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

Course Outline

BIOE 3590 Mechanics of Materials in Biosystems
Fall 2023

Course Instructor
- Dr. Qiang Zhang, P.Eng. (he/him)
  E1–339 EITC
  (204) 474–9819
  Qiang.Zhang@UManitoba.ca

Student Hours
- Dr. Zhang will be present during lecture
- Office hours: open door

Lab Instructor
- Mr. Derek Inglis, P. Eng. (he/him)
  A206 Agriculture Engineering Building
  (204)474-7964
  Derek.Inglis@umanitoba.ca

Student Hours
- Mr. Inglis will be present during lab
- Office hours: open door

Teaching Assistant
- Mr. Kenton McCorquodale-Bauer
  mccorquk@myumanitoba.ca

Student Hours
TBA

Location
- **E2-320 EITC Building**
  Lectures, MWF 10:30 – 11:20 AM
- **322 Human Ecology Building**
  Labs, T 2:30 – 3:45 PM (B01)
  T 4:00 – 5:15 PM (B02)

Contact Hours
- 4 credit hours
- Lectures:
  3 hours x 12 weeks = 36 hours
- Lab Time:
  1.5 hours x 12 weeks = 18 hours

Prerequisites:
- BIOE 2800 or CIVL 2800

Course Website:
http://umanitoba.ca/umlearn

Course Objectives
- to gain the knowledge of mechanical behavior of materials in biosystems and understand how the theories of mechanics of materials are applied to predict the mechanical behavior of materials.
- to learn how to conduct physical tests to assess the mechanical properties of materials.

Course Content
Lecture topics

1. Introduction
   1.1. The role of mechanics of materials in design
   1.2. Material behavior and modes of failure
2. Elastic and inelastic behavior of materials
   2.1. Linear elastic behavior under uniaxial loading
   2.2. Nonlinear and inelastic behavior
   2.3. Yield criteria
   2.4. Fracture mechanisms
3. Mechanical behavior of materials in biosystems
   3.1. Steel
   3.2. Concrete
   3.3. Wood
   3.4. Bone
   3.5. Other materials
4. Flexural analysis of beams
   4.1. Serviceability of beam
   4.2. Beam deflection equations
   4.3. Methods of deflection analysis
5. Stability analysis of columns
   5.1. Stability of structures
   5.2. Euler's formula
   5.3. Lateral support
   5.4. Column design
6. Introduction to energy methods in structural analysis
   6.1. Strain energy
   6.2. Work-energy method
   6.3. Castigliano's theorem

Lab topics:
- Calibration of loading frame
- Tensile test of steel and aluminum
- Structural failures (videos)
- Concrete making
- Compression and bending test of wood
- Concrete testing
- Bone testing
- Beam deflection test
- Stability test of column
- Site tours

Course Delivery
The course will be delivered using a combination of lectures and hands-on labs. The materials presented include a wide range of design engineers may be involved with, including steel; wood; concrete; bone; and other biological materials and composites.

Traditional Territories Acknowledgement

The University of Manitoba campuses are located on the original lands of the Anishinaabeg, Cree, Oji-Cree, Dakota, and Dene peoples, and on the homeland of the Métis Nation.

We respect the Treaties that were made on these territories, we acknowledge the harms and mistakes of the past, and we dedicate ourselves to move forward in partnership with Indigenous communities in a spirit of reconciliation and collaboration.

Accreditation Details

Accreditation Units

- Mathematics: 0%
- Natural Science: 0%
- Complementary Studies: 0%
-
- Engineering Science: 100%
- Engineering Design: 0%

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)

Ongoing pandemic note: The Department of Biosystems Engineering has devised a plan so that there is minimal impact on the delivery and content of the course, should the instructor fall sick and is unable to continue lectures in-person. Please be assured that the alternative plan outlining any deviation from the normal mode of instruction will be communicated to you as quickly as possible if/when the need arises.

Recommended Reading

1. Mechanics of Materials, Ferdinand P. Beer et al., McGraw-Hill.
2. Advanced Mechanics of Materials, Boresi et al., John Wiley & Sons, Inc.
3. **LECTURE NOTES (PDF FILES) WILL BE POSTED ON UM LEARN FOR DOWNLOAD.**

Learning Outcomes

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

No.	Learning Outcome
1	apply the knowledge of material behaviour in designing machines, structures, and other engineering systems
2	understand the mechanisms of material failure under loads
3	conduct common mechanical tests for assessing material behaviour, including uniaxial tension and compression, and three-point bending; write test report
4	characterize mechanical behaviour of materials in biosystems, such as steel, wood, concrete, and bones
5	understand the relationship between the mechanical behaviour and physical, chemical and biological properties of the material
6	perform flexural analysis of beams
7	perform stability analysis of columns

Graduate Attribute Competency Levels Developed

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
1	1	1	1									
2	3	3										
3		3	3				2					
4	3	3	3									
5	2		2									
6	3	3										
7	3	3										

CEAB Graduate Attributes Assessed

KB.3 – Recalls and defines, and/or comprehends and applies information, first principles and concepts in fundamental engineering science.
PA.3 – Analyzes and solves complex engineering problems.
IN.3 – Interprets results and reaches appropriate conclusions
CS.2 – Designs and produces appropriate engineering documents (i.e., research reports, engineering reports, design documents, graphics).

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 year-to-year grading consistency.

Letter	Mark
A+	92–100
A	85–91
B+	78–84
B	72–77
C+	66–71
C	60–65
D	50-59
F	< 50

Important Dates

- **Early Withdrawal Deadline**
  September 19, 2023
- **National Day for Truth and Reconciliation**
  Mon. Oct. 2, 2023
  No classes or examinations
- **Thanksgiving**
  Mon. Oct. 9, 2023
  No classes or examinations
- **Mid-term examination**
  October 31 (2:30-4:30 pm)
- **Fall Term Break**
  Nov. 13-17, 2023
  No classes or examinations
- **Remembrance Day (observed)**
  Mon. Nov. 13, 2023
  No classes or examinations
- **Voluntary Withdrawal Deadline**
  November 21, 2023
- **Last Day of Classes**
  Mon. Dec. 11, 2023

Evaluation

Component	Value (%)	Assessor	Method of Feedback*	Learning Outcomes Evaluated	I/T**
Final examination	50	Instructor	S	1,2,3,4,5,6,7	I
Midterm examination	20	Instructor	S, F	1,2,3,4,5	I
Lab reports	25	TA	S, F	1,2,3,4,5,6,7	T
Assignments	5	TA	S, F	1,2,3,4,5,6,7	I

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

** I/T: **I** – Individual effort, **T** – A team effort

Descriptions of Lab Reports, Assignments, and Examinations

A significant element of this course is testing various materials to determine their mechanical properties. Weekly lab reports will be required to analyze and summarize the test results. In each report, you will be asked to describe the test apparatus and procedure, perform data analysis, present the test results, and use the theories learned in the lectures to discuss/explain the results. The reports are to be typed, following the format below:

1. Title page
2. Description of apparatus and procedure
3. Data analysis (you must show sample data and calculations)
4. Results and discussion

NOTE: Data plots only are required. The data files compiled on the data acquisition (DAQ) system need not be submitted with the lab reports. Use only metric units in your reports.

You will be given assignments for each topic covered in the course. Assignments will be posted and submitted through UM Learn.

Lab reports and assignments are required be completed on time. The lab reports and assignments are normally due one week after assigned to you. **Submissions after the due date will be docked 10% per day**. All lab reports must be submitted to pass the course.

There will be one (1) midterm examination and one (1) final examination in this course. The midterm examination will be scheduled before the VW deadline. The final examination will be based on 80% of the materials covered after the midterm and 20% before the midterm. The examinations will be closed book, and a formula sheet will be provided to you.

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

- All email communication must conform to the Communicating with Students university policy.

Communicating with Students

- As the Instruction Team, we will do our best to respond to all emails **within 48 hours during working hours** (8:30 AM – 5:30 PM Monday thru Friday). Ex. A Friday night email may not be responded to until the following Tuesday.
- 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 Form for Brief or Temporary Absence

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

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

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)

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 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.

Copyright Notice

Copyright Office