Course Outline

BIOE 2800 Solid Mechanics

Winter 2023

Instruction Team

- Mr. Jean-Christophe Habeck, MSc. PhD Candidate, EIT (he/him)
  Sessional Instructor
  E1–351 EITC
  (204) 204-880-7146
  umhabeck@myumanitoba.ca

Student Hours

- Tuesdays 11:30AM – 2:30PM
- E1-351 (Dr. Morrison's Lab)
- Individual assistance is always available by appointment – speak with or email me to schedule an appointment

Teaching Assistant

- Mahdi Alaei-Varnosfaderani
  mahdi.alaeivarnosfaderani@umanitoba.ca

Locations

- **Lectures E3-270 EITC**
  T, TR, 10:00 - 11:15AM
- **Tutorials E2-125**
  W 2:30 – 4:20PM

Contact Hours

- 4 credit hours
- Lectures:
  3 hours x 12 weeks = 36 hours
- Tutorials:
  2 hours x 12 weeks = 24 hours

Prerequisites:

- ENG 1440/1441 Introduction to Statics
- MATH 1710/1700/1701 Applied Calculus

Course Website:

http://umanitoba.ca/umlearn

Course Objectives

The intent of this course is to:

- Provide students with knowledge of analyzing stress-strain behavior of deformable bodies under typical loading conditions.

Course Content

Solid Mechanics is a fundamental engineering course covering the principles that constitute the foundations upon which other more advanced and related courses are built. This course establishes a working knowledge of the relationships between applied loads to a deformable body or a structure and the deformations (strains) and stresses developed in the body or the structure.

How does this course fit into the curriculum?

Students take this course in the second year of their program. This course gives the students fundamental knowledge of stress-strain analysis, which is required for an advanced course of Mechanics of Materials in Biosystems. The combination of these two mechanics courses provides a foundation for analyzing load response behaviour of materials in designing structures, machines, and other engineering systems.

The following topics will be covered:

1. Introduction
2. Chapter 1 – Properties of Plane Areas
   - 2.1. Centroid of an arbitrary area
   - 2.2. Moment of Inertia of an area
   - 2.3. Parallel axis theorem
3. Chapter 2 – Stress and Strain
   - 3.1. Static equilibrium and free body diagrams
   - 3.2. Internal forces and stresses
   - 3.3. Deformations and strains
   - 3.4. Stress-strain relationship and Hooke's Law
   - 3.5. Allowable stresses and factor of safety
4. Chapter 3 – Axially-loaded members
   - 4.1. Basic theory of axial deformation
   - 4.2. Thermal effects on axial deformation
   - 4.3. Saint Venant's principle and stress concentration
5. Chapter 4 - Torsion
   - 5.1. Geometry and deformation
   - 5.2. Stress distribution and equilibrium equations
   - 5.3. Twisting moment and angle of twist
   - 5.4. Torsion of thin-walled tubes
   - 5.5. Comparison with axially-loaded members
6. Chapter 5 – Shear force and bending moment diagrams
   - 6.1. Bending moments and shear force diagrams for beams
   - 6.2. BMD and SFD by graphics
   - 6.3. How to construct the SFD and BMD
   - 6.4. BMD using the Method of Superposition
7. Chapter 6 – Stresses due to bending
   - 7.1. Pure bending
   - 7.2. Stresses in symmetric beams
   - 7.3. Shear stress distribution in symmetric beams
   - 7.4. Combined loads

Important Dates

- **Early Withdrawal Deadline**
  January 20, 2023
- **Midterm Exam 1**
  Wednesday, February 15, 2023
  (2:30 – 4:00)
- **Louis Riel Day**
  February 20, 2023
  No classes or examinations
- **Winter Term Break**
  February 21-24, 2023
  No classes or examinations
- **Voluntary Withdrawal Deadline**
  March 22, 2023
- **Midterm Exam 2**
  Wednesday, March 29, 2023
  (2:30 – 4:00)
- **Good Friday**
  April 7, 2023
- **Last Day of Classes**
  April 12, 2023

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 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)

8. Chapter 7 – Stress and strain transformation
   - 8.1. State of stress at a point in an arbitrary loaded member
   - 8.2. Principal stresses and maximum shear stresses
   - 8.3. Mohr's Circle for plane stress
   - 8.4. Principal stresses and the absolute maximum shear stress in 3-D
   - 8.5. Thin-walled pressure vessels
   - 8.6. State of strain at a point
   - 8.7. Principal strains and maximum shear strain
   - 8.8. General stress-strain relationship for isotropic materials

Textbook, Readings, Materials

Required textbook – None

Supplementary Reading

1. Mechanics of Materials, Ferdinand P. Beer et al., McGraw-Hill

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	Understand internal forces incurred from external loads	Knowledge Base
2	Understand the concept of stress and strain	Knowledge Base
3	Be able to determine axial force and deformation of an axially-loaded member	Knowledge Base; Problem Analysis
4	Be able to calculate stresses and twisting of a bar subjected to torsion	Knowledge Base; Problem Analysis
5	Know the behaviour of a beam subjected to loading	Knowledge Base
6	Be fluent in constructing shear force diagrams (SFD) and bending moment diagrams (BMD)	Knowledge Base; Problem Analysis; Use of engineering tools
7	Be able to evaluate bending (normal) and shear stresses in a beam	Knowledge Base; Problem Analysis
8	Be able to calculate the state of stress at different points of a structure due to combine loading	Knowledge Base; Problem Analysis
9	Be able to evaluate the principal stresses/strains, maximum shear stress/strain using stress/strain transformation equations or Mohr's Circle	Knowledge Base; Problem Analysis; Use of engineering tools

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										
5	3											
6	3	3			3							
7	3	3										

Outcome	KB	PA	IN	DE	ET	IT	CS	PR	IE	EE	EP	LL
8	3	3										
9	3	3			3							

CEAB Graduate Attributes Assessed

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

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

ET.3 – Uses engineering tools – SFD, BMD and Mohr's Circle (Intermediate)

Evaluation

Component	Value (%)	Assessor	Method of Feedback*	Learning Outcomes Evaluated	I/T**
Final Exam	40	INS	S	KB, PA	I
Midterm 1	20	INS	S	KB, PA	I
Midterm 2	20	INS	S	KB, PA	I
Assignments & Tutorials	20	TA	FS	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

Assignment and Tutorial Description

1. Weekly assignments will be posted on UM Learn and tutorials will be distributed at the beginning and handed in at the end of each tutorial session.
2. Solutions of assignment/tutorial problems shall be **neatly laid out** and all intermediate and final **answers clearly highlighted/boxed**. The detailed working out of the solution must also be included.
3. Solutions must be written on **one side of each page only**.
4. A declaration form (will be posted on UM Learn) has to be filled, signed and attached to each assignment submission.
5. Late submission of assignments will be accepted up to 5 days (including weekend 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 5 days will have no credit.
6. If you wish to discuss your mark, please make an appointment to discuss the matter with the Teaching Assistant **no later than 2 weeks** after receiving your grade. If after meeting with the TA you still wish to discuss the mark, I am available for an appointment.

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

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 two (2) midterm examinations and one (1) final examination in this course. The first midterm examination will be scheduled before the VW deadline. Exams will be closed book. Lecture notes, books, and other references will not be allowed. One formula sheet (one sided 8.5 x 11") written and signed by the student (and student #) will be allowed and handed in at the end of the examination.

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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