

## **ABEN 263 —Biological Materials Processing (3 credits) Spring 2024**

Classroom portion meets in **Ladd 209** on **WF 12:00-12:50 p.m.**

Lab meets in the **Pilot Plant or Ladd 201** on **T 2:00-4:50 p.m.**, as arranged.

### **Instructor and contact information:**

*Name:* Dr. Ewumbua Monono

*Office location:* Ladd 101F

*Contact Information:* [ewumbua.monono@ndsu.edu](mailto:ewumbua.monono@ndsu.edu) and Phone: 701-231-7277

*Office hours:* Mondays 10 a.m. – Noon; Thursdays 3-5 p.m.; and by appointment

### **Bulletin Description of Course:**

Quantitative analysis of processing systems for food, biofuels and bioproducts using principles of mass and energy balances, fluid flow, steam properties, and heat and mass transfer. Includes 3 hour lab.

*Prerequisite:* ABEN 255 for ABEN students and Math 146 for CFS students

### **Required and Recommended Student Resources:**

*Textbook:* *Biological Materials Processing: Process Engineering for Food, Biofuels & Bioproducts*, 7<sup>th</sup> edition v2 & v3, 2020, and freely available through the Blackboard course site.

*Other required resources:* electronic calculator, lab notebook, safety glasses or goggles, protection for your clothes in lab such as a lab coat or apron

*Recommended resources:*

*Fundamentals of Engineering Reference Handbook (FERH)*, available as a free download from <http://ncees.org/exams/study-materials/download-fe-supplied-reference-handbook/>

*Introduction to Food Engineering*, 5<sup>th</sup> edition, by Singh & Heldman, Academic Press, 2013

### **Course Objectives:**

Process scientists and engineers must be able to quantify relationships between process parameters—such as temperatures and flow rates—and product quality, yield and cost. This requires an understanding of the underlying principles and methods of formulating and using equations that model these relationships, also, an understanding of rheological and thermal properties.

Therefore, students completing this course should be able to:

- A. Analyze processes for food and biological materials using one or more of (1) mass, component and thermal energy balances, with correct use of units and conversions; (2) mechanical energy balances applied to fluid systems; (3) properties of process steam, especially through use of steam tables; and (4) principles of steady state heat transfer, including heat transfer resistances in series [A, Student outcome 1 (Table 1)].
- B. Apply professional standards for performing and documenting analyses [B, Student outcome 3 (Table 1)].
- C. Conduct experiments, record data, write reports, and accomplish tasks as a member of a team [A, Student outcome 6; B, Student outcome 5 (Table 1)]
- D. Program and use dataloggers and PLCs at a basic level [C, Student outcome 2 (Table 1)]

Table 1. ABEN program educational objectives and supporting student outcomes.\*

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Graduates are expected to have established themselves as practicing engineers who, within a few years of graduation:

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- 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 engineering 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)

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\* See [https://www.ndsu.edu/aben/about/abet\\_accredited/](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-2022-2023/> for information on ABET student outcomes 1-7, effective as part of the "Criteria for Accrediting Engineering Programs, 2022-2023."

† 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).

## Evaluation Procedures and Criteria:

*Graded assignments and their relative contribution to your grade are tentatively as follows:*

Tests (3, each 100 points)	300 points	<b>Feb. 6, Mar. 5, Apr. 9</b>
Final exam	100	<b>May 9 (3:30 pm)</b>
Graded problem sets	80	
Lab quizzes/worksheets/reports	180	
Professional practice/notebook	40	Notebook due on <b>Apr. 12</b>
<b>Total</b>	<b>700</b>	

Letter grades assigned as follows: A=90-100%; B=80-89.9%; C=70-79.9%; D=60-69.9%; F<60%. Grades might be round-up to the nearest unit, e.g. 69.6% to 70%.

A *mid-term grade* will be posted at Spring Break which will be based on the first two tests and other graded assignments from the first half of the semester.

***Problem Sets and Professional Standards*** (please follow format on p. 10 of online textbook)

Working the problems is the best way to master the material in this course. You may work in a small group, particularly if you have limited time and find the problems frustrating. While students are encouraged to share ideas on solving problems and compare final answers, *the work you submit should still be essentially your own* -- not a solution you copied from someone else.

Professional standards apply to all work in this course. ***The foremost expectation is to clearly communicate the method used to solve the problem.*** Students with good penmanship may complete problem sets *in pencil* on *only one side* of lined or grid 8-1/2" x 11" notepad paper (not spiral-bound paper); otherwise, use a word processor and then print on standard printer paper. Concisely *summarize* the **GIVEN** information, briefly state what you are asked to **FIND**, and then give a clear, organized, logical **SOLUTION** to the problem. ***Clearly communicate the method for solving the problem.*** Be generous with space. Show correct units throughout your solution, especially in the final answer. Round off your final answers. Professional practice is to show no more than 2-3 significant figures in the final answers, unless the accuracy of the data warrants more; please round your answers accordingly. Underline your final answers.

You typically have one week to complete assigned problem sets. If you cannot meet that deadline, assignments are *sometimes* accepted with advance permission up to 3 days late (10% deduction per day, based on maximum possible score). Problem sets may not be returned in advance of the corresponding test. Thus, *photocopy your answers and compare them to the posted solution key* to ensure that you are using correct procedures.

### Tentative Lectures and Labs Schedule

Wk	Dates	Tuesday Lab	Wednesday class	Friday class
1	<u>1</u> /9,10,12	Course Intro & Syllabus <b>Pilot Plant</b>	Ch. 1: Mass Balances	Ch. 1: Mass Balances
2	<u>1</u> /16,17,19	Quality Evaluation, Cleaning, and Tampering of Canola Seed, <b>Pilot Plant</b>	Ch. 2: Units & Dimension	Ch 3: Thermal Energy Balances
3	<u>1</u> /23,24,26	Mass Balance for Screw Pressing of Canola Oil, <b>Pilot Plant</b>	Ch 3: Thermal Energy Balances	Ch 3: Thermal Energy Balances
4	<u>1</u> /30,31; <u>2</u> /2	Spreadsheet Software for Lab Data Analysis, <b>Ladd 201</b>	Ch 4: Mechanical Energy Balances	Ch 4: Mechanical Energy Balances
5	<u>2</u> /6,7,9	<b>Test 1, Ladd 201</b>	Ch 5: Viscosity	Ch 6: Flow Properties of Fluid and Fluid Friction
6	<u>2</u> /13,14,16	Fluid Properties Measurement, <b>Pilot Plant</b>	Ch 6: Flow Properties of Fluid and Fluid Friction	Ch 7: Pumps and Pressure Drop
7	<u>2</u> /20,21,23	Field Trip, <b>Busch Ag Resources, Moorhead MN</b>	Ch 8: Properties and Use of Steam	Ch 9: Evaporator Analysis
8	<u>2</u> /27,28; <u>3</u> /1	Thermal Energy Balance on an Evaporator, <b>Pilot Plant</b>	Ch 9: Evaporator Analysis	Ch 9: Evaporator Analysis
9	<u>3</u> /5,6,8	<b>SPRING BREAK</b>		
10	<u>3</u> /12,13,15	<b>Test 2, Ladd 201</b>	Ch 10: Steady State Conduction	Ch 10: Steady State Conduction
11	<u>3</u> /19,20,22	Mid-course Review & Assessment, <b>Ladd 201</b>	Ch 11: Steady State Convection	Ch 11: Steady State Convection
12	<u>3</u> /26,27,29	Double Pipe Heat Exchanger, <b>Pilot Plant</b>	Ch 12: Analysis of Heat Exchangers	<b>Good Friday Holiday</b>
13	<u>4</u> /2,3,5	Field Trip to a Processing Industry, <b>RDO Frozen, Park Rapids, MN</b>	Ch 12: Analysis of Heat Exchangers	Ch 13: Heat Exchangers through a Cylindrical Wall
14	<u>4</u> /9,10,12	<b>Test 3, Ladd 201</b>	Ch 13: Heat Exchangers through a Cylindrical Wall	Ch 15: Dataloggers
15	<u>4</u> /16,17,19	Datalogger and "Hot Box", <b>Ladd 201</b>	Ch 15: Dataloggers	Ch 16: Programmable Logic Controllers
16	<u>4</u> /23,24,26	Programmable Logic Controllers, <b>Ladd 201</b>	Ch 16: Integration of Process Principles	Ch 16: Integration of Process Principles
17	<u>4</u> /30; <u>5</u> /1,3	Makeup for Weather-related Postponement	Ch 16: Integration of Process Principles	Course Assessment & Review
18	<u>5</u> /7,8,10	<b>FINAL EXAM, Thursday May 9<sup>th</sup>, 3:30 - 5:30 pm</b>		

### ***Laboratory Exercises:***

Students will be able to download the lab guide by the Friday before the corresponding lab exercise is performed. The lab exercise will usually be conducted by separate teams of 3-4 students, with teams usually working at separate parts of the period. For some exercises, teams will share data with one another. Please study the lab guide for 30 to 60 min prior to reporting to lab to perform the exercise. You will usually be quizzed on the lab guide when you arrive to perform the exercise. Please make it a habit to record your original data in a neat and orderly way directly into a *bound lab notebook* (avoid using photocopies of data); *this is due by April 12.*

### ***Professionalism in the Lab***

1. Lab guide is carefully studied before the lab period, and consulted as needed during the lab.
2. Work is performed safely according to precautions, e.g., with eye protection if needed.
3. Questions are asked and constructive suggestions offered, where needed to perform experiments safely and accurately, and to help discern relevance of the lab to the course.
4. Experiments are repeated, to the extent that time and resources allow.
5. Your team's data are recorded neatly *in ink* directly into a bound notebook.
6. Behavior towards others is courteous and helpful; use of humor is graceful.
7. Equipment and facilities are treated with respect, and assistance with clean-up is volunteered.

### ***What should be entered into the lab notebook?***

1. Title of experiment (title used in lab guide)
2. Your name and date of lab exercise, and your lab partner names
3. Brief statement of objective(s) of lab exercise
4. Simple, labeled sketch of lab apparatus, where appropriate
5. Complete record of relevant data *with units*, organized in a table where appropriate
6. Record departures from the lab guide procedure, and observations made

Please write *in black or dark blue ink* and use *only the front side* of each notebook sheet.

### **Professional Practice: Participation and Attendance**

According to [NDSU Policy 333 \(www.ndsu.edu/fileadmin/policy/333.pdf\)](http://www.ndsu.edu/fileadmin/policy/333.pdf), attendance in classes is expected. In this course students should participate in the course, especially the labs.

*Attendance is incorporated into the professional practice component of your course grade, through punctuality, class discussions, volunteering answers to questions, asking constructive questions, and by helping to create a spirit of cooperation within the class.*

***Please also note:*** *Students who exceed two unexcused absence for the semester should provide documentation of a valid excuse for all absences, such as from an advisor of an NDSU student organization, to avoid a grade penalty of at most 2 points per unexcused absence.*

**Americans with Disabilities Act for Students with Special Needs:** 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 Center for Accessibility

and Disability Services ([www.ndsu.edu/disabilityservices](http://www.ndsu.edu/disabilityservices))

**Veterans:** Veteran or military personnel with special circumstances or who are activated are encouraged to notify the instructor as soon as possible and are encouraged to provide Activation Orders.

**Family Educational Rights and Privacy Act (FERPA):** Your personally identifiable information and educational records as they relate to this course are subject to [FERPA](#).

**Academic Honesty:** The academic community is operated on the basis of honesty, integrity, and fair play. [NDSU Policy 335: Code of Academic Responsibility and Conduct](#) applies to cases in which cheating, plagiarism, or other academic misconduct have occurred in an instructional context. Students found guilty of academic misconduct are subject to penalties, up to and possibly including suspension and/or expulsion. Student academic misconduct records are maintained by the [Office of Registration and Records](#). Informational resources about academic honesty for students and instructional staff members can be found at [www.ndsu.edu/academichonesty](http://www.ndsu.edu/academichonesty).

*Last updated: Jan. 4, 2024*