

ABEN 458/658: Process Engineering for Food, Biofuels and Bioproducts
3 credits, Fall 2023

Meets in **ECE 213** on MWF 10-10:50 a.m.

Instructor and contact information:

Name: Dr. Ewumbua Monono

Office location: Ladd 101F

Contact Information: ewumbua.monono@ndsu.edu /231-7277

Office hours: MWF 11 a.m. – Noon; TTh 1-2:30 p.m.; and by appointment

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 providing instruction on the above topics to other engineering students

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.

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 in analyzing processing systems [A, student outcomes 1 and 6 (Table 1)].
- 2 Design their own processing systems with an actual reboiler, distillation column, and condenser.

Conduct experiments, record and analyze data, 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. The results of the experiments are reported orally to the class. [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
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
6. an ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions

- 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
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

- 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
7. an ability to acquire and apply new knowledge as needed, using appropriate learning strategies

* 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-2023-2024/> for information on ABET student outcomes 1-7, effective as part of the "Criteria for Accrediting Engineering Programs, 2023-2024."

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, project, including the on-line textbook: *Process Engineering for Food, Biofuels & Bioproducts*, and other reading materials. An electronic calculator is needed.

Table 2. Course Outline of Events (Tentative):

Week	Topics/Events
1	Course introduction & syllabus; Mass balance review
2	Moles balances & stoichiometry; Energy balance with heat of reaction
3	<i>Labor Day holiday</i> ; Enthalpy of process streams; Intro to reboiler project;
4	Steady state heat transfer and heat exchangers esp. double-pipe heat exchanger
5	Evaporators review; Evaporators with energy efficiency (Mollier)
6	1st Test (Sept 25) ; Quantifying change in biological processing;
7	Thermal sterilization; Field trip: CHS Sunflower, Fargo (Oct 6)
8	Reboiler project demonstrations & analysis; Reboiler project presentation
9	Psychrometric chart; Drying of biological materials; Spray dryer demonstration
10	Spray dryer data analysis; 2nd Test (Oct 25) ; Intro to vapor-liquid equilibriums
11	Continuous distillation and McCabe-Thiele analysis
12	Mechanical refrigeration; <i>Veteran's Day holiday</i>
13	Freezing of biological materials; Field trip: Proof Artisan Distiller, Fargo (Nov 19)
14	Distillation project planning; <i>Thanksgiving Break</i>
15	Distillation project demonstration, data analysis, and presentation planning
16	Formal team project presentations; Course assessment and review

Evaluation procedures and criteria:

<i>Grading (tentative):</i>	458	658	
Tests (2)	180	180	Sept 25, Oct 25
Final Exam	150	170	8 a.m., Dec. 12
Process Testing & Reports	50	55	
Team Project	180	200	
Problem Sets (5, 10-30 points each)	90	95	
In-class activities/attendance	10	10	
Total	660	710	

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 3-4 students, probably in the 4th week of class, 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 2 days late with a penalty of 10% maximum possible score per day late.

Attendance: According to NDSU policy 333 (<https://www.ndsu.edu/fileadmin/policy/333.pdf>), attendance in classes is expected. *Your attendance and full participation is expected*, through classroom discussions, volunteering answers to questions, asking appropriate questions, thoughtful evaluation of a team oral presentation, evaluating of team member's participation in project, and by helping to create a spirit of cooperation within the class. The mode of instruction is face-to-face. You are required to attend lectures, project, and lab demonstrations in-person. However, there will be a zoom option for lectures only if you get sick and need to quarantine because of COVID. You must notify me at least an hour before class because I expect to see you in-person, especially during project demonstrations.

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 point 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. Recorded lectures will be made available. Veterans and student soldiers with special circumstances or who are activated are encouraged to notify the instructor in advance.

Last updated: August 11, 2023