdue.webex.com/purdue/j.php?MTID=m13ce6f492e7afdb9d04340d8ca3867cf

TA: Veerupaksh Singla (he goes by Veeru)  
In-person recitation: Tuesday 4:30 – 5:20 pm in FRNY B124  
Virtual Office Hrs. time??? via WebEx at purdue.webex.com/???????

Class Format:  
The lecture materials have been recorded and are available on Brightspace under ChE597 Introduction to Engineering Mathematics. In addition, there will be an optional weekly help session on Tuesday from 4:30 to 5:20 in FRNY B124 that will be led by Veeru Singla. In addition, both Prof. Caruthers and Veeru Singla will have weekly office hours to answer questions.

Texts:  
1. The initial part of the course will be a review of pre-calculus and calculus material, where any textbook will cover the necessary material – you can use your old undergraduate text.  
2. “Elementary Differential Equations and Boundary Value Problems: 10th edition” W.E. Boyce and R.C. DiPrima, Wiley, NY, 2012. Any edition of this text from the 6th edition on is acceptable; however, homework problems will be from the 10th edition (i.e. the material has been the same in all editions).  

Supplemental Texts:  

Objectives  
The intent of this course is to introduce the mathematical methods that are needed to solve a variety of chemical engineering problems. There will be an initial review of topics in algebra, differential calculus, integral calculus and vector math – topics that have been previously taken as an undergraduate. The course will then introduce differential equations that are the basis for analysis of many engineering processes and the methods for solving those differential equations. Finally, matrices will be introduced to address engineering problems where there are two or more variables. At the end of the course one should be prepared to take additional courses in Engineering at the 500 or 600 level that use differential equations or linear algebra to quantify the physical/engineering processes being analyzed.
Organization

The course is organized with approximately two online lectures per week. The lectures are broken into several segments, where after each segment there are a number of short answer questions to ensure that you have learned the key points of each segment. The response to the short answer questions will make up a portion of the grade.

Homework problems will be assigned weekly. Homework constitutes an important part of the course and should be done conscientiously. Homework will be assigned each Monday and due to be submitted to Brightspace by 11:59 pm on the following Monday. NO LATE HOMEWORK WILL BE ACCEPTED. Any adjustments to the homework grades should be requested with the TA within one week after the homework is returned. Solutions for the homework will be posted on Brightspace.

Although the course will not focus on numerical methods, it is important to be able to numerically solve more complex problems. On every homework set their will be one or more problems that will require a numerical solution. You can use Mathematica, Matlab, Maple or any other software package you choose – I use Matlab, but that is a personal choice. In order to encourage use of the numerical packages, there will be an explicit part of the grade that will be for performance on this part of the homework. The operation of the numerical packages is your responsibility (the online documentation/tutorials for the various software packages is excellent) – we will not discuss software syntax in class or in office hours. You need to online references, your classmates and senior graduate students to learn the numerical package of your choice.

Group discussions concerning the homework are encouraged, since the sharing of ideas is an excellent way to learn. However, you should eventually develop your own solution. Experience has shown that if you do not develop your own solution to the homework, your performance on the exams will suffer.

Graded homework/exams will be distributed via Brightspace.

A lecture-by-lecture breakdown of the course is attached along with the required reading assignment. The reading assignment should be completed prior to coming to class in order obtain maximum education value from the lectures.

The final course grade will be weighted as follows:
2 - 1 hour examination 200 points
final examination 200 points
short anwer questions from lectures 50 points
weekly homework 100 points
numerical homework 50 points
TOTAL 600 points

The dates for the 2 one hour examinations will be given in the Lecture Schedule. THERE WILL BE NO MAKE-UP EXAMINATIONS. If a mistake has been made you should return your exam paper along with a written description of the error to myself within one week of the time the exam is returned. Any requests for regrades after the one week period following the return of the exam will not be accepted. We will regrade the whole exam, when you request a regrade; thus, your grade may go up or down.

There is a possibility that there may be a disruption during the semester if there is an outbreak of COVID, measles, bird flu, etc.. If the University closes for a period of time, we will continue ChE 530 through Brightspace, including communication via Brightspace. If there is a disruption I
except that each student will (i) take their textbooks and notes home and (ii) stay connected via your Purdue email account.

The highest standards of Academic Honesty are expected in CHE 530. You are expected to do your own work on all examinations. Any participation in an academically dishonest practice such a copying on exams, etc. will result in an F in CHE 530 as well as forwarding your case to the Dean of Students for appropriate disciplinary action.

CHE 530 Lecture Schedule – 2021

<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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<tbody>
<tr>
<td><strong>Part A: Pre-Calculus and Calculus Review</strong></td>
<td></td>
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</tr>
<tr>
<td>1 Aug. 24</td>
<td>ChE Mathematics - Introduction</td>
<td></td>
</tr>
<tr>
<td>2 Aug. 26</td>
<td>Algebra: single variable equations</td>
<td>Any algebra book</td>
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<tr>
<td>3 Aug. 31</td>
<td>Numerical solutions using MatLab</td>
<td>MatLab tutorial</td>
</tr>
<tr>
<td>4 Sept. 2</td>
<td>Differential calculus review</td>
<td>Undergrad text</td>
</tr>
<tr>
<td>5 Sept. 7</td>
<td>Partial differential calculus review</td>
<td>Undergrad text</td>
</tr>
<tr>
<td>6 Sept. 9</td>
<td>Integral calculus review</td>
<td>Undergrad text</td>
</tr>
<tr>
<td>7 Sept. 14</td>
<td>Vectors</td>
<td>BSL Appendix</td>
</tr>
<tr>
<td>8 Sept. 16</td>
<td>Review</td>
<td></td>
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</tbody>
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<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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<tbody>
<tr>
<td><strong>Exam 1: Time and location to be announced</strong></td>
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<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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<tbody>
<tr>
<td><strong>Part B: Ordinary Differential Equations</strong></td>
<td></td>
<td></td>
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<tr>
<td>0 Sept. 23</td>
<td>Why Study Differential Equations</td>
<td></td>
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<tr>
<td>1 Sept. 28</td>
<td>Classification of ODEs; 1st Order ODE – integrating factor</td>
<td>B&amp;D 2.1-2.4</td>
</tr>
<tr>
<td>2 Sept. 30</td>
<td>Separable and Exact ODEs</td>
<td>B&amp;D 2.5-2.7</td>
</tr>
<tr>
<td>3 Oct. 5</td>
<td>Introduction to numerical methods</td>
<td>B&amp;D 8.1-8.4</td>
</tr>
<tr>
<td>4 Oct. 7</td>
<td>1st Order Difference Equations</td>
<td>B&amp;D 2.9</td>
</tr>
<tr>
<td>5 Oct. 14</td>
<td>2nd Order ODEs: constant coefficients</td>
<td>B&amp;D 3.1-3.2</td>
</tr>
<tr>
<td>6 Oct. 19</td>
<td>2nd Order ODEs: Complex Roots</td>
<td>B&amp;D 3.3</td>
</tr>
<tr>
<td>7 Oct. 21</td>
<td>2nd Order ODEs: Repeated Roots</td>
<td>B&amp;D 3.4-3.5</td>
</tr>
<tr>
<td>8 Oct. 26</td>
<td>2nd Order ODEs: Undetermined Coefficients</td>
<td>B&amp;D 3.6</td>
</tr>
<tr>
<td>9 Oct. 28</td>
<td>Higher order ODEs</td>
<td>B&amp;D 4.1-4.3</td>
</tr>
<tr>
<td>10 Nov. 2</td>
<td>Series solutions; ordinary points</td>
<td>B&amp;D 5.1-5.2</td>
</tr>
<tr>
<td>11 Nov. 4</td>
<td>Series solutions; Regular singular Points; Euler equation</td>
<td>B&amp;D 5.4</td>
</tr>
<tr>
<td>12 Nov. 9</td>
<td>Bessel’s Equation</td>
<td>B&amp;D 5.7</td>
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<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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<tbody>
<tr>
<td><strong>Exam 2: Time and location to be announced</strong></td>
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<table>
<thead>
<tr>
<th>Date</th>
<th>Topic</th>
<th>Reading</th>
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</thead>
<tbody>
<tr>
<td><strong>Part C: Systems of 1st Order Differential Equations</strong></td>
<td></td>
<td></td>
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<tr>
<td>1 Nov. 18</td>
<td>Matrix operations</td>
<td>B&amp;D 7.1-7.2</td>
</tr>
<tr>
<td>2 Nov. 23</td>
<td>Vector Spaces and Simultaneous Equations</td>
<td>B&amp;D 7.3</td>
</tr>
<tr>
<td>3 Nov. 30</td>
<td>Eigenvalues and eigenvectors</td>
<td>B&amp;D 7.4-7.5</td>
</tr>
<tr>
<td>4 Dec. 2</td>
<td>Systems of 1st order linear ODEs</td>
<td>B&amp;D 7.6-7.7</td>
</tr>
<tr>
<td>5 Dec. 7</td>
<td>Numerical Methods for Systems of ODEs</td>
<td>B&amp;D 8.5</td>
</tr>
<tr>
<td>6 Dec. 9</td>
<td>Nonlinear Systems of 1st Order ODEs</td>
<td>B&amp;D 7.8 &amp; 7.9</td>
</tr>
</tbody>
</table>

Final Exam: In Scheduled Final Exam Period Dec. 13 to Dec. 18
Industrial Marketing Management  
Fall 2020, Module 2

Course Information

- Course number and title: CHE 59700 Industrial Marketing Management
- Meeting time: Class meets in FRNY G124 from 1.30 to 3.00, Monday, Wednesday and Friday from October 19 to December 4, 2020, Team presentations on December 2 and 4, 2020
- Course credit hours: **3 credit hours**
- Course information and materials will be available through the Brightspace page
- Prerequisites: none

Instructor(s) Contact Information

Cristina Farmus  
Office: DLR 203  
Phone: 765-494-0027 (office)  
Email: cfarmus@purdue.edu  
Office Hours: Wednesdays, from 12.00 to 1.00 via Zoom, or by arrangement of another time through email

Cristina Farmus is the Managing Director for the National Science Foundation Engineering Research Center for Innovative and Strategic Transformation of Alkane Resources (CISTAR), led by Purdue Chemical Engineering. She has over 15 years of experience managing finances and projects in the School of Chemical Engineering. She is also a Project Management Consultant for start-ups and small businesses. Cristina serves on the Board of Directors for Purdue Federal Credit Union. She has a BS in Commerce and Marketing from Transilvania University, Romania, and an MBA from Purdue’s Krannert School of Management, US.

William (Bill) Clark  
Office: FRNY 2158  
Phone: 317-691-1438 (cell)  
Email: clarkw@purdue.edu  
Office Hours: by appointment, please email

Dr. William Clark joined the Davidson School of Chemical Engineering in 2017 as a Visiting Professor and now serves as the Director of the Professional MS Program. He received his B.S. and M.S. degrees in chemical engineering from Purdue and his medical degree from Indiana University, where he also received post-graduate training in internal medicine and nephrology (kidney disease). He held a variety of positions at Baxter Healthcare and subsidiaries for 20 years, working exclusively in the dialysis field.
Course Description

Marketing is about identifying and meeting human and social needs. Marketing can also be defined as meeting needs profitably. Marketing management is the science and art of choosing target markets and getting, keeping, and growing customers through creating, delivering, and communicating superior customer value. This course will explore marketing concepts such as market, product, segmentation positioning, brand equity, wholesale distribution, logistics, business-to-business, marketing research, demand, and price settings, with the goal of helping company executives and managers make decisions. The perspective will be from that of an engineer in a business context. The course will review elements of a marketing strategy, culminating in preparing a marketing plan for an industrial product. The course will enable interaction with industry representatives with ample experience in industrial marketing and product management.

The class format will be delivery of a lecture covering a topic listed in the course schedule and ample discussion with the students. Students are expected to read the assigned chapters before each class and be active participants. For some classes, a guest speaker will give a presentation focused on an industrial topic that is relevant for marketing management.

Learning Resources, Technology & Texts

Required Texts
“Marketing Management” Phillip Kotler, Kevin Lane Keller, 15th edition

We will read approximately one chapter of the textbook for each class session and you will have to prepare reading reports and take quizzes based on the text. week (following the schedule below), and the in-class quizzes will be based on reading from the textbook. Other articles will be provided to you through Brightspace.

Brightspace Page
You can access the course via Brightspace. It is strongly suggested that you explore and become familiar not only with the site navigation, but with content and resources available for this course. See the Help tab for resources.

Live Instruction
The course will be offered live and recorded via BoilerCast. Recording will be made available via Brightspace approximately 24 hours after the lecture.

Learning Outcomes

1. Identify Marketing Management concepts such as market, product, marketing research, segmentation, positioning, brand equity, wholesale, logistics, business to business, demand, and price settings and understand how they contribute to decision making.
   Method of evaluation: quizzes, writing assignments
2. Demonstrate how Marketing Management is applied to industrial settings  
   Method of evaluation: prepare a Marketing Plan for an industrial product  
3. Describe how globalization, technology and social responsibility affect the  
   marketing strategy  
   Method of evaluation: written assignments  

Assignments and Grading Scale

The final grade will be based on:

- Written marketing plan 40% (400 points)
- Team presentation 30% (300 points)
- Reading assignments /quizzes, writing assignments 30% (300 points)

<table>
<thead>
<tr>
<th>Deadline</th>
<th>Assignment</th>
<th>Points</th>
</tr>
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<tbody>
<tr>
<td>23-Oct</td>
<td>CV, LinkedIn</td>
<td>50</td>
</tr>
<tr>
<td>23-Oct</td>
<td>Paper about Corporate Social Responsibility</td>
<td>50</td>
</tr>
<tr>
<td>30-Oct</td>
<td>Quiz on chapters 3-7 (open ended answers and multiple</td>
<td>50</td>
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<tr>
<td></td>
<td>choice)</td>
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<tr>
<td>2-Nov</td>
<td>Check point # 1 for marketing plan</td>
<td>20</td>
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<tr>
<td>6-Nov</td>
<td>Writing assignment for segmentation and targeting</td>
<td>50</td>
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<tr>
<td>13-Nov</td>
<td>Quiz chapters 11-14 (open ended answers and multiple</td>
<td>50</td>
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<tr>
<td></td>
<td>choice)</td>
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<tr>
<td>16-Nov</td>
<td>Check point # 2 for marketing plan</td>
<td>50</td>
</tr>
<tr>
<td>30-Nov</td>
<td>Writing assignment based on global markets</td>
<td>50</td>
</tr>
<tr>
<td>1-Dec</td>
<td>Marketing plan - written document</td>
<td>300</td>
</tr>
<tr>
<td>Dec 2, Dec 4</td>
<td>Marketing plan - virtual presentation and slides</td>
<td>300</td>
</tr>
<tr>
<td>4-Dec</td>
<td>Team and self evaluation</td>
<td>30</td>
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</tbody>
</table>

**Total possible points 1000**

Homework will be collected/uploaded to Brightspace as instructed. Most assignments will be due by Friday at 8.00 pm Eastern for the week when it was due.

A range: 90 – 100% of the weighted points  
B range: 80 – 89% of the weighted points  
C range: 65 – 79% of the weighted points  
D range: 50 – 64% of the weighted points  
F: Less than 50% of the weighted points  

For the team presentations, members of the class will be divided into groups of three – four people who will collaboratively work on a marketing plan. Each group’s work will prepare a written marketing plan that will be summarized in a team presentation to be given during
the last week of classes. More details about the expectations for the plan and presentations will be provided during the first weeks of class. Teamwork is an important element of the grade. Each student will have the opportunity to evaluate and to be evaluated by its peers. Even if a team earns the maximum grade for the report, if a teammate’s contribution is evaluated by its peers to be inadequate, that student will not earn the maximum grade.

The students are expected to read the chapters and articles assigned for every lecture. There will be regular quizzes and written assignments through Brightspace.

Missed or Late Work
All homework is expected to be completed and submitted on time. Late submissions will be penalized by 10% of the grade for each day it is late.

Academic dishonesty will result in a lower grade and lost trust from the instructors.

(New!) Academic Guidance in the Event a Student is Quarantined/Isolated
If you become quarantined or isolated at any point in time during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide you academic support during this time. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources around communicating with your instructors, be available for academic support, and offer suggestions for how to be successful when learning remotely. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and notify me via email or Brightspace. We will make arrangements based on your particular situation. The Office of the Dean of Students (odos@purdue.edu) is also available to support you should this situation occur.

Course Schedule

The course will start on October 19 and end on December 4. A separate document is available with the lecture schedule via Brightspace.

- October 19 – 1st lecture
- Nov. 25-28 – Thanksgiving Break
- (no classes – 25, 26, 27; University Holidays – 26, 27)
- December 2-4 – Team presentations
- Dec. 5 – Classes End
- Dec. 7-12 – Final Exams
- Dec. 13 – Commencement
- Dec. 15 – Grades Due

(New!) Attendance Policy during COVID-19

In the current context of the COVID-19 pandemic, the only reasonable approach this semester to attendance is that in-person meetings of a course cannot be a factor in final grades. This temporary interpretation will ensure that students are able to follow the
guidelines in the Protect Purdue Pledge. Most specifically, students must refrain from attending class if they are exhibiting any symptoms of COVID-19, are otherwise ill, or are quarantined or isolated.

Students should stay home and contact the Protect Purdue Health Center (496-INFO) if they feel ill, have any symptoms associated with COVID-19, or suspect they have been exposed to the virus. In the current context of COVID-19, in-person attendance will not be a factor in the final grades, but the student still needs to inform the instructor of any conflict that can be anticipated and will affect the submission of an assignment or the ability to take an exam. Only the instructor can excuse a student from a course requirement or responsibility. When conflicts can be anticipated, such as for many University-sponsored activities and religious observations, the student should inform the instructor of the situation as far in advance as possible. For unanticipated or emergency conflict, when advance notification to an instructor is not possible, the student should contact the instructor as soon as possible by email, through Brightspace, or by phone. 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, quarantine, or isolation, the student or the student’s representative should contact the Office of the Dean of Students via email or phone at 765-494-1747. Our course Brightspace includes a link on Attendance and Grief Absence policies under the University Policies menu.

(New!) Classroom Guidance Regarding Protect Purdue

The Protect Purdue Plan, which includes the Protect Purdue Pledge, is campus policy and as such all members of the Purdue community must comply with the required health and safety guidelines. Required behaviors in this class include: staying home and contacting the Protect Purdue Health Center (496-INFO) if you feel ill or know you have been exposed to the virus, properly wearing a mask in classrooms and campus building, at all times (e.g., mask covers nose and mouth, no eating/drinking in the classroom), disinfecting desk/workspace prior to and after use, maintaining appropriate social distancing with peers and instructors (including when entering/exiting classrooms), refraining from moving furniture, avoiding shared use of personal items, maintaining robust hygiene (e.g., handwashing, disposal of tissues) prior to, during and after class, and following all safety directions from the instructor.

Students who are not engaging in these behaviors (e.g., wearing a mask) will be offered the opportunity to comply. If non-compliance continues, possible results include instructors asking the student to leave class and instructors dismissing the whole class. Students who do not comply with the required health behaviors are violating the University Code of Conduct and will be reported to the Dean of Students Office with sanctions ranging from educational requirements to dismissal from the university.

Any student who has substantial reason to believe that another person in a campus room (e.g., classroom) is threatening the safety of others by not complying (e.g., not wearing a mask) may leave the room without consequence. The student is encouraged to report the
behavior to and discuss next steps with their instructor. Students also have the option of reporting the behavior to the Office of the Student Rights and Responsibilities. See also Purdue University Bill of Student Rights.

**Academic Integrity**

Academic integrity is one of the highest values that Purdue University holds. Individuals are encouraged to alert university officials to potential breaches of this value by either emailing integrity@purdue.edu or by calling 765-494-8778. While information may be submitted anonymously, the more information is submitted the greater the opportunity for the university to investigate the concern. More details are available on our course Brightspace table of contents, under University Policies.

**Nondiscrimination Statement**

A link to Purdue’s nondiscrimination policy is included in Brightspace and can also be found here.

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. More details are available on our course Brightspace table of contents, under University Policies.

**Accessibility**

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at: drc@purdue.edu or by phone: 765-494-1247. More details are available on our course Brightspace under Accessibility Information.

**Mental Health Statement**

If you find yourself beginning to feel some stress, anxiety and/or feeling slightly overwhelmed, try WellTrack. Sign in and find information and tools at your fingertips, available to you at any time.

If you need support and information about options and resources, please contact or see the Office of the Dean of Students. Call 765-494-1747. Hours of operation are M-F, 8 am- 5 pm.
If you find yourself struggling to find a healthy balance between academics, social life, stress, etc. sign up for free one-on-one virtual or in-person sessions with a Purdue Wellness Coach at RecWell. Student coaches can help you navigate through barriers and challenges toward your goals throughout the semester. Sign up is completely free and can be done on BoilerConnect. If you have any questions, please contact Purdue Wellness at evans240@purdue.edu.

If you’re struggling and need mental health services: Purdue University is committed to advancing the mental health and well-being of its students. If you or someone you know is feeling overwhelmed, depressed, and/or in need of mental health support, services are available. For help, such individuals should contact Counseling and Psychological Services (CAPS) at 765-494-6995 during and after hours, on weekends and holidays, or by going to the CAPS office of the second floor of the Purdue University Student Health Center (PUSH) during business hours.

Emergency Preparation

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 or TAs via email or phone. You are expected to read your @purdue.edu email on a frequent basis.

Related Considerations and Guidelines
1. If you experience any symptoms of COVID-19 or suspect you may have been exposed to someone with COVID-19 stay home and call the Protect Purdue Health Center at 765-496-INFO.
2. Keep your cell phone on to receive a Purdue ALERT text message.
3. Log into a Purdue computer connected to the network to receive any Desktop Popup Alerts.
4. If you have a “no cell phone” in class policy, allow one or two students who have signed up for Purdue ALERT to keep their phones on to receive any alerts.
5. A two-page supplement (see Appendix B) at the end of this document provides resources to communicate or engage with your students in case of unexpected emergencies that affect the West Lafayette campus. Emergency notification is vital! Please consider allowing one or more of the options below to ensure you are quickly notified of an emergency.
Appendix A - Guidelines for Academic Integrity

In a society that increasingly questions the value of higher education, upholding academic integrity takes on added significance. The time and effort necessary to champion high expectations of academic integrity are well understood, and the University is in full support of faculty and instructors who uphold these standards. Please consider these five steps for your class.

1. Define academic dishonesty for your class in your syllabus and emphasize it on the first day of class. The OSRR website offers a faculty guide on responding to academic dishonesty. Revisit your expectations at key junctures of the semester (e.g., before an exam or term project).

2. Provide greater clarity to students about what is acceptable and unacceptable. Some classes routinely use team assignments and encourage collaboration for projects, labs, or homework. Yet at other times of the term, students are expected to work independently. Be very clear about your expectations for each assignment.

3. Students should be told prior to—and as part of—the instructions on each test what is acceptable in terms of notes, phones, calculators, etc. From class to class our practices vary widely so, here again, it’s important to be very clear in your expectations.

4. Define penalties that will be enforced for academic dishonesty. One example might be:

   “Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor’s discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.”

5. At a minimum, if you penalize a student’s grade by deducting points, report the instance of scholastic dishonesty using the OSRR reporting form. Reporting all incidents helps to ensure consistent treatment both at the course level and across the institution. Staff members from OSRR are available to consult on an individual basis. Their office is in B50 of Schleman Hall, and their phone is 765-494-1250.

6. While faculty and instructors have raised concerns about student academic integrity, students have indicated that some instructors appear reluctant to uphold academic standards. Be clear in your syllabus on the steps you will take in your class to uphold academic integrity.
Appendix B: Emergency Preparedness Face-to-Face

1. Prior to the first day of class, obtain a copy of the building emergency plan for each building in which you will be teaching. Note the evacuation route and assembly area, as well as the shelter in place locations. BEPs are located on the Emergency Preparedness website.

2. On the first day of class, the following information is required to be presented to students:

   1) As we begin this semester, I want to take a few minutes and discuss emergency preparedness. While COVID-19 is currently a major focus of our campus health and safety preparations, we must also take time to be prepared for other possible emergencies as we would in any semester. Purdue University is a very safe campus and there is a low probability that a serious incident will occur here at Purdue. However, just as we receive a “safety briefing” each time we get on an aircraft, we want to emphasize our emergency procedures for evacuation and shelter-in-place incidents. Our preparedness will be critical IF an unexpected event occurs!

   2) Emergency preparedness is your personal responsibility. Purdue University is actively preparing for natural disasters or human-caused incidents with the ultimate goal of maintaining a safe and secure campus. Let’s review the following procedure:

   - For any emergency text or call 911.
   - There are more than 300 Emergency Telephones (aka blue lights) throughout campus that connect directly to the Purdue Police Department (PUPD). If you feel threatened or need help, push the button and you will be connected right away.
   - If we hear a fire alarm, we will immediately evacuate the building and proceed to the space between FRNY and MSEE. Do not use the elevator. Go over the evacuation route (see specific Building Emergency Plan).
   - If we are notified of a Shelter in Place requirement for a tornado warning we will stop classroom or research activities and shelter in the lowest level of this building away from windows and doors. Our preferred location is the FRNY basement.
   - If we are notified of a Shelter in Place requirement for a hazardous materials release, we will shelter in our classroom shutting any open doors and windows.
   - If we are notified of a Shelter in Place requirement for an active threat such as a shooting, we will shelter in a room that is securable preferably without windows. Our preferred location is G124.
This course will discuss the role that design plays in the chemical process industry and in particular the techniques for flowsheet alternatives generation that have found industrial applicability. Topics will include alternative paradigms for process synthesis, practical methods for heat exchanger network synthesis, systematic identification of designs which exploit distillation, azeotropic distillation, extractive distillation, extraction, reactive distillation, and related separation technologies, techniques for coordinating the specification of separation conditions in a way to minimize energy requirements and equipment costs, separation synthesis for mixtures with very nonideal solution thermodynamics, reaction network or supply chain network synthesis, and the interaction of process synthesis with control system synthesis.

Instructor:
Jeff Sirola
Office: FRNY 1029A
Email: jjsirola@gmail.com
Office Hours: Almost any time and by appointment

Course Topics:
The innovation process
Levels of detail and expectation
The design paradigm
Alternatives generation
Evolutionary modification approaches to process synthesis
Superstructure optimization approaches to process synthesis
Systematic generation approaches to process synthesis
Goal-oriented process synthesis (Means-Ends Analysis)
Emphasis on task
Hierarchical decomposition
Reaction path synthesis
Species allocation (input-output-recycle structure)
Task integration (multiple components)
Heat integration synthesis (various approaches)
Power integration
Combined heat and power (heat pumps)
Distillation scheme sequencing (algorithmic and heuristic)
Distillation task optimization
Heat-integrated distillation
Enhanced distillation (azeotropic, extractive, and reactive)
Standard separations patterns
Other separations synthesis
Task integration into equipment
Process intensification
Constraint-oriented process synthesis (Strategic Process Synthesis)
Residue curve theory
Residue curve applications in synthesis and analysis
Identification of critical features (constraints)
Interaction of strategic and opportunistic tasks
Synthesizing separation schemes for nonideal mixtures
Plant network synthesis
Interaction of process synthesis and plant-wide control scheme synthesis
Process synthesis implementation tools
Synthesis in other areas of the innovation process

Formal Textbook:  none

Grading:
10% Attendance and class participation
30% Homework
30% Quizzes
30% Term Project
Bonus Activities:  Up to +15 percentage points

Tentative Course Schedule:
Week of 22 Aug  Innovation process and design paradigm
Week of 29 Aug  Process synthesis introduction
Week of 5 Sep  Heat and power integration
Week of 12 Sep  Distillation sequences
Week of 19 Sep  Heat-integrated distillation
Week of 26 Sep  Enhanced distillation
Week of 3 Oct  Process intensification
Week of 10 Oct  Constraint-oriented process synthesis
Week of 17 Oct  Azeotropic and extractive distillation
Week of 24 Oct  Strategic process synthesis
Week of 31 Oct  Process synthesis implementation
Week of 7 Nov  Plant network synthesis
Week of 14 Nov  AIChE ANNUAL MEETING
Week of 21 Nov  Interaction of process design and control
Week of 28 Nov  Chemical product design
Week of 5 Dec  Outlook and challenges
The critical importance of Chemical Process Safety is widely recognized after many significant world-wide industrial incidents, such as the fertilizer explosion in Beirut last year, the Deepwater Horizon oil spill in the Gulf of Mexico, and numerous incidents in the last few years claiming lives, harming the environment, with significant loss of property. All aspects of chemical process safety and loss prevention are addressed in this course. Process safety is concerned primarily with the identification of potential hazards and risks associated with equipment and chemical processing across a variety of industries including oil, gas and chemicals, as well as pharmaceuticals, agriculture, etc. It includes methods for predicting the possible severity of incident scenarios and preventing or mitigating them. The material is thus different from personnel safety, which addresses slips, trips and falls.

As such, it is necessary to understand the operation of these processes and equipment, and to apply sound engineering fundamentals to the analysis and prediction of performance, under adverse circumstances. Thus, the course emphasizes quantitative engineering analysis, and in a broader context critical thinking, complex reasoning and written communication. This is based on the application of mass and energy balances, fluid mechanics of liquid / gas / two-phase flow, heat transfer and the conservation of energy, mass transfer, reaction kinetics, process control, and diffusion & dispersion under highly variable conditions.

Techniques for performing process hazard analysis, risk assessment, and accident investigations are covered, including the review of numerous significant industrial incidents. The course topics follow those in the text: Daniel A. Crowl and Joseph F. Louvar, ‘Chemical Process Safety: Fundamentals with Applications’, Prentice Hall (4th edition), which will be supplemented with other pertinent materials, such as videos of incident investigations by the US Chemical Safety Board. All students will perform an incident investigation of a significant industrial incident. CHE 597 graduate students have additional homework problems and a research project with a written report.

Course Materials / Lectures: Pertinent class materials will be posted on Brightspace. Students are encouraged to use the Discussion feature under Course Tools to communicate among each other, the professor and TAs as to questions, etc.

Teams: Students will be grouped into teams of ~3 by the CATME system, and work on homework assignments and project(s) as a team. Every student will submit homework, which will not be identical among teammates. The purpose of working in teams is not to ‘spread the work around’ but to capture the synergies of teamwork, benefiting from each member’s perspective. Team members will periodically evaluate each other in terms of their contribution to homework and team project(s), which will be reflected in course grades.
Homework: Homework will generally be assigned each week and **due at noon ET on Friday's**. Late homework will **not** be accepted, except with prior approval. Homework will be submitted, graded and solutions posted on Brightspace. Copying from a Solutions Manual or classmates will not be tolerated, with a zero given on homework assignments for infractions.

Attendance: Class attendance is important. Class participation is encouraged, material will be covered in class beyond the text, including several videos and there will be unannounced quizzes. Notify the instructor in **advance** for all excused absences (e.g., employment interviews).

Incident Investigation: Each team will investigate a major incident and prepare a report (selected from a list of incidents provided or another of their choice). Topics will be distributed during the 3rd week of class, teams will submit their top three choices by September 15, with the final topic confirmed by the Instructor on September 20. The report will be due on October 25. Grading of the report is based on the written report and teammate evaluations of individual contributions.

Project: **For 597 students only.** Each team will prepare a research project (selected from a list of topics provided or another of their choice) and submit a formal report. Topics will be distributed the 6th week of class, teams will submit their top three topics by October 6, with the final topic confirmed by the Instructor on October 13. An abstract is due on November 3 and the report due on December 1, both electronically and as a hard copy. Grading of the project is based on the abstract, written report, and teammate evaluations.

Exams & Quizzes: There will be three exams and three quizzes during the term, with the last during the scheduled final exam. **All exams will be open-book and thus it is imperative that each student have access to a hard copy of the text (no xeroxed copies).** Exam III will not be comprehensive. Missing a quiz / exam results in a zero, unless arrangements were made with the Instructor in advance. Regrade requests for exams / quizzes and homework should be made to the party who did the initial grading, the TAs for the former and Graders for the latter. Any such requests must be made within two weeks of the posting of the graded work product in Brightspace.

### Grading Criteria:

<table>
<thead>
<tr>
<th></th>
<th>CHE 420</th>
<th>CHE 597</th>
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</thead>
<tbody>
<tr>
<td>Homework</td>
<td>20%</td>
<td>20%</td>
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<tr>
<td>Incident Investigation</td>
<td>15%</td>
<td>10%</td>
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<tr>
<td>Project Report</td>
<td>0%</td>
<td>10%</td>
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<tr>
<td>Quizzes</td>
<td>10%</td>
<td>5%</td>
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<tr>
<td>Exams</td>
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**Grades:**

- 90-100 A
- 80-89 B
- 70-79 C
- 60-69 D
- <60 F

Grading may also include +/- for each grade level.
Support: Professor Ray Mentzer (rmentzer@purdue.edu)

TAs – tbd
Graders – tbd

The TAs will conduct two one-hour weekly help sessions.

NOTICES:
• Accommodations - Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at drc@purdue.edu or by phone: 765-494-1247.
• In the event of COVID quarantine - if you become quarantined due to COVID during the semester, in addition to support from the Protect Purdue Health Center, you will also have access to an Academic Case Manager who can provide academic support. Your Academic Case Manager can be reached at acmq@purdue.edu and will provide you with general guidelines/resources. Importantly, if you find yourself too sick to progress in the course, notify your academic case manager and the instructor via email.
• It is tantamount that students reflect on and adhere to the Purdue Honors Pledge, “As a Boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue.” Integrity / ethics violations such as plagiarism, copying from others work, or use of unauthorized online services (e.g., Chegg) will not be tolerated. Penalties include up to a failing grade and notifying the Dean of Students.

CHE 420 / 597 Chemical Process Safety (Fall, 2022)

Course Schedule

<table>
<thead>
<tr>
<th>Date</th>
<th>Topics</th>
<th>Note</th>
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<tbody>
<tr>
<td>August</td>
<td>Wk1a-8/23 Why study process safety? Syllabus &amp; Chapter 1</td>
<td>Piper Alpha video</td>
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<td></td>
<td>Wk1b – 8/25 Chapter 1. Introduction – cont’d</td>
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<td></td>
<td>Wk2a-8/30 Chapter 1. Regulations &amp; Mgmt Systems</td>
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<td></td>
<td>Wk2b -9/1 Teamwork</td>
<td>Fatal Exposure – DuPont video</td>
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<td></td>
<td>Wk3a-9/6 Chapter 2. Toxicology</td>
<td>Quiz 1</td>
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<tr>
<td></td>
<td>Wk3b – 9/8 Chapter 2. Toxicology &amp; Incident Investigations</td>
<td>Incident investigation project introduced; Bhopal</td>
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<td></td>
<td>Wk4a-9/13 Chapter 3. Industrial Hygiene</td>
<td>Acknowledge team member evaluation with hwk</td>
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<tr>
<td></td>
<td>Wk4b – 9/15 Chapter 4. Source Models - I</td>
<td>Teams select incidents; BP TX City video</td>
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<tr>
<td></td>
<td>Wk5a-9/20 Chapter 4. Source Models – II</td>
<td>Instructor confirms projects</td>
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<td></td>
<td>Wk5b – 9/22 Exam I</td>
<td></td>
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<tr>
<td></td>
<td>Wk6a-9/27 Chapter 5. Toxic Release &amp; Dispersion Models</td>
<td>Blast Waves in Danvers video; 597 Project topics distributed</td>
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<td></td>
<td>Wk6b – 9/29 Chapter 5. Toxic Releases – cont’d</td>
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<td></td>
<td>Wk7a-10/4 Chapter 6. Fires &amp; Explosions - I</td>
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<tr>
<td>Week</td>
<td>Date</td>
<td>Chapter/Activity</td>
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<td>October</td>
<td>Wk7b – 10/6</td>
<td>Chapter 6. Fires &amp; Explosions – II</td>
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<td>Wk8a-10/13</td>
<td>Chapter 7. Designs to Prevent Fires &amp; Explosions</td>
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<tr>
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<td>Wk 9a– 10/18</td>
<td>Chapter 7. Designs to Prevent Fires &amp; Explosions – cont’d</td>
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<td>Wk9b-10/20</td>
<td>Chapter 8. Chemical Reactivity</td>
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<td>Wk10a-10/25</td>
<td>Safe Designs &amp; Operations</td>
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<td></td>
<td>Wk10b-10/27</td>
<td>Safe Designs &amp; Operations – cont’d</td>
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<td>Wk11a – 11/1</td>
<td>Exam II</td>
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<td>Wk11b-11/3</td>
<td>Chapter 9. Intro to Reliefs</td>
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<td>Wk12a – 11/8</td>
<td>Chapter 10. Relief Sizing</td>
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<td>Wk12b-11/10</td>
<td>Chapter 11. Hazards Identification – I</td>
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<td>Wk13a- 11/15</td>
<td>Chapter 11. Hazards Identification – II</td>
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<td>Wk13b-11/17</td>
<td>Chapter 11. Hazards ID – II – cont’d</td>
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<td>Wk14a- 11/22</td>
<td>Thanksgiving Break</td>
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<td>Wk14a- 11/22</td>
<td>Chapter 12. Risk Assessment</td>
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<td>Wk15a-11/29</td>
<td>Chapter 12. Risk Assess. – cont’d</td>
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<tr>
<td>November</td>
<td>Wk15b-12/1</td>
<td>Chapter 12. Risk Assess. – cont’d</td>
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<tr>
<td></td>
<td>Wk16a – 12/6</td>
<td>Chapter 12. Risk Assess. – cont’d</td>
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<td></td>
<td>Wk16b – 12/8</td>
<td>Emergency Response</td>
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### ABET Syllabus

1. **CHE 42000: Process Safety Management and Analysis**

2. **Credits and contact hours:**
   - 3 credits
   - Lecture – taught virtually due to COVID; equivalent of 3 days per week at 50 minutes each for 15 weeks

3. **Instructor’s or course coordinator’s name:** Professor Ray Mentzer

4. **Textbook(s):**

5. **Specific course information**
   - **Catalog description:** Develop knowledge of process safety management and analysis in the process industries – including hazard identification, hazard analysis and risk management.
   - **Prerequisites:** CHE 34800, 37800 (both concurrent)
c. **Course Status:** Required

6. **Specific goals for the course**
   a. **Specific outcomes of instruction**
      - Demonstrate knowledge and understanding of the elements of process safety management (→45000)
      - Apply the techniques, analytical skills, and modern computational tools necessary for performing process safety calculations in the design of safety equipment (20500, 21100, 34800, 37700, 37800→); (→45000)
      - Demonstrate an understanding and appreciation of the need for professional integrity and ethical decision making to promote safety in the workplace (20000, 30000, 40000→); (→45000)
      - Be able to pro-actively identify and analyze safety hazards (→45000)
      - Demonstrate an understanding of the detrimental effects of the unsafe operation of chemical facilities on environmental, health, and safety issues and other public interests. Our graduates will be aware of the wide-reaching effects that engineering decisions have on society, our global community and our natural environment (20000, 30000, 34800, 37700, 37800, 40000→); (→45000)
      - Demonstrate knowledge and understanding of risk management tools, programs and processes associated with process safety. (→45000)

   b. **Student outcomes addressed by the course:**
      1) Apply principles of engineering, science, and mathematics to solve complex chemical engineering problems.
      2) Apply engineering design to produce solutions that meet specified needs with consideration of public health, safety, and welfare, as well as global, cultural, social, environmental, and economic factors.
      4) Recognize ethical and professional responsibilities in chemical engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts.
      7) Acquire and apply new knowledge as needed, using appropriate learning strategies.

7. **Topics**
   Process Safety Management and Hazard Identification
      Regulations – 29 CFR 1910.119
      People, Technology, Facilities
      Management/Leadership, Required Management Systems
   Analysis of Hazards
      Numerous Case Studies: Piper Alpha, Bhopal, BP TX City, Imperial Sugar, T2 Laboratories, West Explosion, ...
      What If, Checklist, Hazard and Operability (HAZOP) Study
      Hazard vs. Risk, Qualitative & Quantitative Risk Assessment
      Failure Mode and Effect Analysis
      Fault Tree Analysis
   Risk Management
      Safety Culture
      Regulations and Audits, Ethics and Safety
      Operating Procedures, Safe Work Practices
Asset Integrity
Training, Management of Change
Contractor Management
Operations: Start-up/Shutdown/Unsteady State
Emergency Management
Incident Investigation

Process Safety Calculations and Design
Toxicology and Industrial Hygiene
Liquid & Gas Source Models
Toxic Releases & Dispersion Modeling
Flammability and Explosions & Designs for Prevention
Chemical Reactivity
Sizing Relief Valves
Knockout Drums & Flares

6-1-22
This course is required for all seniors in the Davidson School of Chemical Engineering, and is taught each fall at Purdue. Open to Masters and PhD students, the course addresses how to prevent industrial incidents that can result in significant loss of life, environmental, and facility damage. Several case studies are reviewed and analyzed, in a variety of industries, which form the basis for many industry best practices and regulations. Few universities offer this course, and many companies value those who have completed it. The instructor, Dr. Ray Mentzer, has over 30 years of industry experience, with expertise in process safety.

The comprehensive course addresses:

- How does one design and operate a facility safely in a variety of industries?
- How does one reduce the chance for fires, explosions, runaway reactions and toxic releases?
- What regulations exist to foster safe operations?
- How does one conduct hazard and risk analyses?

The Davidson School of Chemical Engineering is well-grounded in process safety with its Purdue Process Safety & Assurance Center (P2SAC) conducting research. Dr. Mentzer serves as Associate Director. Students funded by the Center are encouraged to enroll. Professional Master’s Students will benefit from this training, since typically 1/3 of the summer research projects are process safety related and mentored by P2SAC industry sponsors.

DO YOU WANT TO KNOW MORE?

Dr. Ray Mentzer
rmentzer@purdue.edu
Forney Hall of Chemical Engineering 3019
(936) 443-5579
Fall 2020
CHE 59700 – Advanced Solar Conversion

T/TH 10:30 AM – 11:45 AM
Remote | WebEx or Zoom

Instructor: Dr. Rakesh Agrawal
Office: FRNY, RM 3053D
Email: agrawalr@purdue.edu

TA: Aaron B. Woeppel
Email: awoeppel@purdue.edu

Melissa LaGuire
NRT Program Coordinator
Email: mlaguire@purdue.edu

Recommended Books: There is no textbook for this course, but following are recommended as references.


Both books are available in the Reserve Section of the Potter Engineering Library. Although, not essential, it may like to own one of the books, preferably the one by Nelson.

Homework and Exams: The following weightages assigned to homework and exams:

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<table>
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<tbody>
<tr>
<td>Homework</td>
<td>30%</td>
</tr>
<tr>
<td>Exam 1</td>
<td>35%</td>
</tr>
<tr>
<td>Exam 2</td>
<td>35%</td>
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</tbody>
</table>

In order to master the course, it is essential that you do all the home works in a timely manner. Since the course is being offered remotely, please email your home work to Aaron Woeppel in a timely manner- generally on the due date before the class lecture.

Homework Policy:  
For the first homework that is less than one day late, 30% mark will be deducted. For the second homework that is less than one day late, 50% mark will be deducted. For any other late homework, no credit will be given.

Important Dates:
Exam 1 – Thursday 8th October
Exam 2 – Thursday 19th November

All the exams will be during the lecture period. Final grading for the course will be done using letter grades A, B, C, D and F.
**Makeup Classes:**
Please be aware there is a possibility of makeup classes for this course. The dates and times will be announced in advance if necessary.

**BrightSpace:** You can access the course via Brightspace. It is strongly suggested that you explore and become familiar not only with the site navigation, but with content and resources available for this course.

**Guidelines for Academic Integrity:**
All students will conduct according to Purdue’s Honor Pledge ([https://www.purdue.edu/provost/teachinglearning/honor-pledge.html](https://www.purdue.edu/provost/teachinglearning/honor-pledge.html)): “As a boilermaker pursuing academic excellence, I pledge to be honest and true in all that I do. Accountable together - we are Purdue.” Every student will sign this pledge in their first homework assignment, each exam and project report.

While Students are encouraged to discuss homework problems with each other, the submitted work must be work of the individual and no copying is allowed.

We will enforce the penalty if a student is caught cheating as proposed by Purdue:

“Incidents of academic misconduct in this course will be addressed by the course instructor and referred to the Office of Student Rights and Responsibilities (OSRR) for review at the university level. Any violation of course policies as it relates to academic integrity will result minimally in a failing or zero grade for that particular assignment, and at the instructor’s discretion may result in a failing grade for the course. In addition, all incidents of academic misconduct will be forwarded to OSRR, where university penalties, including removal from the university, may be considered.”

**Expected Conduct in the Class:**
Avoid being late to the lectures (even though it is remote). Be attentive during lectures. It is encouraged to ask clarifying questions during lecture.

**Covered Topics:** The following major topics will be covered in the lectures:
1. Solar Radiation
   a. Thermal radiation from a black body – Planck’s law
   b. Thermal radiation from Sun on an area on Earth
   c. Solar radiation through Earth’s atmosphere

2. Thermodynamic Efficiency of Solar Energy Recovery as work

3. Solar Thermal Power
   a. Concentrating Solar Power
   b. Advantages and disadvantages for solar thermal

4. General Introduction to Solid State Solar Cells
   a. Concept of a diode

5. Electrons and Holes in Semiconductors
   a. Brief Review of the Physical Structure of Solids
   b. Energy bands in Solids
   c. Brief Introduction to quantum mechanics
   d. Density of energy states for free electrons in a box
   e. Density states for a 3D body
   f. Fermi-Dirac distribution function (Fermi function)
   g. Electron in a periodic potential – Origin of band diagrams
   h. Concept of holes in valence band

6. Intrinsic and Extrinsic Semiconductors
   a. Electron and hole concentrations in intrinsic semiconductors
   b. n & p type extrinsic semiconductors

7. Charge transport in a semiconductor
   a. Charge neutrality relationship
   b. Mobility of electron and holes in an electric field – drift current
   c. Diffusion current
   d. Einstein relationship relating diffusion coefficient and mobility
   e. Nonequilibrium semiconductor – quasiFermi levels
   f. Charge separation and collection – charge separation under illumination

8. Generation and recombination in semiconductors

9. p-n junction in the absence of light
   a. Internal electric field in a homo p-n junction
   b. Calculation of built in potential
   c. Width of space charge region under forward or reverse bias
   d. Transport equations for the p-n junction
   e. Saturation current and diode factor
   f. Performance of thin p-n diodes

10. Solar Cells – p-n junction under illumination
    a. Governing equations for p-n junction under light illumination
    b. Dimensionless parameters for assessing solar cell performance

11. Different Solar Cell Structures – Advantages and Limitations
    a. Silicon solar cells
    b. Thin film inorganic solar cells – CdTe/CdS, CIGS/CdS etc.
    c. Organic solar cells
    d. Solar modules and the balance of systems

12. General Discussion on the Future of Solar Cells
    a. Interdisciplinary nature of solar cells
    b. Cost and efficiency issues
Additional Information:

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. Here are ways to get information about changes in this course.

- **Blackboard Learn website:** [http://www.itap.purdue.edu/learning/tools/blackboard/](http://www.itap.purdue.edu/learning/tools/blackboard/) (Melissa – what is the equivalent site on Brightspace?)

Purdue University strives to make learning experiences as accessible as possible. If you anticipate or experience physical or academic barriers based on disability, you are welcome to let me know so that we can discuss options. You are also encouraged to contact the Disability Resource Center at [drc@purdue.edu](mailto:drc@purdue.edu) or by phone: 765-494-1247.

In addition to the University policy, the Davidson School of Chemical Engineering has established procedures for students seeking accommodations. These can be found online at the ChE Undergrad Office website. Only those accommodation requests that conform to both University and ChE policy guidelines will be implemented.