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| | **MECH 260**, Mechanics of Materials<br>Course Syllabus, Term1, 2021 |

**Course Overview**

This course is intended to be a core course in the Engineering. This course reviews core issues necessary for engineering design: When applying forces to an object, how much will it deform and when will it break? After completion of this course, students will learn fundamental topics in solid mechanics: Equilibrium, statically determinate frames and trusses, shear force and bending moment diagrams, normal and shear stresses and strains, the theory of beam bending, torsion of circular rods, the transformation of stress and strain, Mohr's circle, stress in thin-walled pressure vessels, failure criteria, beam deflections, buckling of columns, Energy method and Castigliano's theorem and stress measurement technique using strain gage as well as other fundamental topics.

Students will master these topics through solving many problems, assignments and 3 exams.

Credit: 3

**Course description for calendar:**

Equilibrium, statically determinate frames and trusses, shear force and bending moment diagrams, normal and shear stresses and strains, the theory of beam bending, torsion of circular rods, shearing stress in beams and shear center, the transformation of stress and strain, Mohr's circle, stress in thin-walled pressure vessels, failure criteria, beam deflections, column buckling; Castigliano's theorem, statically indeterminate problems

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| Instructor: Ahmad Mohammadpanah<br>Contact: mpanah@mail.ubc.ca | Date/Time |

**Pre-Requisite:** Either (a) all of MATH 101, PHYS 170 or (b) all of APSC 172, APSC 173, APSC 180.

Co-Requisite: -

**Required Textbook:**

Statics and Mechanics of Materials: An Integrated Approach, 2nd Edition

William F. Riley, Leroy D. Sturges, Don H. Morris

Other requirements:

Note: This course is restricted to students in ENPH program.

Note: This course is equivalent of MECH 260 + MECH 360

**Course Format**

The course will be delivered through lectures supported by application examples in mechanical engineering and a plethora of structures in different fields. A standard mechanics of materials text book will be used, and complementary lecture materials will be distributed to the students. This course will be delivered in 11 Modules:

**Module 1:** Review of basics concepts, Free-Body-Diagrams and basic statically determinate problems

**Module 2:** Stress and Strain axial loading

**Module 3:** Structures: Frames, Machine, Trusses

**Module 4:** Geometrical Properties (Center of Area and Moment of Inertia)

**Module 5:** Beams (Shearing and Bending Diagram, Theory of beam bending, Beam deflection, Statically indeterminate beams), Composite/Sandwich beams, Plastic bending

**Module 6:** Torsion

**Module 7:** Shearing stress in Beams and Shearing center

**Module 8:** Combined Loading (Stress under combined loading, Stress Transformation, Mohr's circle)

**Module 9:** Energy Method and Castigliano's theorem, Statically indeterminate probelems

**Module 10:** Failure Criteria

**Module 11:** Buckling

## Course Objectives

After completion of this course, students will learn fundamental topics in solid mechanics: Equilibrium, statically determinate frames and trusses, Shear force and bending moment diagrams, normal and shear stresses and strains, the theory of beam bending, torsion of circular rods, the transformation of stress and strain, Mohr's circle, stress in thin-walled pressure vessels, failure criteria, energy method for solving determinate and indeterminate problems, column buckling and stress measurement technique using strain gage as well as other fundamental topics.

## Learning Outcomes

- Draw Free Body Diagrams for a rigid body, and write the equilibrium equations to find the reactions at the support
- Compute the internal reactions for structures such as Trusses, Frames, and Machines
- Describe a Tensile test, Module of Elasticity and other physical properties of a material, such as Poisson's ratio.
- Compute normal stress and deformation for a flexible body under axial loads
- Draw the shearing and bending diagram for a beam under lateral loading, compute bending and shearing stress, and a beam deflection
- Compute shearing stress under Torsional loading for circular and non-circular rods
- Compute stress under combined loading
- Calculate principal stresses
- Use basic failure criteria, such as Von Mises, Tresca, to compute the Factor Safety of a part under combined loading
- Familiar with buckling
- Use Castigliano's theorem to calculate deformation of statically determinate or indeterminate problem
- Use a strain gage to measure strain and compute stress for a structure under static loading

**Evaluation Criteria**

The assessment strategy for this course is typical of many engineering courses, as we routinely assess students on the basis of their ability to recall and apply relevant facts and theories, to perform calculations correctly and evaluate their responses for plausibility, to demonstrate competence in design methodologies, and to be able to communicate technical information effectively.
Assignments allow students to practice and apply newly learned techniques. They are frequently calculation-based and thus quite mathematical in nature. The topics in this course build upon each other, and so material presented early in the term is critical to the understanding of material presented later in the term. Giving some weight to weekly or bi-weekly assignments encourages students to practice the material covered in the course consistently throughout the term, which improves the overall outcome for the students. Because the students do have the ability to work

with others and seek help during office hours, the emphasis on the assignments will be on achieving the correct solutions for the given problems.

After each Module Quizzes (11 in total), plus two Midterms during the term give the students an opportunity to demonstrate their knowledge in a controlled testing environment and may include a combination of calculation-based problems and illustration of knowledge of relevant facts. The after-each-Module-Quiz will be used to assess the students' understanding of the fundamental theorems and concepts before moving on to the next module. The first midterm will be on topics in Module 1-3, and the second midterm on Module 5-7.

The cumulative final exam (covers all the topics in modules 1-11) verifies that students have mastered a majority of the material covered in the class, again in a controlled environment where it is clear that the work is that of an individual student. Grading of the final exam will be based on both appropriate methods and correctness of final solution. Some problems on the final exam may serve to assess only one of the stated learning outcomes and others may serve to assess a multiple learning outcome in combination, thus giving the ability to assess the capacity of the students to solve both simple and complex problems.

**Grading scheme:**

Module Quizzes: 10%

Midterm 1: 15%

Midterm 2: 15%

Final Exam: 60%

**Required Reading and Videos**

For each module, short videos will be recommended to watch prior the lectures. Specific section of the course textbook will also be recommended for reading for each module (see the Table below).

The course instructor would be remiss in his duty if he neglects to underscore the fact that learning the concepts in each module is demanding and takes time. One Key in true and lasting knowledge in this course is practicing many problems. Luckily, the recommended textbook contains a plethora of practice problems.

Examples from industry will also be used to show how these theories and concepts may apply in practice. Demos such as strain gage measurement, will be sued to teach some stress measurement techniques. For complex topics videos and illustrations will also be used.

**Course Schedule** *(tentative)*

| | **Topics** | **Required Reading from Textbook** |
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| Week 1 | Module 1 | • **Chapter 2:**<br>  ○ Sections 2.1, 2.2, and 2.3<br>  ○ Example Problems: 2.1, 2.5<br>• **Chapter 3:**<br>  ○ Sections 3.1, 3.2, and 3.3<br>  ○ Example Problems: 3.2, 3.5<br>• **Chapter 5:**<br>  ○ Section 5.1<br>  ○ Example Problems: 5.1, 5.2 |
| Week 2 | Module 2 | **Chapter 4:**<br>• All Sections<br>• Example Problems: All examples |
| Week 3 | Module 3 | **Chapter 6:**<br>• Sections: 6.1, 6.2, 6.3, 6.5,<br>• Example Problems: 6.1, 6.2, 6.3, 6.4, 6.5, 6.6, 6.7, 6.8, 6.9, 6.10, 6.11, 6.12, 6.17 |
| Week 4 | **Midterm 1**<br>Module 4 | Three geometrical properties of an area, Center of an area, Second Moment of Inertia, and Polar Moment of Inertia are studied in this Module.<br>**I. Centroid of an area**: To study this topic, the lecture notes are given in the class is enough. If you want to study more, read section 5.8 from Chapter 5<br>**II. Second Moment of Inertia:** To study this topic, the lecture notes are given in the class is enough. If you want to study more, read from Chapter 8, Section 8.4 and example 8.1<br>**Polar Moment of Inertia:** To study this topic, the lecture notes are given in the class is enough. |
| Week 5 | Module 5 | **I. Distributed Loads**<br>• Sections to Study: 5.10<br>• Example Problems: 5.22<br>**II. Bending Moment Diagram**<br>• Sections to Study: 8.6, 8.7 |

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| | | • Example Problems: 8.7, 8.8, 8.9, 8.10<br>**III. Bending Stress**<br>• Sections to Study: 8.1, 8.2, 8.3, 8.4, 8.5<br>Example Problems: 8.1, 8.4, 8.6<br>**IV. Beam Deflection**<br>• Sections to Study: 9.1, 9.2, 9.3<br>• Example Problems: 9.1 |
| Week 6 | Module 6 | **Chapter 7:**<br>• Sections: 7.1, 7.2, 7.3, 7.4<br>• Example Problems: 7.1, 7.2, 7.3, 7.4 |
| Week 7 | Module 7 | **Chapter 8:**<br>• Section 8-8 |
| Week 8 | **Midterm 2**<br>Module 8 | • **Stress at a General Point:**<br>o The class lecture notes<br>o Examples solved in the class<br>• **General Hook's Law:**<br>o The class lecture notes<br>o Examples solved in the class<br>• **Plane (Two Dimensional) Stress:**<br>o The class lecture notes<br>o Examples solved in the class<br>• **Stress Transformation:**<br>o Section 10.4 from Chapter 10<br>o Examples solved in the class |
| Week 9 | continue<br>Module 8 | • **Principal Stresses and Maximum Shearing Stress:**<br>o Section 10.5 from Chapter 10<br>o Example Problems: 10.3<br>• **Mohr's Circle**<br>o Sections: 10.6<br>o Example Problems: 10.5<br>• **Stress in Thin-Walled Pressure Vessels**<br>o Sections: 10.13<br>o Example Problems: 10.11<br>• **Combined Loading**<br>o Section 10.14<br>o Example Problems: 10.12, 10.13,<br>**Measurement of Strain (Strain Rosette)**<br>• In class demo; Materials for reading will be posted on Canvas. |
| Week 10 | Module 9 | Reading materials will be available on Canvas notes. |

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| Week 11 | Module 9 | Reading materials will be available on Canvas notes. |
| Week 12 | Module 10 | **Design Criteria**<br>• Section 10.15<br>• Example Problems: 10.15, 10.17 |
| Week 13 | Module 11 | **Columns Buckling**<br>• Section 11.2<br>• Section 11.6 |
| Week 14 | Review | - Review problems will be posted on Canvas. |

**Academic Integrity**

The academic enterprise is founded on honesty, civility, and integrity. As members of this enterprise, all students are expected to know, understand, and follow the codes of conduct regarding academic integrity. At the most basic level, this means submitting only original work done by you and acknowledging all sources of information or ideas and attributing them to others as required. This also means you should not cheat, copy, or mislead others about what is your work. Violations of academic integrity (i.e., misconduct) lead to the breakdown of the academic enterprise, and therefore serious consequences arise and harsh sanctions are imposed. For example, incidences of plagiarism or cheating may result in a mark of zero on the assignment or exam and more serious consequences may apply if the matter is referred to the President's Advisory Committee on Student Discipline. Careful records are kept in order to monitor and prevent recurrences.
A more detailed description of academic integrity, including the University's policies and procedures, may be found in the Academic Calendar at

http://calendar.ubc.ca/vancouver/index.cfm?tree=3,54,111,0.