ABEN 458/658: Process Engineering for Food, Biofuels and Bioproducts
3 credits, Fall 2019

Meets regularly in **ABEN 224** on MWF 10-10:50 a.m.
Only meets in Service Center Rm 101 when announced
Course website: enter Blackboard at *www.ndsu.edu/its/bb_login/*

Instructor and contact information:
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Bulletin description:
Analysis and design of processing systems to preserve, purify and/or transform biological materials and products, especially through refrigeration, freezing, sterilization, aseptic processing, dehydration, extraction, distillation and chemical reaction. Prereq: Junior standing

Course objectives:
The food, biofuels and bioproducts industries are complex and diverse, consisting of countless products and processes. However, despite such complexity and breadth, processes can be broken down into common, constituent steps or *unit operations*. These operations are similar between processes, and can be analyzed in terms of widely-shared principles, such as conservation of mass and energy; momentum, heat, and mass transfer; kinetics; and vapor-liquid equilibriums. Understanding those principles—together with knowledge of the properties of biological materials—can be a powerful tool when applied to improving or designing new processes.

Upon successful completion of this course, students will be able to:
1. Use mass, component and energy balances to analyze and model processes.
2. Use *kinetic theory* to analyze and model processes, such as sterilization.
3. Use balances and *psychrometric principles* to analyze and model processes involving air-water vapor mixtures, such as spray drying.
4. Use balances and *pressure-enthalpy diagrams* to analyze and model refrigeration cycles.
5. Use balances, heat transfer principles, and *vapor-liquid equilibrium diagrams* to analyze, model and design a distillation unit.
6. Use steady-state analysis to evaluate performance of actual process equipment.
7. In addition to the above course objectives, students taking ABEN 658 should demonstrate an enhanced understanding of these topics by: (a) providing instruction on the above topics to other engineering students, and (b) evaluating the work of other student engineers related to the above topics.

Companies hire engineers to solve problems. Processing poses many challenges, including food safety risks to consumers, variable quantity and quality of raw materials, equipment failure, and pressures to conserve resources, be competitive and innovative. An understanding of fundamental principles can help you understand what causes a process to work or not work as planned, and how to innovate. Occasional reference will be made to issues that affect these industries, for example the alarming increase in obesity in the U.S. and the concomitant rise in diet-related diseases such as diabetes, concerns about trans fats and other harmful components introduced into the food supply by processing, and the need for more sustainable technologies. Therefore, students completing this course should be able to:

1 Apply principles of mass and energy conservation; momentum, heat, and mass transfer; kinetics; and thermodynamics. Many examples require use of calculus, spreadsheet software, and/or numerical methods [A, student outcomes 1 and 6 (Table 1)].
2 Design their own experiments with an actual heat exchanger, evaporator, dryer, etc. The results of the experiments are reported orally to the class. Conduct experiments, record data, write reports, and accomplish tasks as a member of a team [A, Student outcome 2; B, Student outcome 5 (Table 1)].
3 Apply professional standards for performing and documenting analyses [B, Student outcome 3(Table 1)].

Table 1. Program educational objectives and supporting student outcomes.*

Graduates are expected to have established themselves as practicing engineers who, within a few years of graduation:	
A	Successfully address emerging engineering challenges in the design or evaluation of machine systems, processing systems, and natural resources and environmental systems affecting the production of food, feed, and other biobased products. Technical learning outcomes include student outcomes (1), (2), and (6): 1. an ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics (a, e)† 2. an ability to 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 (c) 6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions (b)
B	Effectively use professional communication, critical thinking, and interpersonal skills as team leaders and team members. Communicational learning outcomes include student outcomes (3) and (5): 3. an ability to communicate effectively with a range of audiences (g) 5. an ability to function effectively on a team whose members together provide leadership, create a collaborative and inclusive environment, establish goals, plan tasks, and meet objectives (d)
C	Responsibly serve the public and their employers by participating in professional development and by maintaining the highest standard of professional ethics. Contextual learning outcomes include student outcomes (4) and (7): 4. an ability to recognize ethical and professional responsibilities in engineering situations and make informed judgments, which must consider the impact of engineering solutions in global, economic, environmental, and societal contexts (f, h, j) 7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies (i)

* See https://www.ndsu.edu/aben/about/abet-accredited/ for the current ABEN program educational objectives. See https://www.abet.org/accreditation/accreditation-criteria/criteria-for-accrediting-engineering-programs-2019-2020/#GC3 for information on ABET student outcomes 1-7, effective as part of the "Criteria for Accrediting Engineering Programs, 2019-2020."
† ABET student outcomes (a) – (k) from the previous review cycle are included for cross-referencing only. Former student outcome (k) is implied in (1), (2), and (6).

Note: The table shows how course contributes to program outcomes, and how assessment is carried out to continually improve the course. The course is estimated to consist of 2 credits of "engineering topics" and 1 credit of "engineering design."

Required student resources:
Students are expected to have daily access to the course Blackboard website for access to course announcements, assignments, including the on-line textbook: *Process Engineering for Food, Biofuels & Bioproducts, and* an electronic calculator.

Fundamentals of Engineering Reference Handbook (FERH), available as a free download from http://www.ncees.org/exams/study_materials/fe_handbook/

Table 2. Course Outline of Events (Tentative):

Week	Topics/Events
1	Course introduction & syllabus; Mass balance review
2	*Labor Day holiday*; Moles, chemical reactions & stoichiometry
3	Energy balance review; Heat of reaction, Enthalpy of process streams, esp. steam; Evaporator review
4	Intro to Reboiler Project; Mollier diagram; Distillation & reboilers
5	Steady-state heat transfer prediction; Guest Speaker; Energy efficiency;
6	Review; **1st Test (Oct 2);** Quantifying change in biological processing
7	Thermal sterilization; Conclusion to quantifying change
8	Preservation of biological materials; 1st Field Trip (CHS Fargo); Mechanical refrigeration
9	Reboiler demonstrations & reports; Freezing of biological materials
10	Reboiler presentation; Psychrometric chart; Drying of biological materials
11	Spray dryer demonstration & data analysis; Intro to Distillation Project/Vapor-liquid equilibriums, Test 2 review
12	*Veteran's day;* **2nd Test (Nov. 13);** Vapor-liquid equilibriums/Continuous Distillation
13	Continuous Distillation; McCabe-Thiele analysis; 2nd Field trip (in town; TBD)
14	Distillation project prototype planning; *Thanksgiving Break*
15	Distillation project demonstrations & data analysis; Project presentations planning
16	Formal team project presentations; Course assessment and review

Evaluation procedures and criteria:

Grading (tentative):	***458***	***658***	
Tests (2, 100 points each)	200	200	Oct 2, Nov. 13
Final Exam	125	145	8 a.m., Dec. 18
Process Testing & Reports	50	70	
Team Project	180	200	
Problem Sets (4 or 5, 15-30 points each)	85	95	
In-class activities/attendance	10	10	
Total	***650***	***720***	

A ≥ 90%, B = 80-89%, C = 70-79%, D = 60-69%, F < 60%

Tests & Final Exam: Detailed information will be posted on the Blackboard website under "Test Central" one week in advance. The final exam will be held on the appointed day and time for

classes meeting MWF at 10 a.m. *Students in ABEN 658* will also undertake a 20-point oral exam during final exam week (not on the same day as the written final exam) or have additional question(s) in the final exam.
Process Performance Testing: You will operate a pilot-scale spray dryer and determine the performance of each unit. *Students in ABEN 658* will help lead one of these tests, and will apply advanced process engineering analysis.
Team Project: The main team assignment is the design, development and testing of a working prototype process unit. You will be assigned to a team of 2-4 students, probably in the 4th week, at which time the project will be described in more detail. You will also have some team-based problem sets.
Problem Sets: Clearly *communicate the method for solving the problem.* Thus, please use the standard problem-solving format for ABEN courses. Problem sets should be completed in pencil on *only one side* of lined or grid 8-1/2" x 11" notepad paper (not spiral-bound paper). Concisely *state* the given information, what must be found, and then give a clear, logical solution to the problem. Show proper units throughout your solution, especially in the final answer. *Underline your final answers.* Round final answers to an appropriate number of significant figures.
You have one week to complete assigned problem sets. If you cannot meet that deadline, you may turn in assignments up to 3 days late with a penalty of 10% maximum possible score per day late. *Students in ABEN 658* will grade one problem set, in consultation with Dr. Monono.

Attendance:

How deeply you participate in class discussions and lectures will undoubtedly determine how much you benefit from this course. *Your attendance and full participation is expected*, through classroom discussions, volunteering answers to questions, asking appropriate questions, thoughtful evaluation of a team oral presentation, and by helping to create a spirit of cooperation within the class.

Students who exceed two absences for the semester should provide documentation of a valid excuse, such as from a medical professional or advisor of an NDSU student organization, to avoid a grade penalty of 2 points per unexcused absence.

Students with Special Needs and/or Circumstances:

Any students with disabilities or other special needs, who need special accommodations in this course are invited to share these concerns or requests with the instructor and contact the Disability Services Office as soon as possible. All students are welcome to record lectures. Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance.

COE Honor Pledge:

"On my honor I will not give nor receive unauthorized assistance in completing assignments and work submitted for review or assessment. Furthermore, I understand the requirements in the College of Engineering Honor System and accept the responsibility I have to complete all my work with complete integrity. Students who are suspected of academic dishonesty may not withdraw from the course in which dishonesty is suspected while the case is under review by the Honor Commission (NDSU Policy 335, 5b)."
http://www.ndsu.edu/coe/undergraduate_students/honor_code/
Last updated: August 21, 2019