The University of Manitoba
Faculty of Agricultural and Food Sciences

Course Title: Agricultural Buildings and Environments

Department: Biosystems Engineering **Course Number:** BIOE 0700

Academic Session: Winter 2024 **Credit Hours:** 4

Prerequisites and how they apply to this course: None

Classroom Location: 138 Agriculture

Meeting Days and Class Hours: MWF 11:30 -12:20

Lab Location: 138 Agriculture **Lab Hours:** F 2:30 -3:20

Department Office Location: E2-376 EITC **Phone Number:** 204-474-6033

Instructor Information

Name & Title: Dr. Qiang (Chong) Zhang, Professor, P.Eng.
Email Address: Qiang.Zhang@umanitoba.ca
Office Location: E1-339 EITC
Office Phone: 204-474-9819
Office Hours: Flexible. You may stop by office or contact me by phone or email. Emails sent after business hours will not likely be answered until the next day.

Teaching Assistant(s) (if applicable): Ellery Burton

TA Office Hours and Location: Flexible in-person, or by email (burtone2@myumanitoba.ca)

Course Philosophy

Students' Learning Responsibilities

Learning is most effective when both the teacher and the student are engaged in the subject material. The role of the teacher is to create an environment that facilitates students' engagement and learning. Students are expected to attend classes and labs, participate in class discussions, complete assignments, and write tests and the final examination with academic integrity and honesty. Students are encouraged to suggest topics for discussion where the situation or problem is related to the subject matter of the lectures.

Why this course is useful?

Digital technologies are playing a more and more important role in agriculture. This course focuses on the applications of digital technologies in controlled environment for livestock and crop production, covering such topics as precision livestock farming (PLF), controlled environment agriculture (CEA) (for crop production), and smart vertical farming (SVF). This course will provide students with fundamental knowledge of controlled environment and digital technologies. Students will acquire skill sets of selecting and using digital technologies in controlled environment systems for animal and crop production.

Who should take this course?

This course is of value to a wide range of students who wish to work in the livestock and greenhouse sectors.

Course Description/Objectives

Undergraduate Calendar Description

Factors that impact the practicality of farm buildings. Components of buildings, including materials and construction techniques. Techniques of maintaining building environments to facilitate production and/or storage.

Instructional Methods

The course is delivered by lectures with in-class discussion. Controlled environment systems for animals and plants, digital technologies, and data collection and analysis will be demonstrated and/or explained through lab activities for students to gain knowledge and hands-on experiences in selecting and using technologies.

Course Objectives

To assist/facilitate students to:

- understand the concept, principles, and benefits of controlled environment systems for animal and crop production;
- understand the impact of digital technologies on livestock farming and indoor crop production;
- understand the principles of environment sensing in PLF and SVF;
- gain the knowledge of sensors commonly used in PLF and SVF;
- understand the principles of data (information) analysis and integration in PLF and SVF;
- become familiar with digital technologies available for various livestock operations;
- become familiar with digital technologies available for smart vertical farming;
- gain knowledge and skills of selecting and using digital technologies for PLF and SVF.

Learning outcomes

- understanding how controlled environment systems work;
- understanding how digital technologies can improve the efficiency in livestock farming and controlled environment agriculture for crop production;
- understanding how the digital technologies can be used to optimize the environment for animals and plants;
- understanding how the digital technologies can be used to reduce resource usage (energy, labour, water, etc.) in livestock farming and controlled environment crop production;
- understanding how the digital technologies in PFL are used to improve animal health and welfare, as well as the product quality;
- understanding the technical challenges of VSF in cold climates;
- understanding how smart sensors work in PLF and SVF;
- understanding sensor networking (IoT);
- knowing the basics of data analytics in PLF and SVF;
- knowing the currently available technologies for PLF and SVF.

Grade Evaluation

Mid-term test	15%
Lab reports and assignments	15%
Group project	20%
Final Examination	50%

Grading

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

Important Dates

Mid-term test	February 14, 2024
Voluntary withdrawal date	March 20, 2024
Final examination	(to be scheduled)

Descriptions of Assignments, Lab Reports, and Examinations

- There will be weekly assignments or lab reports throughout the term.
- Assignments and lab reports shall be neatly laid out and all intermediate and final answers clearly highlighted. The detailed working out of the solution must also be included.
- There will be one (1) midterm examination and one (1) final examination in this course. The midterm examination will be 1.0-hour long and closed-book. The final examination will be 2-hour long and closed-book, covering the entire course.

Texts, Readings, Materials

Textbook(s)

None

Supplementary Reading

1. Precision Livestock Farming Applications, edited by Ilan Halachmi, Wageningen Academic Publishers, https://doi.org/10.3920/978-90-8686-815-5.
2. Kozai, Toyoki, et al. Plant Factory: An Indoor Vertical Farming System for Efficient Quality Food Production. Academic Press (imprint of Elsevier), 2016. https://doi.org/10.1016/C2018-0-00969-X.
3. Kozai, Toyoki. Smart Plant Factory: The Next Generation Indoor Vertical Farms. 1st ed., Springer Singapore Pte. Limited, 2018, https://doi.org/10.1007/978-981-13-1065-2.

Lecture Notes

Lecture notes (pdf files) will be posted on UM Learn for download.

Course Policies

Late Assignments

Late submission of assignments (including lab reports) will be accepted up to 7 days (including weekends and holidays) following the due date. Each late day after the due date will result in 10% reduction of the marks for each individual assignment. Assignments submitted after 7 days will have no credits.

Missed Examinations

There is NO make-up examination for the missed mid-term examination! If missed for a valid medical or compassionate reason, marks for the missed mid-term examination will be added to the final examination. Students who miss the examination without a valid reason will receive a grade of zero (0) for the mid-term examination.

If a student misses the final examination, she/he will be assigned an F No Paper grade for the course unless an acceptable medical certificate or a confirmable compassionate reason is provided, in which case a supplementary examination will be arranged.

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. Examination cheating can also include examination impersonation. A student found guilty of contributing to cheating in examinations or 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 (Academic Integrity | University of Manitoba (umanitoba.ca)).

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

Students are allowed to discuss assignments and labs with each other, but the individual assignments and reports must be independently completed. Copying or joint production of assignments and reports will result in all involved students receiving zero marks.

Other Requirements/Regulations

- All email communication must conform to the Communicating with Students university policy.
  - *Communicating with Students*
- Self-declaration forms may be completed for missed tests, exams, or assignments during short-term absences (≤72 hours) for extenuating circumstances. 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*.
  - *General 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

Course Content

1. Introduction
    1.1. Concept of controlled environment for animal and crop production (CEACP)
        1.1.1. Animal production environment
        1.1.2. Indoor crop production environment
    1.2. Digital technologies for CEACP
2. Basics of controlled environment
    2.1. Heat transfer
    2.2. Psychrometrics
    2.3. Light
3. Environmental control for animal facilities
    3.1. Sensible heat balance
    3.2. Moisture and air contaminant balance
    3.3. Heating and ventilation
4. Precision (smart) livestock farming (PLF)
    4.1. Challenges in livestock farming and benefits of PLF
    4.2. Framework of PLF
    4.3. Added values of PLF to farmers and adaptation of PLF by farmers
    4.4. Sensing and sensors in PLF
        4.4.1. Environment sensing
        4.4.2. Animal behavior sensing
        4.4.3. Animal health sensing
        4.4.4. Animal product sensing
        4.4.5. Types of sensors in PLF
        4.4.6. Sensor networks, IoT, and cloud computing
    4.5. Data analytics
        4.5.1. Sensor data fusion
        4.5.2. Pattern recognition
        4.5.3. Big data
        4.5.4. Statistical analysis
        4.5.5. Model-based or prediction-based control of processes
        4.5.6. Digital twins
    4.6. PLF technologies for specific livestock operations
5. Controlled environment for indoor crop production
    5.1. Environmental requirements by plants
    5.2. Overview of indoor crop production systems
        5.2.1. Greenhouses
        5.2.2. (Smart) vertical farming (SVF) (smart plant factory)
    5.3. Soilless crop production

5.4. Framework of smart vertical farming
5.5. Sensing and sensors in SVF
    5.5.1. Thermal environment and HVAC
    5.5.2. Lighting
    5.5.3. Nutrients
    5.5.4. Crop growth
    5.5.5. Disease detection
5.6. Data analytics for SVF
5.7. Application examples of SVF

6. Controlled environment in grain storage (added after in-class discussion)

Labs:

1. Construct and test an indoor plant growing system
2. Tour of SiAF: smart vertical farming
3. Tour of greenhouses in Plant Science, or livestock facilities at Glenlea Research Station
4. Tour of T.K. Cheung Centre: environmental control in livestock production facilities
5. Environmental control model demonstration
6. Guest lecture: animal behavior in PLF
7. Accelerometer for sensing motion behavior
8. Sound analysis of animals