University of Manitoba
Faculty of Agricultural & Food Sciences
Department of Biosystems Engineering

COURSE DETAILS

Course Title & Number	Bioprocessing for Biorefining BIOE 4440
Number of Credit Hours:	4
Class Times & Days of Week:	1:30-2:20 pm, MWF; Tutorial: 2:30-5:00 pm, W
Location for classes/labs/tutorials:	Lectures: E2-351 EITC, Tutorials: 300 Human Ecology
Pre-Requisites:	BIOE 2110, BIOE 3320

Instructor Contact Information

Instructor(s) Name:	Stefan Cenkowski, P.Eng. (Professor) and David B. Levin (Professor)
Preferred Form of Address:	We prefer to be addressed as Doctor or Professor
Office Location:	E1-352 EITC (SC), E1-354 EITC (DL)
Office Hours or Availability:	By appointment during working hours (Mon. – Fri.) or email (24/7)
Office Phone No.	474-6293 (SC) 474-7429 (DL)
Email:	Stefan.Cenkowski@umanitoba.ca; David.Levin@umanitoba.ca All email communication must conform to the Communicating with Students university policy. E-mails or phone calls will be returned with 24 hours except for weekends or holidays.
Contact:	Students may contact instructors in person, by e-mail, or by phone. Date and time for consultations will be selected during the 1st tutorial. Instructors will be available to answer short (2-3 min) questions at any time.

Course Description

Bioprocessing engineering is a series of steps that engineers use to guide them as they solve problems. This course will provide students with an understanding of principles involved in the design of proper conditions for processing biomaterials for production of high quality bio-fuels and bioproducts. The content of this course is built on the fundamentals of physics, transport phenomena, thermodynamics, reaction kinetics, and industrial unit operations.

This is an engineering elective course in the Biosystems Engineering program for someone specializing in Bioprocessing. It is intended that students take this course during the fourth year in the program of Biosystems Engineering with interest in the bioprocessing specialization.

General Course Information

This course will help students learn engineering as it applies to processing industry. The syllabus for this course communicates to the students the design of the course including goals, organization, policies, expectations and requirements.

We want students to understand the material and embrace the learning process, therefore; we have designed our course following a concept of building blocks. We typically provide the important points, key area and objectives in class using PowerPoint. Calculation methods are presented and discussed during tutorials. This system enables us to provide clear and systematic lectures notes to ensure the base understanding of the concept is grasped. These notes are available for review on a virtual learning environment, such as UM Learn. We have also prepared a textbook for the course that will enhance the students' learning ability. We encourage students to participate in class and ask clarification questions.

Course Goals

This course deals with upstream bioprocessing technology and 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. The course will assist students in understanding principles involved in the designing aspect of handling and processing parameters of biomaterials.

Intended Learning Outcomes

At the conclusion of the course, the student should be able to:

1) Determine design parameters for:
   - Mixing solids/liquids, gases, fluids, powders, pastas, and agitation processes
   - Drying of biological solids
   - Multi-effect evaporators
   - Filtration and ultrafiltration
   - A biofuel production plant
2) Understand upstream bioprocessing technology for:

- the 1st and 2nd generation of biofuels
- Consolidated bioprocessing
- Energetics of growth, cell yields
- Metabolic engineering

3) Prepare a conceptual design of a grain-based ethanol production plant
- Collaborate with group members in a team setting to manage an engineering design project
- Apply laws and theories to practical solutions
- Communicate orally and in writing a design solution

Using Copyrighted Material

Please respect copyright. We will use copyrighted content in this course. We have ensured that the content we use is appropriately acknowledged and is copied in accordance with copyright laws and University guidelines. Copyrighted works, including those created by us, are made available for private study and research and must not be distributed in any format without permission.

Recording Class Lectures

Dr. Stefan Cenkowski, Dr. David B. Levin and the University of Manitoba hold copyright over the course materials, presentations and lectures which form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission of the instructors. Course materials (both paper and digital) are for the participant's private study and research.

Textbook, Readings, Materials

1. Cenkowski, S, and D. Levin 2016. Bioprocessing for Biorefining (Textbook). The textbook is available from the University of Manitoba Bookstore.
2. Levin, D. 2016 Set of lecture slides posted on UM Learn
3. Cenkowski, S. 2016. Set of lecture slides posted on UM Learn.

Course Technology

It is the general University of Manitoba policy that all technology resources are to be used in a responsible, efficient, ethical and legal manner. The student can use all technology in classroom setting only for educational purposes approved by instructor and/or the University of Manitoba Disability Services. Student should not participate in personal direct electronic messaging / posting activities (e-mail, texting, video or voice chat, wikis, blogs, social networking (e.g. Facebook) online and offline "gaming" during scheduled class time. Please remember to switch your cell phone to vibrate mode to avoid interruptions. Laptops may be used during lectures only for the purpose of taking notes.

The course slides and assignments are posted on UM Learn website: https://universityofmanitoba.desire2learn.com/d2l/login assigned to the course.

Class Communication

The University requires all students to activate an official University email account. For full details of the Electronic Communication with Students please visit: http://umanitoba.ca/admin/governance/media/Electronic_Communication_with_Students_Policy_-_2014_06_05.pdf

Please note that all communication between the instructors and you as a student must comply with the electronic communication with student policy (http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_with_students_policy.html). You are required to obtain and use your U of M email account for all communication between yourself and the university.

Expectations: You Can Expect Us To

Learning is most effective when both the instructor and the student are engaged in the subject material. The role of the teacher, therefore, is to create an environment that facilitates student engagement and learning. In this course, some dissemination of information will occur using the traditional lecture format. However, a substantial portion of the content will be distributed as reading materials, which will be covered using classroom discussion or other learning activities. You can expect us to endeavour to create an active learning environment.

Expectations: We Expect You To

We expect you to be in attendance, and on time, for all scheduled lectures and tutorials. If you must be absent, please show us the courtesy of sending an e-mail notifying us of your absence.

A large part of our teaching practice includes the use of figures, diagrams, equations. We frequently ask questions re the presented material. It is expected that students will interact with us but we do not expect the answers to be perfect.

The University of Manitoba promotes equity in our learning programs. Please see Respectful Work and Learning Environment Policy on the UofM website.

Academic Integrity:
All applicable rules and regulations published in this year's University of Manitoba General Calendar, including those on academic dishonesty, plagiarism, cheating and examination impersonation are to be read and followed (Schedule "A" Policies and Resources). Continued registration in this course implies that you accept and will comply with these conditions.

For individual work and group work for assignments and the design project:

(i) group projects are subject to the rules of academic dishonesty;
(ii) group members must ensure that a group project adheres to the principles of academic integrity, and
(iii) all work is to be completed independently unless otherwise specified.

Students Accessibility Services

Student Accessibility Services (SAS)
If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation.
Student Accessibility Services http://umanitoba.ca/student/saa/accessibility/
520 University Centre
204 474 7423
Student_accessibility@umanitoba.ca

Class Schedule (E2-351 EITC)

This schedule is subject to change at the discretion of the instructor or based on the learning needs of the students. Such changes are subject to Section 2.8 of the – ROASS 2016 - Procedure.

Date	Class Content - Lectures		Readings
Sept.9	1.	Course outline	
Sept. 12	2.	Biofules: Background and rationale	ch. 11
Sept. 14	3.	Bioprocessing for 1st generation of biofuels – bioethanol and biodiesel	ch. 12-13
Sept. 16	4.	Biomass processing for biofuels	ch. 13
Sept. 19	5.	Bioprocessing for 2nd generation of biofuels – cellulosic bioethanol	ch. 14
Sept 21	6.	Unit operations in biomass conversion	ch. 1
Sept. 23	7.	Slurry transport	ch. 2
Sept. 26	8.	Fixed and moving beds	ch. 3
Sept. 28	9.	Fluidized and spouted beds	ch. 3
Sept. 30	10.	Drying systems design	ch. 3
Oct. 3	11.	Theory of mechanism of mixing	ch. 4
Oct. 5	12.	Mixing equipment and operation	ch. 4
Oct. 7		no classes	-
Oct 10		no classes	-
Oct. 12	13.	Power curves	ch. 4
Oct. 14	14.	Power curves	ch. 4
Oct. 17	15.	Evaporation for fluid food concentration	ch. 7
Oct. 19	16.	Evaporation for fluid food concentration	ch. 7
Oct. 21	17.	Filtration	ch. 5
Oct. 24	18.	Filtration equipment	ch. 5
Oct. 26	19.	Constant pressure, constant rate filtration	ch. 5
Oct. 28	20.	Membrane separation	ch. 6
Oct. 31	21.	Evaluation of mass transfer coefficient	ch. 6

Nov. 2	22.	Review of unit operations	ch. 1-7
Nov. 4	23.	Predicting flux in ultrafiltration	ch. 6
Nov. 7	24.	Types of membranes	ch. 6
Nov. 9	25.	Centrifugal separation	ch. 8
Nov. 11		no classes	-
Nov. 14	26.	Centrifugal separation	ch. 8
Nov. 16	27.	Energetics of cell growth & cell yields	ch. 15
Nov. 18	28.	Consolidated bioprocessing	
Nov. 21	29.	Bioreactor design for microbial systems	ch. 17
Nov. 23	30.	Biopolymers and bioplastics	
Nov. 25	31.	Microbial fermentation for PHA production	
Nov. 28	32.	Bioreactor design for eukaryotic systems	ch. 18
Nov. 30	33.	Microalgae production in photo-bioreactors	
	34.	Single cell oils	
Dec. 2	35.	Cell immobilization	
Dec. 5	36.	Review of upstream bioprocessing technology	ch. 11-18
Dec. 7	37.	Review of transport processes	ch. 1-8
Dec. 9	38.	Review for Final Exam (Peer Evaluation due)	

Tutorial Expectations

The tutorials will include numerical examples and determination of process-design parameters. Students are expected to lead in problem solutions. Take home assignments will be given weekly during the tutorial period. A hard copy of the solution to the assignment will be due to the next week submitted at 2:30 pm at the beginning of the tutorial. When the solution is handed in, the front page need to contain the name of the student and the problem assigned. Page two and so on should contain the solutions to the problem(s) including the original equations used with the heading indicating what is being determined or calculated. Also, all the engineering calculations need to have units attached. Assignments will be posted on the UM Learn website: https://universityofmanitoba.desire2learn.com/d2l/login assigned to the course

Tutorial Schedule (Wed. 2:30-5:00 pm, 300 Human Ecology Bldg.)

Date	Lab Content	Readings	Evaluation
Sept. 14	1. Introduction and lab organization	ch. 11-12	Individual
Sept. 21	2. 2nd generation of biofuels	ch. 13-14	assignments
Sept. 28	3. Designing of spouted- and fluidized-bed transport systems	ch. 3	
Oct. 5	4. Design parameters for drying	ch. 3	
Oct. 12	5. Designing parameters in mixing and agitating	ch. 4	
Oct. 19	6. Design parameters for multi-effect evaporators	ch. 7	
Oct. 26	7. Design conditions for filtration (constant pressure, const. rate, cont. filtration)	ch. 5-6	
Nov. 2	8. Midterm examination		Mid-term

Nov. 9	9. Selection parameters for designing of a bio-fuel production plant	ch. 1-8	Group projects
Nov. 16	10. Designing parameters for bio-product production	ch. 11-15	
Nov. 23	11. Group consultation on the design	ch. 16	
Nov. 30	12. Oral presentations of the design (group) projects	ch. 17	
Dec. 7	13. Submission of the design reports	ch. 18	

Course Evaluation Methods

The students learning will be assessed using several different measures: i.e. (i) individual assignments, (ii) a group project report, (iii) group project presentations, (iv) Midterm examination and (v) a final examination. If a student is unable to write a midterm exam due to a medical reason or other justifiable reason, the percentage of the missed midterm-exam will be added towards the final examination and the final exam will be valued at 40%. The basis of the final grade is upon weighting as follows:

Due Date:	Assessment Tool	Value of Final Grade
2:30 pm every Wed.	Assignments	20%
2:30 pm Wed. Nov. 2, 2016	Midterm test	15%
2:30 pm Wed. Nov. 30, 2016	Oral presentation of the group design project	10%
2:30 pm Wed. Dec. 7, 2016	Submission of the group design project	30%
Scheduled by registrar's office	Written final examination	25%

Grading

The grading scale used in this course is shown below:

Letter Grade	Percentage out of 100
A+	92-100
A	85-91
B+	78-84
B	72-77
C+	66-71
C	60-65
D	50-59
F	Less than 50

Referencing Style

When applicable, the referencing should follow the referencing style of the Canadian Biosystems Engineering journal. This will be important when submitting a report on the major designed project.

Assignment Descriptions

Assignments will be posted on the UM Learn Portal and will provide a detailed description of the problem and the format of the solution.

The midterm examination will cover chapters 1-7 and 11-14. All the necessary equations will be given at the beginning of the exam as a handout.

The final examination will cover the entire content of the course. All the necessary equations will be given at the beginning of the exam as a handout.

Assignment Grading Times

Assignments are expected to be the independent work of each student. The assignments will be graded within a week from the submission. Students will receive their graded assignments with the feedback during the next tutorial.

The results of the midterm examination will be available on Nov. 9th 2016 and prior to the voluntary withdrawal deadline (Nov 18, 2016).

Assignment Extension and Late Submission Policy

There will be one week given to complete assignments. Penalties deducted for late assignments and reports will be 10% for each working day. All assignments need to be submitted to pass the course even if the late submission has reduced the value of the assignment to 0%.