The University of Manitoba
Department of Biosystems Engineering

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

Academic Session Fall 2023 **Credit Hours** 3

Prerequisites and how they apply to this course
BIOE 3110 Heat transfer in Biosystems 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.

Classroom Location J.H. Ellis 342
Meeting Days and Class Hours TR 2:30 am to 3:45 pm
Lab Location Lab Hours There are labs each week. The time will be decided after discussion with the class.

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 (he/him), P. Eng. Associate Professor
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Office Hours Please make an appointment

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Important Dates

Assignment due date	One or two weeks (will be specified)
Nov. 13-17, 2023	Reading Week: No Classes
Voluntary withdrawal date	Nov. 21, 2023
Midterm examination	Nov. 21, Tuesday (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. 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.
5. Grain moisture contents: change in moisture content. Moisture migration.

6. Controlled atmosphere storage.
7. Psychometric chart. Grain depth and air flow resistance, vertical vs horizontal air flow resistance.
8. Grain drying: Principles of drying.
9. Design of non-ventilated storages. Design of aerated storages.
10. Design of near-ambient drying systems.
11. Design of heated-air drying systems.
12. Advanced grain storage practice. Safety and health hazards. Monitoring of stored grain.

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. Conduct experiment every two weeks. Write a report.

Description of Examinations
The mid-term exam is scheduled after the reading break - 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)
Dr. W. E. Muir. 1999. Grain Preservation Biosystems.
Additional Materials
Supplied by instructor.
Jian, F., D.S. Jayas. 2022. Grains: Engineering Fundamentals of Drying and Storage. CRC Press, Boca Raton, London, New York. 477-pages.

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.

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Deferred Final Examinations

Students who miss the regularly scheduled writing of a final examination for valid medical or compassionate reasons will only be allowed to write a deferred exam if the Associate Dean (Undergraduate) approves the request. All requests for a deferred examination *must* be made within 48 hours of the missed exam and follow the procedure described on the Faculty website without exception. Course Instructors *do not have the discretion* to grant deferred final examinations.

Deferred Exam Policy (student experience website)