SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ONTARIO

SAULT COLLEGE

COURSE OUTLINE

COURSE TITLE: STRENGTH OF MATERIALS II

CODE NO. : MCH202 **SEMESTER:** SIX

PROGRAM: MECHANICAL TECHNOLOGY

AUTHOR: MARK S. SEELER

DATE: JAN 2011 **PREVIOUS OUTLINE DATED:**

APPROVED: *"Corey Meunier"*

CHAIR **DATE**

TOTAL CREDITS: FOUR

PREREQUISITE(S): MCH103 - STRENGTH OF MATERIALS

HOURS/WEEK: THREE

I. COURSE DESCRIPTION:

This course is an extension of MCH103 and will elaborate on concepts from the prerequisite. Concepts that will be covered are shear force and bending moment diagrams in beams, flexure formula, shearing stresses due to bending, design of beams, materials, testing, columns.

II. LEARNING OUTCOMES AND ELEMENTS OF THE PERFORMANCE:

Upon successful completion of this course, the student will demonstrate the ability to:

1. Design Properties of Materials

Potential Elements of the Performance:

- Identify and be able to apply properties of metals for mechanical design applications
- Define and explain important failure modes
- Identify, categorize and apply classifications of metals and alloys
- Identify and describe conditions for steel
- Identify and describe applications for the following materials
    - a) Cast Iron
    - b) Aluminum
    - c) Copper, Brass and Bronze
    - d) Zinc, Magnesium and Titanium
    - e) Non Metals in Engineering Design such as wood, concrete. Plastics and composites

2. Stress Due To Bending

Potential Elements of the Performance:

- To learn the statement of the flexure formula and to apply it properly to compute maximum stress due to bending at the outer fibers of the beam
- Compute the stress at any point within the cross section of the beam and to explain the variation of stress with position of the beam
- Understanding of the conditions on the use of the Flexure formula
- Understanding of the concepts that it is necessary to ensure that the beam does not twist under the influence of the bending loads
- Define the neutral axis and understand that is is coincident with the centroidal axis of the cross section of the beam
- Understand the derivation of the flexure formula and the importance of the moment of inertia to bending stress

- Determine the appropriate design stress for use in designing beams
- Design beams to carry a given load safely
- Define and apply the section modulus of the cross section of the beam
- Identify and select standard structural shapes for use as beams
- Understand when it is necessary to use the stress concentration factors in the analysis of stress due to bending and to apply appropriate factors properly
- Define the flexural center and explain its proper use in the analysis of stress due to bending

3. Shearing Stresses in Beams

Potential Elements of the Performance:

- Define the conditions under which shearing stresses are created in beams
- Compute the magnitude of shearing stresses in beams by using the general shear formula
- Define and evaluate the statical moment required in the analysis of shearing stresses
- Identify where the maximum shearing stress occurs on the cross section of a beam
- Compute the shearing stress at any point within the cross section of a beam
- Describe the general distribution of shearing stress as a function of position within the cross section of a beam
- Understand the basis for the development of the general shearing stress formula
- Describe four design applications where shearing stresses are likely to be critical in beams
- Develop and use special shear formulae for computing the maximum shearing stress in beams having rectangular or solid circular cross sections
- Understand the development of the approximate relationships for estimating the maximum shearing stress in beams having cross sections with tall thin webs or those with thin walled hollow tubular shapes
- Specify a suitable design shearing stress and apply it to evaluate the acceptability of a given beam design
- Define shear flow and compute its value
- Use the shear flow to evaluate the design of fabricated beam sections held together by nails, bolts, rivets, welding or other means of fastening

4. Combined Stress and Mohr's Circle

Potential Elements of the Performance:

- Recognize cases for which combined stress occurs
- Represent the stress condition on a stress element
- Understand the development of the equations for combined stresses, from which you can compute the following
    a) the maximum and minimal principle stresses
    b) the orientation of the principle stress element
    c) the maximum shear stress on an element
    d) the orientation of the maximum shear stress element
    e) the normal stress that acts along with the maximum shear stress
    f) the normal and shear stress that occurs on the element oriented in any way
- Construct and apply Mohr's circle for biaxial stress
- Interpret the information available from Mohr's circle for the stress condition at a point in any orientation
- Use the data from the Mohr's circle to draw the principal stess element and the maximum shear stress element
- Compute the combined normal stress resulting from the application of bending stress with either direct tensile or compressive stresses using the principle of superposition
- Recognize the importance of visualizing the stress distribution over the cross section of a load-carrying member and considering the stress condition at a point
- Recognize the importance of free-body diagrams of components of structures and mechanisms in the analysis of combined stresses
- Evaluate the Design factor for combined normal stress
- Optimize the shape and dimensions of a load-carrying member relative to the variation stress in the member and its strength properties
- Analyze members subjected to combined bending and torsion only by computing the resulting maximum shear stress

5. Deflection in Beams

Potential Elements of the Performance:

- Understand the need for considering beam deflections
- Understand the development of the relationships between the manner of loading and support for a beam and the deflection of the beam
- Graphically show the relationships among the load, shearing force, bending moment, slope, and deflection curves for beams

- Develop formulae for the deflection of beams for certain cases using the successive integration approach
- Apply the method of successive integration to beams having a variety of loading and support conditions
- Use the standard formulae to compute the deflection of beams at selected points
- Use the principle of superposition along with standard formulae to solve problems of greater complexity
- Use the moment-area method to solve for the slope and deflection or beams

6. **Statically Indeterminate Beams**

<u>Potential Elements of the Performance:</u>

- Define Statically determinate and statically indeterminate
- Recognize statically indeterminate beams from given descriptions of the loading and support conditions
- Define continuous beam
- Define supported cantilever
- Defined fixed end beam
- Use established formulae to analyze certain types if statically indeterminate beams
- Use superposition to combine simple cases for which formulae are available to solve more complex loading cases
- Use the theorem of three moments to analyze continuous beams having three or more supports and carrying any combination of concentrated or distributed loads
- Compare the relative strength and stiffness of beams having different support systems for given loadings

6. **Columns**

<u>Potential Elements of the Performance:</u>

- Define Column
- Differentiate between a column and a short compression member
- Describe the phenomenon of buckling, also known as elastic instability
- Define radius of gyration for the cross section of a column and be able to compute its magnitude
- Understand the a column is expected to buckle about the axis for which the radius of gyration is the minimum
- Define end-fixity factor, K.
- Specify the appropriate value of the end fixity factor, K, depending on the manner of supporting the ends of the column

- Define effective length, L
- Define slenderness ration and compute its value
- Define transition slenderness ratio, also called the column constant, C, and compute its value
- Use the values for the slenderness ratio and the column constant to determine when the column is long or short
- Use the Euler formula for computing the critical buckling load for long columns
- Use the J.B. Johnson formula for computing the critical buckling load for short columns
- Apply a design factor to the critical buckling load to determine the allowable load on a column
- Recognize efficient shapes for column cross sections
- Design columns to safely carry given axial compression loads

III. TOPICS:

1. Design Properties of Materials
2. Stress Due to Bending
3. Shearing Stresses in Beams
4. Combined Stress and Mohr's Circle
5. Deflection of Beams
6. Statically Indeterminate Beams
7. Columns

IV. REQUIRED RESOURCES/TEXTS/MATERIALS:

Mott, Robert L., Applied Strength of Materials, 2nd Ed., Prentice Hall, ISBN 0-13-043415-9

Material not covered in the above manual will be provided.

V. EVALUATION PROCESS/GRADING SYSTEM:

Type of Grading	Duration	Mark Breakdown	Topics
Quizzes	**6*0.25 hours**	**20%**	**All course material**
Class Project		**20%**	**Bridge Building Design and Calculations to determine loading**
Mid Term	**2.0 hours**	**25%**	**Design Properties of Materials, Stress Due to Bending, Shearing Stresses in Beams, Combined Stress and Mohr's Circle**
Final Exam	**2.0 hours**	**35%**	**All Course Material**

The following semester grades will be assigned to students:

Grade	**Definition**	*Grade Point Equivalent*
A+	90 – 100%	4.00
A	80 – 89%	
B	70 - 79%	3.00
C	60 - 69%	2.00
D	50 – 59%	1.00
F (Fail)	49% and below	0.00

CR (Credit)	Credit for diploma requirements has been awarded.
S	Satisfactory achievement in field /clinical placement or non-graded subject area.
U	Unsatisfactory achievement in field/clinical placement or non-graded subject area.
X	A temporary grade limited to situations with extenuating circumstances giving a student additional time to complete the requirements for a course.

NR	Grade not reported to Registrar's office.
W	Student has withdrawn from the course without academic penalty.

VI. SPECIAL NOTES:

Attendance:
Sault College is committed to student success. There is a direct correlation between academic performance and class attendance; therefore, for the benefit of all its constituents, all students are encouraged to attend all of their scheduled learning and evaluation sessions. This implies arriving on time and remaining for the duration of the scheduled session.

VII. COURSE OUTLINE ADDENDUM:

The provisions contained in the addendum located on the portal form part of this course outline.

APPENDIX

SAULT COLLEGE

MECHANICAL ENGINEERING TECHNOLOGY - 4043
Strength of Materials II – MCH202

DISTRIBUTION OF HOURS

Sequence/Type	Topics	# of Hours
Lecture	**Design Properties of Materials**	6
Lecture	**Stress due to Bending**	8
Lecture	**Shearing Stresses in Beams**	10
Lecture	**Combined Stress and Mohr's Circle**	8
Review Lab		2
Mid Term Test		2
Lecture	**Deflection of Beams**	10
Lecture	**Statically Indeterminate Beams**	8
Lecture	**Columns**	8
Presentation	**Class Project Presentation**	8
	Sub-Totals	
	Lectures	64
	Labs/Experiments	
	Testing	
	TOTAL HOURS	**64**

SAULT COLLEGE

MECHANICAL ENGINEERING TECHNOLOGY - 4043

Strength of Materials II – MCH202

COURSE PLAN – Applied Strength of Materials, 2nd Edition, Mott)

Week/Hours	Topic/Chapter	Concepts Covered
Week 1/2 – 6 hours of lecture	**Chapter #2: Design Properties of Materials**	**Design Properties of Materials** 1. Metals in Mechanical Design and their properties 2. Failure Modes 3. Classification of Metals and Alloys 4. Conditions for Steels 5. Cast Iron 6. Aluminum 7. Copper, Brass and Bronze 8. Zinc, Magnesium and Titanium 9. Non-Metals in Engineering Design: Wood, Concrete, Plastics, Composites
Week 2/3/4 – 8 Hours of Lecture	**Chapter 8: Stress Due to Bending**	**Stress Due to Bending** 1. The Flexure Formula 2. Conditions on the Use of the Flexure Formula 3. Derivation of the Flexure Formula 4. Applications – Beam Analysis 5. Applications – Beam Design 6. Stress Concentrations 7. Flexural Center
Week 4/5/6 – 10 hours of Lecture	**Chapter 9: Stress Analysis**	**Shearing Stresses in Beams** 1. Visualization of Shearing Stress in Beams 2. Importance of Shearing Stresses in Beams 3. The General Shear Formula 4. Use of The General Shear Formula 5. Distribution of Shearing Stress in Beams 6. Development of the General Shear Formula 7. Special Shear Formulas 8. Design Shear Stress 9. Shear Flow
Week 7/8 – 8 hours of Lecture	**Chapter 10 and 11: Combined Stress and Mohr's Circle**	**Combined Stress and Mohr's Circle** 1. The Stress Element 2. Stress Distribution Created by Basic Stresses 3. Creating the Initial Stress Element 4. Equations for Stresses in any Direction 5. Principle Stresses

		6. Maximum Shear Stress 7. Mohr's Circle for Stress 8. Examples of the Use of Mohr's Circle 9. Stress Conditions on Selected Planes 10. Maximum Shear Stress Theory 11. Combined Normal Stresses 12. Combined Normal and Shear Stresses
Week 9 – 2 hours of Review Lab and 2 Hour Midterm Test		
Week 10/11/12 – 10 hours of Lecture	**Chapter 12: Deflection of Beams**	**Deflection of Beams** 1. Definition of Terms 2. Basic Principles for Beam Deflection 3. Successive Integration Method 4. The Formula Method 5. Superposition Using Deflection Formulas 6. Moment-Area Method 7. Applications of Moment-Area Method 8. Beams with Distributed Loads
Week 12/13/14 – 8 hours of Lecture	**Chapter 13: Statically Indeterminate Beams**	**Statically Indeterminate Beams** 1. Examples of Statically Indeterminate Beams 2. Formulas for Statically Indeterminate Beams 3. Superposition Method 4. Continuous Beams – Theorem of Three Moments
Week 14/15/16 – 8 hours of Lecture	**Chapter 14: Columns**	**Columns** 1. Slenderness Ratio 2. Transition Slenderness Ratio 3. Euler Formula for Long Columns 4. Formula for Short Columns 5. Design Factors for Columns and Allowable Loads 6. Method of Analyzing Columns 7. Efficient Shapes for Column Cross Sections 8. Specifications
Week 16 – 2 Hours of Presentation	**Presentation of Bridges**	