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

Course Outline

# BIOE 3590 Mechanics of Materials in Biosystems

Fall 2022


### Instruction Team

- Mr. Jean-Christophe Habeck, MSc. PhD Candidate, EIT (he/him)
  Sessional Instructor
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- Dr. Mashiur Rahman, Senior Instructor (he/him)
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### Student Hours

- Mondays 11:30AM – 3:00PM
- Individual assistance is always available by appointment – stop by Mon, Wed, Fri, email, or text.

### Teaching Assistant

- Kenton McCorquodale-Bauer
  mccorquk@myumanitoba.ca

### Locations

- **Lectures E2-150 EITC**
  M, W, F 10:30 - 11:20AM
- **Labs 322 Human Ecology**
  T 2:30 - 3:45PM (B01)
  T 4:00 - 5:15PM (B02)

### Contact Hours

- 4 credit hours
- Lectures:
  3 hours x 12 weeks = 36 hours
- Laboratories:
  1.25 hours x 12 weeks = 15 hours

### Prerequisites:

- BIOE 2800 Solid Mechanics or CIVL 2800 Solid Mechanics 1

### Course Website:

http://umanitoba.ca/umlearn

## Course Objectives

The intent of this course is to:

- Provide students with the knowledge of mechanical behaviour of materials in biosystems.
- Provide students with opportunities to learn how to conduct physical tests to assess the mechanical properties of materials and understand how the theories of mechanics of materials are applied to predict the mechanical behaviour of materials.

## Course Content

In this course students will be exposed to both the theory and physical behaviour of materials when subjected to loads. The course will be delivered using a combination of lectures and hands-on labs. The materials presented include a wide range of design biosystems engineers may be involved with, including steel; wood; concrete; bone and other biological materials and composites.

Mechanics of materials is the foundation to other senior level courses in Biosystems Engineering. In designing structures, machines, and other engineering systems, it is critical to know if the materials used meet the requirements of design, such as load carrying capacity. From this course students will learn how various materials respond to loads imposed on them; how the physical, chemical, and biological properties of the materials affect the response of materials to loads; and how to conduct tests to assess mechanical properties of materials.

**How does this course fit into the curriculum?**

Students take this course in the third year of their program after completing a basic mechanics course (BIOE 2800 Solid Mechanics) and before taking engineering design electives. This course gives the students tools for selecting and assessing materials in designing structures, machines, and other engineering systems in biosystems.

The following topics will be covered:

1. Introduction
   1.1. The role of mechanics of materials in design
   1.2. Characteristics of materials in biosystems
2. Review of selected topics in Solid Mechanics
   2.1. Stresses and strains
   2.2. Stress-strain relations for linear elastic materials (Hooke's law)
3. Elastic and inelastic behaviour of materials
   3.1. Linear elastic behaviour under uniaxial loading
   3.2. Nonlinear and inelastic behaviour
   3.3. Failure (yield) criteria
4. Mechanical behaviour of materials in biosystems
   4.1. Steel
   4.2. Concrete
   4.3. Bone
   4.4. Flexible materials
   4.5. Other materials of interest
5. Flexural analysis of beams
   5.1. Serviceability of beams
   5.2. Beam deflection equations
   5.3. Methods of deflection analysis
6. Stability analysis of columns
   6.1. Stability of structures
   6.2. Euler's formula

## Important Dates

- **Early Withdrawal Deadline**
  September 20, 2022
- **National Day for Truth and Reconciliation**
  September 30, 2022
  No classes or examinations
- **Thanksgiving**
  October 10, 2022
  No classes or examinations
- **Midterm Exam**
  Tuesday, November 1, 2022
  (2:30 – 4:30)
  No lab that day
- **Fall Term Break**
  November 7-10, 2022
  No classes or examinations
- **Remembrance Day**
  November 11, 2022
  No classes or examinations
- **Voluntary Withdrawal Deadline**
  November 22, 2022
- **Last Day of Classes**
  December 12, 2022

6.3. Lateral support
6.4. Column design

7. Introduction to energy methods in structural analysis
   7.1. Strain energy
   7.2. Work-energy method
   7.3. Castigliano's theorem

Laboratories:

1. Calibration of a loading frame (Sept 13th)
2. Tensile test of structural steel and aluminum (Sept 20th)
3. Concrete mix design, *3 weeks curing time* (Sept 27th)
4. Tour of Textile Labs (Oct 4th)
5. Tour of Structures Lab and Sustainability in Action Facility (Oct 11th)
6. Compression test of concrete cylinders (Oct 18th)
7. Compression and bending test of wood (Oct 25th)
8. **Midterm Exam (Nov 1st)**
9. **Fall Term Break**
10. Three-point bending test of bones (Nov 15th)
11. Beam deflection test (Nov 22nd)
12. Stability test of wood column (Nov 29th)
13. **Guest visitor talk, tentative (Dec 6th)**

## Textbook, Readings, Materials

Required textbook – None

Supplementary Reading

1. Mechanics of Materials, Ferdinand P. Beer et al., McGraw-Hill
2. Advanced Mechanics of Materials, Boresi et al., John Wiley & Sons, Inc.

Additional Materials

Lectures notes (pdf files) and lab videos will be posted on UM Learn for download

## Learning Outcomes

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

| No. | Learning Outcome | Transferable Skill |
|---|---|---|
| 1 | Apply the knowledge of material behaviour in designing machines, structures, and other engineering systems | Knowledge Base |
| 2 | Understand the mechanisms of material failure under loads | Knowledge Base |
| 3 | Use the failure (yield) criteria in design | Knowledge Base; Problem Analysis |
| 4 | Conduct common mechanical tests for assessing material behaviour, including uniaxial tension and compression, and three-point bending and deliver reports on findings | Knowledge Base; Engineering Tools; Investigation |
| 5 | Characterize mechanical behaviour of materials in biosystems, such as steel, wood concrete, fabrics, and bones, and deliver repots on findings | Knowledge Base; Engineering Tools; Investigation |
| 6 | Understand the relationship between the mechanical behaviour and physical, chemical, and biological properties of the material | Knowledge Base |
| 7 | Perform flexural analysis of beams | Problem Analysis |
| 8 | Perform stability analysis of columns | Problem Analysis |

## Accreditation Details

- 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 teamwork
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)

## 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 consistency of grading from year-to-year.

| 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 |

## Expected Competency Levels

| Outcome | KB | PA | IN | DE | ET | IT | CS | PR | IE | EE | EP | LL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 3 | | | | | | | | | | | |
| 2 | 3 | | | | | | | | | | | |
| 3 | 3 | 3 | | | | | | | | | | |
| 4 | 3 | | 3,4 | | 3 | | | | | | | |
| 5 | 3 | | 3,4 | | 3 | | | | | | | |
| 6 | 3 | | | | | | | | | | | |
| 7 | | 3 | | | | | | | | | | |
| 8 | | 3 | | | | | | | | | | |

## CEAB Graduate Attributes Assessed

KB.3 – Recalls, defines, comprehends, and applies information and concepts in fundamental engineering science (Advanced)

PA.3 – Analyzes and solves engineering problems (Advanced)

IN.3 – Interprets results and reaches appropriate conclusions (Intermediate)

IN.4 – Understands appropriate safe work procedures during experiments or lab exercises (Intermediate)

ET.3 – Uses hands-on tools (Intermediate)

## Evaluation

| Component | Value (%) | Assessor | Method of Feedback* | Learning Outcomes Evaluated | I/T** |
|---|---|---|---|---|---|
| Final Exam | 30 | INS | S | KB | I |
| Midterm | 20 | INS | S | KB | I |
| Lab reports | 40 | TA | F, S | KB, IN, PA | T |
| Assignments | 10 | TA | F, S | PA | I |

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

** I/T: **I** – Individual effort, **T** – Team effort

## Description of Lab Reports and Assignments

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 (Includes Lab Title, Date Conducted, Date Submitted, Submitted by, Submitted to)
2. Description of apparatus and procedure (essentially a methodology section, be very clear in your explanation of the procedure and the materials and tools required to perform the lab)
3. Data analysis (you must show sample data and calculations)
4. Results, discussion, and summary conclusion

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.

Four assignments will be given to you over the term as well as a practice assignment for the final exam. Assignments will be posted and submitted through UM Learn.

## Assignment Extension and Late Submission Policy

Deadlines are a reality in the world of engineering; we expect reports and assignments to be completed on time. The reports and assignments are due one week after assigned to you. Submission after the due date will be docked 10% per day. All lab reports must be submitted to pass the course. There will be no "make-up" midterm exam; students who miss the midterm with a reasonable explanation will have the value of the final examination increased by the appropriate percentage.

## Examination Description

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. Approximately 80% of the final examination questions will be based on the materials covered after the midterm and 20% before the midterm.

## 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

- No programmable devices or systems (such as calculators, PDAs, iPods, iPads, cell phones, smart watches, wireless communication, or data storage devices) are allowed in examinations unless approved by the course instructor.
- All email communication must conform to the Communicating with Students university policy.

*Communicating with Students*

- Attending lectures and laboratories is essential for the successful completion of this course.
- Self-declaration forms may be completed for missed tests, exams, or assignments during short-term absences (≤72 hours) for extenuating circumstances. Students don't need to share personal information about their situation beyond declaring the nature of the extenuating circumstance on the self-declaration form.

*Self-Declaration Form for Brief or Temporary Absence*

- 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*, as well as Section 3 of the Faculty of Engineering *Academic Regulations* dealing with incomplete term work, deferred examinations, attendance, and withdrawal.

*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*

## Should the instructor fall ill

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.

## 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/or 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.

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