**ABE 557: BIOLOGICAL & FOOD PROCESSING UNIT OPERATIONS**

**Fall 2018**

**INSTRUCTOR**: Martin R. Okos/

Office: FS 1171 Phone: 494-1211 E-mail: [okos@purdue.edu](mailto:okos@purdue.edu)

TA: Troy Tonner, Alyssa Christoffer

Email:Troy Tonner [tonner@purdue.edu](mailto:tonner@purdue.edu) 'Alyssa Shirley Christoffer' [christ65@purdue.edu](mailto:christ65@purdue.edu)

Office: NLSN3199

Lab support Coleen Riley, [riley21@purdue.edu](mailto:riley21@purdue.edu)

Office Hours: By appointment,

**LECTURE/lab**: Tu/Thu 2:30-3:30pm Smith 118

3:30-5:30pm Smith 108/NLSN 1195

2:30-5:30pm Lilly 2-400 (computer room)

**REQUIRED** **TEXTS:**

1. Geankoplis, C.J. 2003. "Transport Processes and Separation Process Principles," 4th Ed., Prentice Hall, Englewood Cliffs, NJ.
2. Peters, Timerhaus and West 2003 Plant Design and Economics for Chemical Engineers 5th Ed McGraw Hill.

**Supplimentary text:**

1. Cussler and Moggridge 2011 “Chemical Product Design” 2nd edition Cambridge University Press.
2. Maloney 2008 “Perry’s Chemical Engineers’ Handbook” 8th edition McGraw-Hill
3. Rhodes 2008 “Introduction to Particle Technology” 2nd edition Wiley
4. Shuler and Kargi 2002 “Bioprocess Engineering” 2nd edition Prentice Hall

NOTE: TA will allow students to borrow the above texts for short periods of time. Please use library copies whenever possible.

**COURSE OBJECTIVES:**

The emphasis of the course is on overall process design and the integration of transport operation principles and design concepts addressed in previous courses. More specifically, students are to come away from this course with:

1. An understanding of the principles and design/scale-up aspects of various unit operations and processes utilized by the biological and food process industries
2. Develop self learning techniques to acquire new knowledge for life long learning
3. A capacity to apply scale-up principles for the development of typical industrial processes,
4. Develop unit operation designs that account for the effect of process variables when producing a high quality, cost effective and safe product using the minimun of resourses.
5. An ability to communicate technical information effectively,
6. Improved computer skills
7. A facility to work in teams
8. Develop a experimental design and develop experimental protocol.
9. Evaluate ethical, global,and societal contemporary issues

**COURSE STRUCTURE& GRADING POLICY:**

This course will consist of a lecture, which will include homework and design projects, and a lab, which will include a team project and your senior design project. Your grade will be determined in the following manner:

Algorithm/Designs 35%

Term Project Design 30%

Homework 10%

Exams/Quizzes: 25%

**The following are some important guidelines for all submissions:**

1. **ALL** assignments **MUST** be submitted for students to receive a grade in the course. ***Students will receive an “incomplete” for the course if they fail to submit assignments via Blackboard by the Tuesday of finals week. Assignments submitted without work are considered incomplete.***
2. Do not just submit numbers and code without any explanation. Each assignment must be accompanied by an executive summary providing a step by step outline with equations, sample calculations and results for each major step, Each report will include the overall process and final results/conclusions from the assignment
3. Include all code or calculations with each assignment in a form that can be run.
4. Submit all assignments in .pdf format on Blackboard.
5. Working with others is encouraged, but do your own work. The grade for an assignment that appears the same will divided by the number of similar submissions. Cheating will not be tolerated. Students will receive a ‘0’ for every assignment where cheating is found. If it happens more than once, further action will be taken and it could lead to a failing grade in the course.
6. Finally, cite your sources! Even within your code, make sure to properly cite your equations.

Industrial Roundtable Sep 10-12. 2018 Purdue University.

Required Trip Pack Expo Oct 14-17 2018 McCormick Place Chicago – - The PACK EXPO brand represents a quality trade show experience that focuses on packaging and processing innovation while bringing together a wide range of industries. PACK EXPO trade shows continue to stay on the cutting edge of industry trends and answer demand for innovations in various industries.

See more at: <https://www.packexpointernational.com/overview>

**COURSE DESCRIPTION AND POLICIES:**

***Designs*:** The purpose of this part of the course is to provide students with an op­portunity to develop the ability to apply unit operation principles to the design of industrial pro­cesses. Process designs will be completed in the areas of drying, fermentation and separation processes. It is preferred that students use MATLAB. The results of each design will be submitted through an executive summary and include the design calculations must be provide in a detailed step-by-step manner, completed with full equations, sample calculations with labeled variables with units.

***Senior Design Project:*** Each group will select a product/process for design of a student operated business. The goal of this part of the course is to simulate a typical industrial process development and manufacturing environment focusing on evaluating specific ethical, global,and societal contemporary issues. It is expected that each group will (in essence) be­come an “expert” in the manufacture of a particular food, biochemical, or pharmaceutical product by drawing on all skills and knowledge acquired through BE course work.

The goal is not only to design the process analytically but also experimentally produce the product in a laboratory setting. Limited funds are available to materials and equipment. Purchase requests must be be made early in the semester and approved by instructors/TAs (Okos, Riley, Toner, Christoffer) before purchase.

Organizational, tech­nical writing, presentation, leadership, and interpersonal skills will be emphasized. The project will be continued in ABE 558 next semester as part of the capstone experience. If a group chooses to enter a design contest such as the Soybean/Corn contest with a topic related to the ABE 557/558 project, both must be viewed as totally separate projects. Each group will develop an algorithm of their process in MATLAB that is fully commented with contributions from each group member regarding their unit operation.

Literature review example: [**Chemical Engineering and Processing - Process Intensification**](http://rt1-t.notifications.elsevier.com/r/?id=h65a9bc8,5532ffb,5533001&p1=www.sciencedirect.com/science/journal/02552701&dgcid=raven_sd_via_email)

<https://www.sciencedirect.com/journal/chemical-engineering-and-processing-process-intensification>

***Homework/Quizzes /Exams*:** The primary aim of the lectures is to give students the background for developing a process design algorithm/model; fundamental aspects and design equations are covered in the lectures. The effect of various pro­cesses on quality, the most important aspect of biological systems, is emphasized in the lectures. Homework will be assigned to ensure that the students understand the basic principles behind unit process design. The exams will test the student’s understanding of the principles.

**ADMINISTRATIVE POLICY:**

All assignment are to be turned in to the instructor by 11:59 pm on the day it is due. Late homework will be reduced 10% (of assigned point value) per week day, extensions will be handled on an in­dividual basis. No credit will be given after two weeks, but it will be accepted for review until the Tuesday of finals week to obtain a grade in ABE 557. Don’t put off doing the assignments! Doing the assignments at the very end doesn’t help you understand the concepts when you need them. Working with others is encouraged, but do your own work. The grade for an assignment that appears the same will divided by the number of similar submissions. Cheating will not be tolerated. Any work deemed very similar to any current or previous solutions will not be tolerated and may result in an F grade for the course.

**2018 TENTATIVE COURSE OUTLINE:** subject to change with notice

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Week | Discussion Topic | Reading/Homework | Lab/design | Assignments |
| 1  8/21-23 | Fermentation | Handout | Fermenter Design | Group Assignments |
| 2  8/28-30 | Fermentation | Handout  PTW Ch 13 | Semester Project Mtg |  |
| 3  9/4-6 | Unsteady Heat/Mass Trans | Geankoplis  Ch. 5 and 9 | Quiz | Fermentation Hwk Sep 3  Model discussion NLSN 1195 |
| 4  9/11-13 | IR  Unsteady Heat/Mass Trans | Geankoplis  Ch. 5 and 9 | Literature Review  Sterilization Design | Fermenter Design Due Sep 10 |
| 5  9/18-20 | Sterilization |  | Sterilization discussion | Phase 1 Project Report |
| 6  9/25-27 |  | Handout | Semester Project Mtg  quiz | Sterilization Design  Model discussion NLSN 1195 |
| 7  10/2-4 | Dehydration | Geankoplis  Ch. 9 | Dryer Design | Literature Review Outline |
| 8  Oct break  10/11 | Dehydration | Handout | Semester Project Review Mtg | Phase2 lit review report Oct 12 |
| 9  10/16-18 Expo | Dehydration | Geankoplis  Ch. 9  PTW Ch 15 |  | Dryer Hwk Oct 15 |
| 10  10/23-25 | Dehydration | Geankoplis  Ch. 9  PTW Ch 15 |  | Dryer Design 1 Due Oct 25 |
| 11  10/30 11/1 | Dehydration |  | Quiz |  |
| 12  11/6-8 | Membrane  Separations | Geankoplis  Ch. 13  PTW Ch 15 | Project Conference  Pilot Plant Demo  Process Design | Dryer Design 2 Due Nov 7 |
| 13  11/13-15 | Membrane  Separations | Geankoplis  Ch. 13  PTW Ch 15 | Experimental Design | Phase 3 and 4 report Nov 14 |
| 14  11/20  Thanks | Membrane  Separations | Geankoplis  Ch. 13  PTW Ch 15 |  |  |
| 15  11/27-29 |  |  |  | Membrane Design Nov 28 |
| 12/4-6 |  |  |  | Phase 5 |
| 12/10-15 | **Finals** |  | **Exam** | Final Report |

**ABE 557  2018   SENIOR DESIGN PROJECT SCHEDULE**

**Phase 1 – Product, Industry Trends, Sustainability Ethical, Global, and Societal issues**

In groups of 3-4, select a process of interest. Each member of the group will be responsible for the design of at least one major unit operation.  Your project should focus on developing a student run business.   The business could serve a worldwide niche market.

As part of your report please provide an in depth discussion of the trends in product/ industry of your choice with a focus on a sustainable process evaluating current ethical, global,and societal contemporary issues   Start with an internet search.   Look at industry publications, and “Trends” journals for ideas. Projects must include a minimum of as many unit operations as there are people in the group.  The process should contain fermentation/reaction along with sterilization/freezing/drying /separation steps.

a.   Statement of purpose – as unambiguously and concisely as possible state the overall goal of the group project.

b.   Project objectives- state clearly the objectives so that accomplishments can be easily assessed upon project completion

c.   Provide an in depth discussion of the trends in product/ industry of your choice with a focus on a sustainable process evaluating current ethical, global, and societal contemporary issues.

d.    Product consumption/marketing data.

e.    Product recipe (i.e. steps and ingredients) Ingredient functionality (i.e. purpose of each ingredient)

f.    Process flow diagram of main unit operations with all material inlet and outlet flows

g.   Management Plan:  Implementation of plan-in an enumerated list, explicitly state the steps that will be taken to meet the objectives, include all deadline dates, phase group leader, and some break-down of responsibilities among the group members.

## Pha**s**e 2: Literature Review

1. Each member of your group will an outline of the review and complete a detailed review of a selected unit operation(s) within the group's semester product/process design project.
2. Emphasis of the review should focus on the overall goal of the unit operation, on alternative ways to accomplish the unit operation, on the effect of a unit operation variables on the product quality,energy, costs, and waste generation, on the advantages and disadvantages of each alternative method, the estimated input and output material and energy flows, design equations and the equipment configurations needed for each alternative.
3. Although the review is submitted individually, please include a cover page that includes your A) group number and title of group project B) a list of group member along with the titles of their reviews and C) Title of your review, your name, and a copy of the abstract.. Please use the Lit review rubrics for the body of the review. Use textbooks, review papers and original research articles related to your project found at the Purdue Library, Google Scholar, ScienceDirect or similar platform.

## Phase 3: Preliminary Recipe and Mass Balances

## a. Identify the recipe that will be used by the processing plant. This requires clearly defined processing steps including (but not limited to) temperatures, times, ingredients, methods. Identify the materials (ingredients and equipment) needed to conduct lab experiments. Develop clearly defined steps including (but not limited to) temperatures, times, ingredients, methods so that the reader can duplicate the product.

## b. For a given hourly production rate perform a component mass balance at each processing step and overall balance for the process

## c. Submit a written statement of the process recipe and a detailed process flow diagram providing the compositions and flows of each stream. Also submit a review of the mass balance calculations. Include information composition of raw ingredients, and intermediate and waste products.

## Phase 4: Preliminary Energy Balances

## a) Perform a energy balance at each processing step and overall energy balance for the process. Provide on the detailed process flow diagram the temperatures and enthalpy of each stream.

## b) Submit a written review of energy requirement calculations. Include tables of thermal and physical properties used in calculations. Also, include the types, flow rates and temperatures of heat transfer mediums required. Include all calculation in an appendix.

## Phase 5: Process Flow Sheet and Lab/Kitchen Experiments

1. Submit the details of the lab/kitchen experiments, this includes a recipe and processing variables to be examined, equipment required to perform experiments, and experimental design method. Develop Plackett-Burman experimental design or other DOE. Present preliminary results. All materials and equipment needs to be available or purchased (limited funds). Submit a formal written lab report on the experiments. This will include: an abstract, objectives, materials and methods, results and discussions, and conclusions.
2. Submit a process flow sheet using Super Pro following the requirements outlined.

## Phase 6: Final Oral Presentation

* Prepare and give a twenty to thirty minute power point presentation to the class which summarizes the semester project-process design. All group members must participate. All class members must attend all presentations.

## Phase 7: Final Report Submission (REQUIRED)

1. Submit the final literature review and all corrected sections in a final report.

2. Guidelines for final submission:

a. Type and double-space all submitted material

b. Use the reference format specified by AICHE or another major peer reviewed journal.

c. Calculations are performed on a spreadsheet and/or well documented coded document: no hand calculations will be accepted. Calculation methods should be explained in the text so that the reader could easily repeat the calculations.

d. Copy of pertinent literature cited

**Final Report Requirements:**

|  |  |
| --- | --- |
| **Technical Content (60%)** | **Writing Skills (40%)** |
| Title Page | Clarity of writing |
| Abstract | Organization |
| Objectives | Tables (appropriate use of) |
| Literature review | Figures (appropriate use of) |
| Recipe and flow diagram |  |
| Mass balance summary |  |
| Energy requirement summary |  |
| Unit Operation design and Model and costs |  |
| DOE and quality measurement methods |  |
| Conclusions and future directions |  |
| References-JFE format and Appendices |  |

3. Each member of the group must submit a completed Group Evaluation after each phase.

**ABE 557**

Project \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Evaluator \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

Date \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

**Group Evaluation**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Name of Member | yourself |  |  |  |  |  |
| Ability to schedule meetings |  |  |  |  |  |  |
| Did they attend scheduled meetings? |  |  |  |  |  |  |
| Initiative in group efforts |  |  |  |  |  |  |
| Completion of assigned duties |  |  |  |  |  |  |
| Communication |  |  |  |  |  |  |
| Commitment |  |  |  |  |  |  |
| Quantity of work done |  |  |  |  |  |  |
| Quality of work done |  |  |  |  |  |  |
| Reliability of work done |  |  |  |  |  |  |
| Respect and Support |  |  |  |  |  |  |
|  |  |  |  |  |  |  |
| Total |  |  |  |  |  |  |

Evaluate your group members on a scale of 1-10 10 = best

Comments:

**Example Format of Report:**

1. Title Page

2. Table of Contents

a. List of all sections

b. List of all tables and graphs

c. Tables and graphs must follow the format of the Journal of Food Engineering.

3. **Executive Summary**

a. Should list all findings, assumptions, and conclusions for each phase.

b. Approximately 2-4 pages long. (max)

c. This is a summary of the entire report and should be a standalone document.

4. **Abstract**

a. A detailed summary of the report. Written so that the reader will find exactly what was done for each phase and specifics regarding the results.

b. No longer than 1 page (does not need to be one page!).

5. **Introduction**

a. Include a broad description of the product/process in the first part of this section, then a more detailed description of your specific tasks in the second part. Longer tables (more than 1 ½ pages long) should be included in the appendix and referred to in the body of the text. Summarize the objectives/goals of the design. Discuss global, societal and ethical impact

6. **Body**

a. Detailed literature review: Product and Process Design

i. Products: recipe-steps and ingredients (by %), ingredient functionality, Chemical & processing issues, quality control issues, product consumption/marketing data.

ii. Process: list steps, processing alternatives, purpose of each step. Add flow diagrams (equipment/recipe networks) to this section, analyze energy consumption, water usage, and waste production.

b. Mass and Energy Balances

i. Overall mass balance and mass balance at each processing step (unit operation).

a) Results of all mass balance calculations in paragraph and table form. Include: composition of raw materials, products, by-products, waste.

b) Overall energy balance and energy balance at each step. (The temperature and enthalpy of each stream) in paragraph and table form. Include the temperature and enthalpy of each stream, and energy requirement of the plant.

ii. NOTE: Spreadsheet work should be in an appendix. Make a note in the text about where the reader can find these calculations. Should be described in paragraph form in the text and the equations should be included. Enough details should be presented so that the calculations can be reproduced at a later date.

1. Detailed Description Design of Experiments

i. Objectives

ii. Materials and experimental methods

iii Preliminary results

iv. DOE and parameter measurement methods.

7 **Conclusion and Future work**

8.  **References**

a. Reference format should follow the style of the Journal of Food Engineering. All ideas and facts that have not originated in the brains of your group members must be properly referenced. (At last 10 relevant references!!)

9. **Appendices**

a. For all spreadsheet pages, sample calculations, or extensively long data tables. This information should be referenced in the text. Graphs can be made to represent the data in concise form.