University of Manitoba
Faculty of Agricultural & Food Sciences
Department of Biosystems Engineering

Course Details

Course Title & Number:	BIOE 3590 Mechanics of Materials in Biosystems
Number of Credit Hours:	4
Class Times & Days of Week:	Lectures: MWF 10:30-11:20 Labs: T 2:30-3:45 (B01), 4:00-5:15 (B02)
Location for classes/labs/tutorials:	Lectures: WebEx (through UM Learn); Labs: WebEx
Pre-Requisites:	BIOE 2800 Solid Mechanics or CIVL 2800 Solid Mechanics 1

Course Description:
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.

Instructor Information

Instructor(s) Name:	Dr. Qiang (Chong) Zhang, P.Eng. (Professor) You may address me as Dr. Zhang
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Instructor(s) Name:	Mr. Derek Inglis, P. Eng. (Instructor) You may address me as Mr. Inglis
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Teaching Assistants:	Mostafizur Rahman
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General Course Information

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 the 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, i.e., 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.

Course Goals

The intent of this course is to:

- provide students with the knowledge of mechanical behavior 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 behavior of materials.

Intended Learning Outcomes

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

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) use the failure (yield) criteria in design
4) conduct common mechanical tests for assessing material behaviour, including uniaxial tension and compression, and three-point bending
5) characterize mechanical behaviour of materials in biosystems, such as steel, wood, concrete, and bones
6) understand the relationship between the mechanical behaviour and physical, chemical and biological properties of the material
7) perform flexural analysis of beams
8) perform stability analysis of columns

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

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

Using Copyrighted Material

Please respect copyright. We will use copyrighted content in this course. The content used is appropriately acknowledged and is copied in accordance with copyright laws and University guidelines. Copyrighted works, including those created by us, are made available for private study and research and must not be distributed in any format without permission.

Recording Class Lectures

Dr. Qiang Zhang, Dr. Derek Inglis and the University of Manitoba hold copyright over the course materials, presentations and lectures that form part of this course. No audio or video recording of lectures or presentations is allowed in any format, openly or surreptitiously, in whole or in part without permission from Dr. Qiang Zhang and Dr. Derek Inglis. Course materials (both paper and digital) are for the participant's private study and research.

Course Technology

This course is delivered on-line through WebEx, which is a web conferencing tool that is integrated within UM Learn. The instructions for using WebEx can be found on UM Learn. All course materials, including lecture notes and lab videos, will be available through UM Learn.

Class Communication

The University requires all students to activate an official University email account. For full details of the Electronic Communication with Students please visit:
http://umanitoba.ca/admin/governance/media/Electronic_Communication_with_Students_Policy_-_2013_09_01_RF.pdf

Please note that all communication between you as a student and your instructors/TAs must comply with the electronic communication with student policy (http://umanitoba.ca/admin/governance/governing_documents/community/electronic_communication_with_students_policy.html). You are required to obtain and use your U of M email account for all communication between yourself and the university.

Expectations: You Can Expect Us To

Learning is most effective when both the teacher and the student are engaged in the subject material. The role of the teacher, therefore, is to create an environment that facilitates student engagement and learning. In this course, dissemination of fundamental knowledge will occur using the traditional lecture format. However, a substantial portion of the content will be delivered through hand-one labs, by conducting physical tests and interpreting the test results.

Expectations: We Expect You To

We expect you to be in attendance, and on time, for all scheduled lectures and labs. If you must be absent, please show us the courtesy of sending an e-mail notifying us of your absence. To benefit the most from this class, you are required to actively participate in lab activities and be willing to participate in class discussions.

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. Electronic detection tools may be used to screen assignments in cases of suspected plagiarism.

Students Accessibility Services

Student Accessibility Services

If you are a student with a disability, please contact SAS for academic accommodation supports and services such as note-taking, interpreting, assistive technology and exam accommodations. Students who have, or think they may have, a disability (e.g. mental illness, learning, medical, hearing, injury-related, visual) are invited to contact SAS to arrange a confidential consultation.

Student Accessibility Services http://umanitoba.ca/student/saa/accessibility/
520 University Centre
204 474 7423
Student_accessibility@umanitoba.ca

Class & Lab Schedule

A preliminary schedule is provided below. The schedule is subject to change at the discretion of the instructors and/or based on the learning needs of the students but such changes are subject to Section 2.8 of the ROASS Procedure.

Topic	Lecture hours
1. Introduction	2
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	1
2.1. Stresses and strains	
2.2. Stress-strain relations for linear elastic materials (Hooke's law)	
3. Elastic and inelastic behavior of materials	6
3.1. Linear elastic behavior under uniaxial loading	
3.2. Nonlinear and inelastic behavior	
3.3. Failure (yield) criteria	
4. Mechanical behavior of materials in biosystems	18
4.1. Steel	
4.2. Concrete	
4.3. Wood	
4.4. Bone	
4.5. Other materials	
5. Flexural analysis of beams	6
5.1. Serviceability of beam	
5.2. Beam deflection equations	
5.3. Methods of deflection analysis	
6. Stability analysis of columns	4
6.1. Stability of structures	
6.2. Euler's formula	
6.3. Lateral support	
6.4. Column design	
7. Introduction to energy methods in structural analysis	2
7.1. Strain energy	

7.2. Work-energy method
7.3. Castigliano's theorem

Laboratory:

1. Calibration of loading frame
2. Tensile test of structural steel and aluminum
3. Concrete mix design
4. Compression test of concrete cylinders
5. Compression and bending test of wood
6. Three-point bending test of bones
7. Beam deflection test
8. Stability test of wood column

Important Dates:

October 12:	No class – Thanksgiving Day
November 3:	Midterm exam (2**:30 pm -4:30 pm**)
November 9-13:	No class – Fall term break
November 23:	Last date for Voluntary Withdrawal for fall term courses.

Course Evaluation Methods

The basis for evaluation is established by agreement at the beginning of each term. Typical weights assigned to various components of the work are:

Final examination	30%
Midterm examination	20%
Lab reports	30%
Assignments	10%
Lab quiz	10%

Grading

The grading scale used for this course is shown below.

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

Descriptions of Lab Reports, Assignments and Lab Quizzes

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.

There will be in-class discussion after each lab testing, followed by a quiz. The quiz questions will be designed to assess your understanding of the testing procedures performed in the lab and the phenomena observed during testing.

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. The final examination will be based on 80% of the materials covered after the midterm and 20% before the midterm. The examinations will be open book and conducted on-line.

Supplemental Course Information for BIOE 3590

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 12 graduate attributes have been defined below for your information.

Graduate Attributes

1. **A Knowledge Base for Engineering:** Demonstrated competence in university level mathematics, natural sciences, engineering fundamentals, and specialized engineering knowledge appropriate to the program.
2. **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.
3. **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.
4. **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.
5. **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.
6. **Individual and Team Work:** An ability to work effectively as a member and leader in teams, preferably in a multi-disciplinary setting.
7. **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.
8. **Professionalism:** An understanding of the roles and responsibilities of the professional engineer in society, especially the primary role of protection of the public and the public interest.
9. **Impact of Engineering on Society and the Environment:** An ability to analyze social and environmental aspects of engineering activities. Such ability includes an understanding of the interactions that engineering has with the economic, social, health, safety, legal, and cultural aspects of society, the uncertainties in the prediction of such interactions; and the concepts of sustainable design and development and environmental stewardship.
10. **Ethics and Equity:** An ability to apply professional ethics, accountability, and equity.
11. **Economics and Project Management:** An ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations.
12. **Life-long Learning:** An ability to identify and address their own educational needs in a changing world in ways sufficient to maintain their competence and to allow them to contribute to the advancement of knowledge.

While there are likely some aspects of many of these attributes that can be found in this course, the attributes being emphasized in this course are: 1) *A Knowledge Base for Engineering, 2) Problem Analysis, 3) Investigation.*

Mapping of Course Evaluation to Graduate Attributes & Indicators

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 3590 are shown in the table below.

The ultimate goal of mapping the course evaluation in specific courses 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.

Grade Component	Specific Evaluation Point	Graduate Attribute	Indicators Being Assessed
Examinations (70%)	Midterm examination	A Knowledge Base for Engineering; Problem Analysis; Investigation	Fundamental concepts of mechanics of materials. Problem solving. Connecting and Integrating theories of mechanics and practical engineering problems.
	Final examination	A Knowledge Base for Engineering; Problem Analysis; Investigation	Fundamental concepts of mechanics of materials. Problem solving. Connecting and Integrating theories of mechanics and practical engineering problems.
Laboratory testing of materials (25%)	Lab reports	Problem Analysis; Investigation	Ability to prepare physical samples to conduct the lab. Ability to use testing/measurement apparatuses. Ability to follow experimental procedures and control variables. Ability to record raw data and make meaningful observations. Ability to present data using charts, tables and/or graphs to facilitate understanding and interpretation, including error analysis. Ability to interpret results, compare them to literature values, identify limitations and weaknesses, and suggest improvements. Ability to organize evidence to reveal patterns, differences and/or similarities. Ability to state conclusions and make recommendations as a result of the investigation. Ability to identify limitations and implications.
Assignments (5%)	Assignments	Problem Analysis; Investigation	Problem Solving