The University of Manitoba
Department of Biosystems Engineering

Course Number **BIOE 7110** **Course Title** **Grain Storage**

Academic Session Winter 2023 **Credit Hours** 3

Prerequisites and how they apply to this course
BIOE 2110 Transport Phenomena provides students with: 1) an introduction to the heat and mass transfer inside the biomass materials, 2) basic knowledge on temperature gradients; and 3) experience on Psychometric chart which will be used to explain grain drying and aeration. BIOE 7110 (3 hr/week) will build upon this knowledge. Equivalent knowledge or background is required.

Classroom Location	E2-399
Meeting Days and Class Hours	MWF 9:30 am to 10:20 am
Tutorial and lab	There are labs and students are expect to conduct the lab study and write report.
Student Contact Time (Hrs)	
Lectures:	3 hrs lecture/week × 12 weeks/term = 36 hrs/term
Laboratories:	2 hrs/week × 4 weeks = 8 hrs
Tutorials:	TBA

Instructor Information

Name & Title	Dr. Fuji Jian, P. Eng. Associate Professor
Office Location	E1-352 EITC
Office Phone Number	474-7965
Email Address	**fuji.jian**@umanitoba.ca
Office Hours	Flexible and by appointment

TA: Vimala Bharathi skvb@myumanitoba.ca

Important Dates

Assignment due date	One or two weeks (will be specified)
Feb. 20 to 24	Reading Week: No Classes
Voluntary withdrawal date	Jan. 20
Midterm examination	First week of March (one class time)
Final examination	Arranged by the Department

Course Philosophy

Students' Learning Responsibilities
Attendance for lectures and laboratories is strongly expected. If you must be absent, please show me the courtesy of sending an e-mail notifying me of your absence. To benefit the most from this class, you must be willing to participate in class discussions. You are expected to read the texts and course materials, do assignments independently (even though you are encouraged to discuss with your

classmates and instructor), and understand principles and theories. Deadlines are a reality in the world of engineering; I expect assignments to be completed on time. Finally, please respect both me as instructor and your classmates by turning off your cell phone during class time. Laptops may be used during lectures only if you are taking notes on the laptop.

Why this course is useful?
Any biomaterials will: 1) spoil if not stored under proper conditions; and 2) have a finite storage life even though it is properly stored. The principles and theories delivered in this course can be used to design qualified storage facilities and make sound storage decisions. This course also focuses on practice. Therefore, the lectures, texts, and course materials can be directly used in industrial applications. Laboratory activities are intended to expose students to grain storage practices.

Students' knowledge will be enriched in the following areas: 1) Engineering such as heat and mass transfer, drying, aeration, ventilation, fan selection, air conditioning, material handling, and engineering design; and 2) biology such as stored product insects, mites, moulds and their monitoring and control; ecosystems; and physical properties of biomaterials.

Who should take this course?
Students in Biosystems Engineering and Agriculture with an interest in the storage life of biomaterials.

How this course fits into the curriculum?
It is intended that students take this course at graduate level after they have gained experiences and knowledge on biology, engineering design, heat and mass transfer, and environmental control. This course introduces the students to several fundamental engineering competencies and "solid skills" for grain and biomass storage and handling.

Course Description/Objectives

Instructional Methods
Learning is most effective when both the instructor and the students are engaged in the subject material. The role of the instructor, therefore, is to create an environment that facilitates students' engagement (and therefore learning). In this course, some dissemination of information will occur using the traditional lecture format (PowerPoint presentations). However, a substantial portion of the content will be distributed as reading materials which will be covered using classroom discussion. Therefore, you will be expected to prepare for class by reading the assigned materials. Also you will design and conduct experiments inside lab.

Course Content:
1. Introduction and overview of the postharvest grain industry in Canada. Grain storage in the world. Why storage is needed?
2. Grain physical properties: moisture contents, relative humidity, ERH-EMC curves, specific heat, thermal conductivity, thermal diffusivity, densities, angles of repose, distribution of dockage, and mass and funnel flow.
3. Ecosystem components: respiration of biological materials, pre- and post-harvest fungi, insects, and mites. Mycotoxin in stored grain and oil seeds. Characteristics of grain storage ecosystems. Example of hot spot and storage life.
4. Psychometric chart. Grain depth and air flow resistance, vertical vs horizontal air flow resistance. Grain drying: Principles of drying.
5. Grain temperature: Initial temperatures, temperatures in stored grain bins. Effect of bin diameter and height, initial grain temperature, bin wall material, solar radiation, and geological location.

6. Grain moisture contents: change in moisture content. Moisture migration.
7. Controlled atmosphere storage.
8. Design of non-ventilated storages. Design of aerated storages.
9. Design of near-ambient drying systems.
10. Design of heated-air drying systems.
11. Advanced grain storage practice. Safety and health hazards.

Course Objectives

Students are expected to gain an understanding of the physical (grain physical properties, temperature, moisture, and gas), chemical (chemical materials and chemical reaction such as grain respiration), biological (insects, mites, and microorganisms), and economic variables affecting the preservation and storage of cereal grains, oilseeds, and other agricultural products such as biomass and vegetables. The principles are applied to the design and operating criteria of storage systems. After the completion of the lectures, students should have the knowledge of industrial grain storage practice to maintain quality of grain and their products.

The laboratory work will also provide students with an opportunity to collaborate equitably with group members in a team setting to manage an engineering testing project and write a technical report.

Learning outcomes

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

- Understand fundamental concepts of the grain and biomass storage and handling
    1. Explain the physical, chemical, biological, and economic variables affecting the preservation and storage of cereal grains, oilseeds, and other agricultural products such as biomass and vegetables.
    2. Identify safety concerns during grain and biomass storage and handling.
- Use the principles and theories delivered in this course to solve problems
    1. Evaluate existing storage scenarios to identify condition likely to cause storage losses.
    2. Design storage systems to preserve the quality of grain, oilseeds, and other agricultural products such as biomass and vegetables.
    3. Design suitable drying and aeration systems to store biomaterials under safe storage conditions.

Grade Evaluation

The grade will be based on the assignments, lab performance and reports, and midterm and final examination.

The final grade is the combination of the following grades:

1. 40% on final examination (April 21, 9:00 am to 12:00 pm)
2. 30% on mid-term test
3. 30% on term work, assignments, design project, and laboratory report.

Final letter grades will be assigned on the basis of the overall performance of the class, the spread of the numerical marks, and in comparison, with previous classes.

Description of Assignments

Questions will be assigned weekly or biweekly and will be evaluated for content (Total eight assignments). The reports should be presented in a neat and easy to read format (handwriting is acceptable but prefer printing). The mark of the lab report will be counted as two assignments.

The questions include the understanding of theories, principles, and design works. The design works will be assigned in one assignment (one project). The mark of the design project will be counted as two assignments.

Students are expected to complete their assignments on an individual basis even though discussion with the instructor and classmates are encouraged.

List of the laboratories
1. Tour to grain storage facility, identification of insects, mites, and molds.
2. Design project: design a detail protocol to evaluate grain quality during storage and when the stored grain is delivered to elevators.
3. Experimental project: read publication related to deterioration of wheat and canola during storage. Do the grain quality test and write a report.

Description of Examinations
The mid-term exam is scheduled on the first week of March - the lecture time.
Date of the final exam will be scheduled by the University of Manitoba.
The examinations will be close-book exams. The questions will be similar to those assignments plus descriptive questions on theory and design works. Material presented in class, in laboratories, and in the textbook will be covered.

Texts, Readings, Materials

Textbook(s) – Authors, Titles, Edition
Dr. W. E. Muir. 1999. Grain Preservation Biosystems. Students are required to purchase this text book.
Supplementary Reading
Canadian Grain Storage CD-Rom.
Jian, F., D.S. Jayas. 2022. Grains: Engineering Fundamentals of Drying and Storage. CRC Press, Boca Raton, London, New York. 477-pages.
Additional Materials
Supplied by instructor.

Course Policies

Late Assignments
Will not be accepted and will receive a zero grade.
Missed Assignments
Will receive a zero grade unless student has a valid medical certificate or compassionate reason (see Missed Exams).
Missed Exams
If the midterm or/and final examination is missed and the student has a valid medical certificate or compassionate reason (i.e., death of an immediate family member), a make-up examination will be scheduled by the course instructor. Students who miss the examination without a valid reason will receive a grade of zero for the examination.

Academic Integrity
Plagiarism or any other form of cheating in examinations, term tests or academic work is subject to serious academic penalty. Cheating in examinations or tests may take the form of copying from another student or bringing unauthorized materials into the exam room. Exam cheating can also include exam impersonation. A student found guilty of contributing to cheating in examinations or term assignments is also subject to serious academic penalty. Students should acquaint themselves with the University's policy on plagiarism, cheating, exam impersonation and duplicate submission.

Use of Third Party Detection and Submission Tools
Electronic detection tools may be used to screen assignments in cases of suspected plagiarism.

Group Work Policies:
You will be required to share your laboratorial results with your classmates. If you could not provide your results on time, penalties deducted for late sharing will be 10% per day.

The University of Manitoba

Department of Biosystems Engineering

Supplemental Course Information for BIOE 7110

All courses in the Biosystems Engineering program are expected to contribute, in some way, to the development of one or more of the 12 graduate attributes that have been identified by the Canadian Engineering Accreditation Board. The graduate attributes which will be emphasized and evaluated in this course have been defined below for your information:

- **A Knowledge Base for Engineering**

Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.

- **Problem Analysis**

An ability to use appropriate knowledge and skills to identify, formulate, analyze, and solve complex engineering problems in order to reach substantiated conclusions.

- **Investigation**

An ability to conduct investigations of complex problems by methods that include appropriate experiments, analysis and interpretation of data, and synthesis of information in order to reach valid conclusions.

- **Design**

An ability to design solutions for complex, open-ended engineering problems and to design systems, components or processes that meet specified needs with appropriate attention to health and safety risks, applicable standards, and economic, environmental, cultural and societal considerations.

- **Use of Engineering Tools**

An ability to create, select, apply, adapt, and extend appropriate techniques, resources, and modern engineering tools to a range of engineering activities, from simple to complex, with an understanding of the associated limitations.

- **Individual and Team Work**

An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.

- **Communication Skills**

An ability to communicate complex engineering concepts within the profession and with society at large. Such ability includes reading, writing, speaking and listening, and the ability to comprehend and write effective reports and design documentation, and to give and effectively respond to clear instructions.

To maintain the accreditation of our Biosystems Engineering program, it is a requirement that student competency with respect to the 12 graduate attributes be assessed. To enable such assessment to occur in a meaningful manner, the Faculty of Engineering and representatives from industry developed a comprehensive list of indicators for each of the 12 graduate attributes. The indicators being formally assessed in BIOE 4420 are shown in the table below.

The ultimate goal of mapping the course evaluation to graduate attributes and indicators is the identification of potential deficiencies in the Biosystems Engineering program so that continuous improvement can occur. Data generated from this course will be compiled with data collected from other sources (i.e., other courses, SEEQ surveys, exit surveys, co-op surveys) to facilitate on-going review and improvement of the Biosystems Engineering curriculum.

Mapping of Course Evaluation to Graduate Attributes & Indicators

Grade Component	Specific Evaluation Point	Graduate Attribute [b]	Indicators Being Assessed [b]
Assignments (15%)	Assignment 1	1. Knowledge base 2. Problem analysis	1.15 Specialized Discipline-specific Engineering Concepts 2.2 Contextualize problem
	Assignment 2	1. Knowledge base 2. Problem analysis	1.15 Specialized Discipline-specific Engineering Concepts 2.2 Contextualize problem
	Assignment 3	1. Knowledge base 2. Problem analysis	2.2 Contextualize problem 2.8 Evaluate solution
	Assignment 4	1. Knowledge base 2. Problem analysis	2.2 Contextualize problem 2.8 Evaluate solution
	Assignment 5	1. Knowledge base 2. Problem analysis	2.2 Contextualize problem 2.8 Evaluate solution
	Assignment 6 (marks as two assignments)	4. Design 5. Use of engineering tools	4.3 Implementing design strategy 4.4 Evaluating final design 5.2 Identify and use tools
	Assignment 7 (marks as two assignments)	4. Design 5. Use of engineering tools	4.3 Implementing design strategy 4.4 Evaluating final design 5.2 Identify and use tools
Laboratory (15%)	Design testing procedure	3. Investigation 4. Design	3.9 Procedure 4.2 Problem solving
	Conduct testing	5. Use of engineering tools 6. Individual and teamwork 3. Investigation	5.2 Identify and use tools 6.2 Time management 6.7 Working with others 3.10 Data/evidence collection
	Lab report	3. Investigation 7. Communication skills	3.11 Data presentation and error analysis 3.12 Evaluation of experiment 7.10 Formatting/layout/design of communication
Midterm Examination (30%)	Part A and B	1. Knowledge base 2. Problem analysis 5. Use of engineering tools	1.15 Specialized Discipline-specific Engineering Concepts 2.2 Contextualize problem 2.8 Evaluate solution 5.2 Identify and use tools
	Part C	4. Design	4.2 Problem solving 4.3 Implementing design strategy
Final Examination: (40%)	Part A and B	1. Knowledge base 2. Problem analysis 5. Use of engineering tools	1.15 Specialized Discipline-specific Engineering Concepts 2.2 Contextualize problem 2.8 Evaluate solution 5.2 Identify and use tools
	Part C	4. Design	4.2 Problem solving 4.3 Implementing design strategy

COVID-19

The University of Manitoba (the "UM") is committed to maintaining a safe learning environment for all students, faculty, and staff. Should campus operations change because of health concerns related to the COVID-19 pandemic or other campus-wide emergency, it is possible that this course will move to a fully remote delivery format. Should the instructor be required to stay at home for an extended period and an alternate instructor not be available, the course may move temporarily to a remote delivery format. In that instance, you may be provided with an asynchronous option to minimize the impact the change may have on your schedule.

PPE and Mask Wearing

In a face-to-face environment, our commitment to safety requires students to observe all physical distancing (2m) and personal protective equipment (PPE) guidelines set by the University (https://umanitoba.ca/coronavirus)

While on campus and in class, you must wear PPE (Personal Protective Equipment) as stipulated in current University policies, procedures, and guidelines. Students who fail to comply are subject to disciplinary action in accordance with the Student Discipline Bylaw and the Non-Academic Misconduct and Concerning Behaviour Procedure.

Medical-grade 3-ply masks are available at many locations on campus, including specific classroom locations, designated by your unit, the Elizabeth Dafoe Library (Fort Garry Campus) and the Brodie Centre main doors (Bannatyne Campus). Additional PPE, if necessary for a specific learning environment, will be provided to you by the teaching unit.

If you do not follow masking and other requirement you will be asked to leave the learning space and may only return to the class already in progress when you have complied with these requirements. Repeated issues will result in disciplinary action as previously noted.

Students should not eat or drink during class time.

Illness

Remember: **STAY HOME IF YOU HAVE SYMPTOMS OR ARE ILL.** If you become sick or are required to self-isolate you should notify your instructor by email so you can develop a plan to complete the course learning outcomes while you are absent.

If you have symptoms, do not come to campus or any UM facilities. Complete the self-assessment on the Manitoba Public Health site and follow the guidelines, which may include booking a COVID-19 test.

What to do if you become ill while at UM:

1. Leave the classroom, lab or workspace immediately. Continue to wear your mask while leaving the premises and/or while waiting for transportation.

2. Perform hand hygiene (soap and water or hand sanitizer) and avoid contact with others, and minimize contact with the physical environment.

3. Once at home, complete the MB self-assessment and follow the directions that are provided.

4. Inform your supervisor(s), instructor(s) or, if in residence, the appropriate individual.

5. You must remain off campus and all UM facilities until cleared to return in accordance with self-assessment, testing results, or MB Health requirements.

For 24/7 mental health support, contact the Mobile Crisis Service at 204-940-1781.

Student Counselling Centre
Contact SCC if you are concerned about any aspect of your mental health, including anxiety, stress, or depression, or for help with relationships or other life concerns. SCC offers crisis services as well as individual, couple, and group counselling. *Student Counselling Centre:* http://umanitoba.ca/student/counselling/index.html
474 University Centre or S207 Medical Services
(204) 474-8592

Student Support Case Management
Contact the Student Support Case Management team if you are concerned about yourself or another student and don't know where to turn. SSCM helps connect students with on and off campus resources, provides safety planning, and offers other supports, including consultation, educational workshops, and referral to the STATIS threat assessment team.
Student Support Intake Assistant http://umanitoba.ca/student/case-manager/index.html
520 University Centre
(204) 474-7423

University Health Service
Contact UHS for any medical concerns, including mental health problems. UHS offers a full range of medical services to students, including psychiatric consultation.
University Health Service http://umanitoba.ca/student/health/
104 University Centre, Fort Garry Campus
(204) 474-8411 (Business hours or after hours/urgent calls)

Health and Wellness
Contact our Health and Wellness Educator if you are interested in peer support from *Healthy U* or information on a broad range of health topics, including physical and mental health concerns, alcohol and substance use harms, and sexual assault.
Health and Wellness Educator https://umanitoba.ca/student/health-wellness/welcome-about.html
britt.harvey@umanitoba.ca

Live Well @ UofM
For comprehensive information about the full range of health and wellness resources available on campus, visit the Live Well @ UofM site:
http://umanitoba.ca/student/livewell/index.html

Your rights and responsibilities

As a student of the University of Manitoba you have rights and responsibilities. It is important for you to know what you can expect from the University as a student and to understand what the University expects from you. Become familiar with the policies and procedures of the University and the regulations that are specific to your faculty, college or school.

The Academic Calendar http://umanitoba.ca/student/records/academiccalendar.html is one important source of information. View the sections *University Policies and Procedures* and *General Academic Regulations*.

While all of the information contained in these two sections is important, the following information is highlighted.

- If you have questions about your grades, talk to your instructor. There is a process for term work and final **grade appeals**. Note that you have the right to access your final examination scripts. See the Registrar's Office website for more information including appeal deadline dates and the appeal form http://umanitoba.ca/registrar/

- You are expected to view the General Academic Regulation section within the Academic Calendar and specifically read the **Academic Integrity** regulation. Consult the course syllabus or ask your instructor for additional information about demonstrating academic integrity in your academic work. Visit the Academic Integrity Site for tools and support http://umanitoba.ca/academicintegrity/ View the **Student Academic Misconduct** procedure for more information.

- The University is committed to a respectful work and learning environment. You have the right to be treated with respect and you are expected conduct yourself in an appropriate respectful manner. Policies governing behavior include the:

Respectful Work and Learning Environment

http://umanitoba.ca/admin/governance/governing_documents/community/230.html

Student Discipline
http://umanitoba.ca/admin/governance/governing_documents/students/student_discipline.html and,

Violent or Threatening Behaviour
http://umanitoba.ca/admin/governance/governing_documents/community/669.html

- If you experience **Sexual Assault** or know a member of the University community who has, it is important to know there is a policy that provides information about the supports available to those who disclose and outlines a process for reporting. The **Sexual Assault** policy may be found at: http://umanitoba.ca/admin/governance/governing_documents/community/230.html More information and resources can be found by reviewing the Sexual Assault site http://umanitoba.ca/student/sexual-assault/

- For information about rights and responsibilities regarding **Intellectual Property** view the policy

  http://umanitoba.ca/admin/governance/media/Intellectual_Property_Policy_-_2013_10_01.pdf

For information on regulations that are specific to your academic program, read the section in the Academic Calendar and on the respective faculty/college/school web site http://umanitoba.ca/faculties/

Contact an **Academic Advisor** within our faculty/college or school for questions about your academic program and regulations http://umanitoba.ca/academic-advisors/

Student Advocacy

Contact Student Advocacy if you want to know more about your rights and responsibilities as a student, have questions about policies and procedures, and/or want support in dealing with academic or discipline concerns.
http://umanitoba.ca/student/advocacy/
520 University Centre
204 474 7423
student_advocacy@umanitoba.ca