University of Manitoba | Price Faculty of Engineering
Department of Biosystems Engineering

Course Outline

Instruction Team

- Dr. David Levin, PhD (he/him)
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- Dr. Chyngyz Erkinbaev (he/him)
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Student Hours

- Dr. Erkinbaev: Wed 3:00 – 4:30 PM
- Dr. Levin: Please e-mail Dr. Levin to make an appointment

Location

- **Lecture E2-351**
  Mon 11:30 AM - 12:20 PM
  Wed 11:30 AM - 12:20 PM
  Fri 11:30 AM - 12:20 PM

Laboratory E2-351
Thur 2:30 PM- 5:15 PM

Contact Hours

- 4 credit hours
- Lectures:
  3 hours x 12 weeks = 36 hours
- Laboratories:
  3 hours x 12 weeks = 36 hours

Prerequisites:

- None

Course Website:

http://umanitoba.ca/umlearn

BIOE 4440 Bioprocessing and Biorefining

Winter 2023

Course Objectives

This course allows students with a background in either biological sciences or engineering to gain an understanding of biochemical engineering processes used to enable important microbial/biochemical conversions by biological systems. Topics include bioprocessing unit operations, production of biofuels, biopolymers, and biopharmaceutical drugs and vaccines, fermentation and bioreactor systems, and downstream processing for product recovery.

Course Content

This course deals with operations that aim at designing proper conditions for processing of biomaterials for production of biofuels and bioproducts of desired quality of the end product. The principles of this course are built based on physics, transport phenomena, thermodynamics, reaction kinetics, fermentation, and industrial unit operations. This course will assist students in understanding the principles involved in the designing aspect of handling and processing parameters of biomaterials.

The following topics will be covered:

- Bioprocessing unit operations
- Bioethanol production
- Biodiesel production
- Biopolymer production
- Fermentation processes
- Bioreactor systems

LECTURES: Three hours of lectures per week in one term.

(Jan. 9) Lecture 1: Course outline (**DL** and **CE**)

(Jan. 11) Lecture 2: Biofuels: Background and rationale (Ch. 11) (**DL**)

(Jan. 13) Lecture 3: Bioprocessing for 1st generation of biofuels: Bioethanol & Biodiesel (Ch. 12 & 13) (**DL**)

(Jan.16) Lecture 4. Biomass processing for biofuels (**DL**)

(Jan. 18) Lecture 5: Bioprocessing for 2nd generation of biofuels: Cellulosic bioethanol (Ch. 14) (**DL**)

(Jan. 20) Lecture 6: The Bioethanol Production Process at Minnedosa, MB (RG)

(Jan. 23) Lecture 7: Unit operations in biomass conversion (Ch. 1) (**CE**)

(Jan. 25) Lecture 8: Slurry transport (Ch. 2) (**CE**)

(Jan. 27) Lecture 9: Fixed and moving beds (Ch. 3) (**CE**)

(Jan. 30) Lecture 10: Fluidized and spouted beds (Ch. 3) (**CE**)

(Feb. 1) Lecture 11: Drying systems design (Ch. 3) (**CE**)

(Feb. 3) Lecture 12: Theory of mechanism of mixing (Ch. 4) (**CE**)

(Feb. 6) Lecture 13: Mixing equipment and operation (Ch. 4) (**CE**)

(Feb. 8) Lecture 14: Power curves (Ch. 4) (**CE**)

(Feb. 10) Lecture 15: Power curves (Ch. 4) (**CE**)

(Feb. 13) Lecture 16: Evaporation for fluid food concentration (Ch. 7) (**CE**)

(Feb. 15) Lecture 17: Evaporation for fluid food concentration (Ch. 7) (**CE**)

(Feb. 17) Lecture 18: Filtration (Ch. 5) (**CE**)

(Feb. 20) **No classes (Louis Riel Day)**

(Feb 22) **No classes (Reading week)**

(Feb. 24) **No classes (Reading week)**

(Feb. 27) **Mid-term Test;** Lecture 2 to 19

(Mar.1) Lecture 19: Filtration equipment (Ch. 5) (**CE**)

(Mar. 3) Lecture 20: Constant pressure, constant rate filtration (Ch. 5) (**CE**)

(Mar. 6) Lecture 21: Membrane separation (Ch. 6) (**CE**)

(Mar. 8) Lecture 22: Evaluation of mass transfer coefficient (Ch. 6) (**CE**)

(Mar. 10) Lecture 23: Review of unit operations (**CE**)

(Mar. 13) Lecture 24: Predicting flux in ultrafiltration (Ch. 6) (**CE**)

(Mar. 15) Lecture 25: Types of membranes (Ch. 6) (**CE**)

(Mar. 17) Lecture 26: Centrifugal separation (Ch. 8) (**CE**)

(Mar. 20) Lecture 27: Centrifugal separation (Ch. 8) (**CE**)

(Mar. 22) Lecture 28: Energetics of Cell Growth & Cell Yields (Ch. 15) (**DL**)

(Mar. 24) Lecture 29: Consolidated Bioprocessing (**DL**)

(Mar. 27) Lecture 30: Bioreactor design for microbial systems (Ch. 17) (**DL**)

(Mar. 29) Lecture 31: Biopolymers and bioplastics (**DL**)

(Mar. 31) Lecture 32: Microbial fermentation for PHA production (**DL**)

(Apr. 3) Lecture 33: Bioreactor design for eukaryotic systems (Ch. 18) (**DL**)

(Apr. 5) Lecture 34: Microalgae production in photobioreactors (**DL**)

(Apr. 7) **No classes (Good Friday)**

(Apr. 10) Lecture 35: Single cell oils (**DL**)

(Apr. 12) Lecture 36: Cell immobilization (**DL**)

Tutorials:

Tutorials will include numerical experiments and determination of process-design parameters. Assignments will be posted on the UM Learn website: https://universityofmanitoba.desire2learn.com/d2l/login assigned to the course.

(Jan. 12)	**No classes**
(Jan. 19)	Introduction and lab organization (**CE**)
(Jan. 26)	**A1**: Minnedosa Bioethanol Production Process (**DL** & **RG**)
(Feb.2)	Tutorial for A1 (**DL**)
(Feb. 9)	**A2**: Design of slurry transport systems (**CE**)
(Feb. 16)	Tutorial for A2 (**CE**)
(Feb. 23)	**No classes (reading week)**
(Mar.2)	**A3**: Design parameters for drying (**CE**)
(Mar. 9)	Tutorial for A3
(Mar. 16)	**A4**: Design parameters for multi-effect evaporators/filtration (**CE**)
(Mar. 23)	Tutorial for A4 (**CE**)
(Mar. 30)	Industry visit, TBD (**DL** and **CE**)
(Apr. 6)	Oral presentations of the design projects (**DL** and CE)

Textbook

The textbook for the course is "*BioProcessing*", by Drs. Stefan Cenkowski and David B. Levin. This book was prepared and edited by Dr. Cenkowski and Dr. Levin in collaboration with several of their graduate students in 2021. An electronic version (.pdf) of the book will be provided to each student registered in the course.

Evaluation

The basis of the final grade is agreed upon with the students at the beginning of the term. The usual weighting is:

- 15% on midterm test
- 20% on design assignments
- 40% major design project (presentation: 10% and written report: 30%)
- 25% on written final examination

Late submission of assignments or laboratory reports would result in loss of 10% marks for each working day.

Accreditation Details

- Mathematics: 10%
- Natural Science: 40%
- Complementary Studies: 0%
- Engineering Science: 25%
- Engineering Design: 25%

Graduate Attributes

KB: A knowledge base for engineering
PA: Problem analysis
IN: Investigation
DE: Design
ET: Use of engineering tools
IT: Individual and team work
CS: Communication skills
PR: Professionalism
IE: Impact of engineering on society/environment
EE: Ethics and equity
EP: Economics and project management
LL: Life-long learning

Competency Levels

1 - Knowledge (Able to recall information)
2 - Comprehension (Ability to rephrase information)
3 - Application (Ability to apply knowledge in a new situation)
4 - Analysis (Able to break problem into its components and establish relationships.)
5 - Synthesis (Able to combine separate elements into a whole)
6 - Evaluation (Able to judge the worth of something)

Grading Scale

Note: These boundaries represent a guide for the instructor and class alike. Provided that no individual student is disadvantaged, the instructor may vary any of these boundaries to ensure consistency of grading from year-to-year.

Letter	Mark
A+	92–100
A	85–92
B+	85–78
B	78–72
C+	72–66
C	66–60
D	60-50
F	< 50

Learning Outcomes

By the end of this course, you will be able to:

No.	Learning Outcome	Transferable Skill
1	Determine design parameters for: mixing solids/liquids, gases, fluids, powders, pastas, and agitation processes	A knowledge base for engineering
2	Parameters for drying of biological solids, multi-effect evaporators, filtration and ultrafiltration	A knowledge base for engineering
3	Prepare a conceptual design of a grain-based ethanol production plant	Teamwork; design
4	Collaborate with group members in a team setting to manage an engineering design project	Design, project management
5	Apply laws and theories to practical solutions	Problem analysis
6	Communicate orally and in writing a design solution	Communication skills

Expected Competency Levels

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	3											
2	3											
3				3		3						
4				3		4						
5		4										
6							4					

CEAB Graduate Attributes Assessed

KB.3 – Determined the engineering problems associated with bioprocessing.

DE.3 – Develops possible solutions to an open-ended design problem, leading to an appropriate recommendation.

IT.3 – Participates in group activities and decision-making.

PA.4 – Provide solution for conceptual design of processing conditions.

CS. 4 – Demonstrate communication and writing skills.

Important Dates

- **Early Withdrawal Deadline**
  January 20, 2023
- **Louis Riel Day**
  February 20, 2023
  No classes or examinations
- **Winter Term Break**
  February 21 -24, 2023
  No classes or examinations
- **Good Friday**
  April 7, 2023
  No classes or examinations
- **Voluntary Withdrawal Deadline**
  March 22, 2023
- **Last Day of Classes**
  April 14, 2023
- **Examination Dates**
  April 14 - 28, 2023

Evaluation

Component	Value (%)	Assessor	Method of Feedback*	Learning Outcomes Evaluated	I/T**
Final Exam	25	DL & CE	S	1	I
Design assignments	20	DL & CE	F, S	1,2,3,4	I
Major design project (presentation 10% and written report 30%)	40	DL & CE	F, S	1, 2, 3, 4, 5, 6	I/T
Midterm test	15	DL & CE	S	1,2,3,4	T

* Method of Feedback: **F** - Formative (written comments and/or oral discussion), **S** - summative (numerical grade)

** I/T: **I** – Individual effort, **T** – Team effort

Academic Integrity

Students are expected to conduct themselves in accordance with the highest ethical standards of the Profession of Engineering and evince academic integrity in all their pursuits and activities at the university. As such, in accordance with the *General Academic Regulations* on *Academic Integrity*, students are reminded that plagiarism or any other form of cheating in examinations, term tests, assignments, projects, or laboratory reports is subject to serious academic penalty (e.g. suspension or expulsion from the faculty or university). A student found guilty of contributing to cheating by another student is also subject to serious academic penalty.

Requirements/Regulations

- No programmable devices or systems (such as calculators, PDAs, iPods, iPads, cell phones, smart watches, wireless communication, or data storage devices) are allowed in examinations unless approved by the course instructor.
- All email communication must conform to the Communicating with Students university policy.

Communicating with Students

- Attending lectures and laboratories is essential for the successful completion of this course.
- Self-declaration forms may be completed for missed tests, exams, or assignments during short-term absences (≤72 hours) for extenuating circumstances. Students don't need to share personal information about their situation beyond declaring the nature of the extenuating circumstance on the self-declaration form.

Self-Declaration Form for Brief or Temporary Absence

- This form cannot be used for planned absences like vacations. It is also not to be used for longer-term absences, or ongoing circumstances (e.g., Authorized Withdrawals, Leaves of Absence, or other accommodations), which will still require additional documentation.

Self-Declaration Policy for Brief or Temporary Absences

- It is the responsibility of each student to contact the instructor in a timely manner if he or she is uncertain about his or her standing in the course and about his or her potential for receiving a failing grade. Students should familiarize themselves with the University's *General Academic Regulations*, as well as Section 3 of the Faculty of Engineering *Academic Regulations* dealing with incomplete term work, deferred examinations, attendance, and withdrawal.

General Academic Regulations

Engineering Academic Regulations

- Students should be aware that they have access to an extensive range of resources and support organizations. These include Academic Resources, Counselling, Advocacy and Accessibility Offices as well as documentation of key University policies e.g. Academic Integrity, Respectful Behaviour, Examinations and related matters.

Supplemental Resources

Retention of Student Work

Students are advised that copies of their work submitted in completing course requirements (i.e. assignments, laboratory reports, project reports, test papers, examination papers, etc.) may be retained by the instructor and/or the department for the purpose of student assessment and grading, and to support the ongoing accreditation of each Engineering program. This material shall be handled in accordance with the University's *Intellectual Property Policy* and the protection of privacy provisions of *The Freedom of Information and Protection of Privacy Act (Manitoba)*. Students who do not wish to have their work retained must inform the Head of Department, in writing, at their earliest opportunity.

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