SAULT COLLEGE OF APPLIED ARTS AND TECHNOLOGY

SAULT STE. MARIE, ONTARIO

COURSE OUTLINE

COURSE TITLE:	MACHINE DESIGN		
CODE NO. :	MCH307	**SEMESTER:**	SIX
PROGRAM:	MECHANICAL TECHNOLOGY		
AUTHOR:	TOM KATAGIS		
DATE:	JAN 2011	**PREVIOUS OUTLINE DATED:**	APRIL 2010
APPROVED:	*"Corey Meunier"*		_____
	CHAIR		**DATE**
TOTAL CREDITS:	FOUR		
PREREQUISITE(S):	MCH103 - STRENGTH OF MATERIALS MTH143 - MATHEMATICS		
HOURS/WEEK:	FOUR		

For additional information, please contact Corey Meunier, Chair
School of Technology & Skilled Trades
(705) 759-2554, Ext. 2610

I. COURSE DESCRIPTION:

This course deals with stress analysis, anti-friction bearings, lubrication and journal bearings, stress concentrations, theories of failure, fatigue and endurance limits, selection of materials and consideration in production methods

II. LEARNING OUTCOMES AND ELEMENTS OF THE PERFORMANCE:

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

1. Nature and Composition of Machines and Aspects of Machines

Potential Elements of the Performance:

- Explain the concept of machines and their purpose
- Identify classifications and characteristics of machines
- Identify and understand the concept of simple machines and how they make up complex machines
- Explain machine elements
- Understand the correlation of work, energy and efficiency in regards to machines
- Define Mechanical efficiency
- Define Power and understand the basic power equation
- Identify and explain power for driven machines such as electric motors, internal combustion engines, air and hydraulic motors.
- Explain the effects of vibration in machine design
- Understand torque characteristics and curves
- Understand and explain service factor and design power
- Explain the basic aspects of design
- Understand the human factors engineering and why it is important in regards to machine design
- Discuss the design process
- Identify and explain various modes of failure
- Explain the design criteria
- Understand the importance of computations, errors that can occur during computations and how to effectively revise computations

2. Design for Strength, Rigidity, Stability and Resistance to Wear

Potential Elements of the Performance:

- Understand Nomenclature surrounding permanent fasteners
- Identify and analyze various loading types
- Understand mechanical properties of engineering material and how materials are selected
- Perform and explain basic analysis of material strength and define and explain Hooke's law, stress-strain parameters, the stress-strain curve and shear modulus
- Explain working stresses while defining de-rating factors, factors of safety and cyclic loading
- Understand and apply the method of dimensioning based on strength
- Interpret stress-cycle diagrams and determine solutions to problems using these diagrams
- Identify and explain common fatigue factors
- Calculate and understand fatigue stress approximations
- Identify and define numerous types of fatigue strength de-rating factors
- Define and apply equations to determine stress concentrations
- Explain surface treatment and corrosion
- Understand and apply knowledge of fatigue stresses
- Explain the concept of designing for rigidity
- Understand the importance and be able to analyze stability of machine columns
- Explain cylindrical piston rod
- Identify friction and wear considerations in machine design

3. Rigid and Elastic Connections

Potential Elements of the Performance:

- Understand the advantages and disadvantages of the various types of permanent fastenings
- Identify and define types of welding and list the field of application, advantages and classification of welds
- Understand the design of weldments and the precautions that should be observed
- Identify and describe characteristics of Primary Welds and Secondary Welds: butt welds, fillet welds, plug welds
- Analyze fatigue strength of weldments
- Understand soldering, brazing and riveting
- Identify and explain various types of fits: interference fits, driving fits, forced fits, shrinkage fits, expansion fits
- Describe and explain the function of detachable fasteners as well as identifying various types of these fasteners

- Analyze screw thread systems and materials used for threaded fasteners
- Identify common types of threaded fasteners and understand the uses for bolts, screws, nuts and locking devices, locknuts
- Explain the importance of washers and lock washers
- Understand and define thread inserts
- Define preload, fatigue and resiliency
- Explain stress considerations for threaded fasteners
- Understand and analyze the torque-tension relationship
- Explain other load conditions of detachable fasteners;
- Explain function, design principles and classification of springs
- Identify types of springs and understand the materials used for springs
- Analyze the load-deflection relationship
- Explain the concepts of energy storage and energy dissipation
- Understand the allowable stress present in spring design
- Analyze helical compression springs, including appropriate equations and computations
- Analyze the spring design chart
- Identify and discuss good design practices
- Analyze extension coil springs, including appropriate equations
- Analyze torsion coil springs, including appropriate equations
- Analyze leaf springs, including appropriate equations
- Analyze Belleville coil springs, including appropriate equations
- Understand coupling of springs

4. Machine Elements for Torque-Speed Change and Rotary Power Transmission

Potential Elements of the Performance:

- Explain the significance of power transmission and control
- Define the principles of power transmission
- Understand power transmission including mechanical power transmission, friction drives and hydraulic power transmission
- Explain and analyze screws for power transmission
- Understand the effects of centrifugal and inertial force
- Define the concept of optimum power
- Identify and describe mechanical adjustable speed drives
- Analyze the transverse force due to torque
- Understand the function and design of flexible couplings
- Identify the classification and standardization of flexible couplings
- Explain the conditions of misalignment and axial displacement

- Analyze flexible couplings design in detail
- Identify and explain overload-release couplings, fluid couplings, magnetic couplings and the universal couplings
- Understand the specification of couplings
- Explain the function and design concept for Spur and Helical Gears
- Understand the involute gear principles and overall conept of involute gears
- Identify and be able to explain gear terminology
- Explain standard spur gears including pitches and modules related
- Define the standard tooth proportions of spur gears
- Identify and explain limitations of spur gears
- Analyze modifications of spear gears and force and stress analysis
- Understand the design for surface durability
- Analyze gear manufacture and material
- Identify modifications for strength and noise abatement
- Describe internal gears and when they are used
- Understand the function and design for helical gears for parallel shafts
- Analysis of helical gears
- Interpret gear drawings
- Identify and describe gear trains for power transmission
- Identify and understand gears for non-parallel shafts: Bevel gears, Hypoid gears, helical gears, worm gearing,
- Analyze terminology, kinematics, efficiency and thermal ratings

5. Machine Elements for Carrying and Transmitting Rotary Power

Potential Elements of the Performance:

- Identify types of axles and shafts
- Explain designing for rigidity and strength for axles and shafts
- Describe the effects of fillets, keyseats and grooves
- Analyze materials for axles and shafts and how they affect rigidity, strength, wear resistance, corrosion resistance, weight and machinability
- Analyze various loading on shaft and axles including simple loading, steady bending loads and combined loading
- Understand the impact of hollow shafts
- Understand design concepts for strength, rigidity and torsional stiffness
- Explain bending of non-uniform shafts and axles

- Explain the function of bearings
- Understand the factors involved in choosing a bearing type
- Analyze the loads on bearings
- Identify types of lubricants utilized for bearings and explain lubricating regimes
- Explain selecting a bearing for light service and how the PV factor is interpreted
- Understand lubrication of journal bearings for severe service
- Apply journal bearing design charts
- Explain lubricant flow, temperature rise and heat balance for pressure fed journal bearings
- Identify and explain practical choices for design factors
- Understand design and characteristics of rolling-element bearings
- Define terminology and understand classification/standardization of rolling element bearings
- Identify and explain various types of rolling-element bearings: ball bearings, roller bearings, needles bearings
- Analyze bearing capacities
- Apply bearing characteristics to determine bearings life
- Understand additional factors affecting bearing life

III. TOPICS:

1. Nature and Composition of Machines and Aspects of Machine Design
2. Design for Strength, Rigidity, Stability and Resistance to Wear
3. Rigid and Elastic Connections; Permanent connections, Flexible connections and Springs
4. Machine Elements for Torque-Speed Change and Rotary Power Transmission
5. Machine Elements for Carrying and Transmitting Rotary Power

IV. REQUIRED RESOURCES/TEXTS/MATERIALS:

Hindhede, Uffe, Machine Design Fundamentals – A Practical Approach, Prentice Hall, ISBN 0-13-054176-3 025

V. EVALUATION PROCESS/GRADING SYSTEM:

Type of Grading	Duration	Mark Breakdown	Topics
Term Test 1	**2.0 hours**	**35%**	**-Introduction to Machine Design. -Basic principles of machine design. -Rigid and Elastic connections**
Term Test 2	**2.0 hours**	**35%**	**Elements for Torque-Speed Change and Rotary Power Transmission. -Elements for carrying and transmitting rotary power**
In Class Quizzes & Assignments	**5 total for 6% each**	**30%**	**-1 quiz or assignment per chapter**

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

MECHANICAL ENGINEERING TECHNOLOGY - 4043
Machine Design – MCH307

DISTRIBUTION OF HOURS

Sequence/Type	Topics	# of Hours
Lecture	**Introduction to Machine Design and Review:** Nature and Composition of Machines and Aspects of Machine Design	4
Lecture	**Basic Principles of Machine Design:** Design for Strength and Design for Rigidity, Stability and Resistance to Wear	8
Lecture	**Rigid and Elastic Connections:** Permanent Connections, Detachable Fasteners and Springs	8
Review Lab		2
Term Test 1		2
Lecture	**Elements for Torque Speed Change for Rotary Power Transmission:** Fundamentals of Transmission and Control of Power, Flexible Couplings, Spur and Helical Gears and Gears for Non-parallel Shafts,	16
Review Lab 2		2
Term Test 2		2
Lecture	**Elements for Carrying and Transmitting Rotary Power:** Axles and Shafts, Sliding Bearings and Rolling Element Bearings	16
Review Lab 3		2
Final Exam		2
	Sub-Totals	
	Lectures	52
	Review Labs	6
	Testing	6
	TOTAL HOURS	**64**

SAULT COLLEGE

MECHANICAL ENGINEERING TECHNOLOGY - 4043

Machine Design – MCH307

COURSE PLAN – Machine Design Fundamentals – A Practical Approach, Hindhede/Zimmerman/Hopkins/Erisman/Hull/Lang)

Week/Hours	Topic/Chapter	Concepts Covered
Week 1 – 4 Hours of Lecture	**Chapter 1 and 2: Nature and Composition of Machines, Aspects of Machine Design**	**Nature and Composition of Machines** 1. Concept of Machines 2. Classification and Characteristics of Machines 3. Simple Machines 4. Machine Elements 5. Work, Energy and Efficiency 6. Mechanical Efficiency 7. Power 8. Power for Driven Machines 9. Torque Characteristics 10. Service Factor and Design Power **Aspects of Machine Design** 11. Basic Aspects of Machine Design 12. The Design Process 13. Modes of Failure 14. Design Criteria 15. Computations: importance, Errors and Revising
Week 2/3 - 8 Hours of Lecture	**Chapter 3 and 4: Design for Strength, Design for Rigidity, Stability and Resistance to Wear**	**Design for Strength** 1. Nomenclature 2. Loading Types 3. Mechanical Properties of Engineering Materials 4. Analysis of Material Strength 5. Working Stresses 6. Dimensioning Based on Strength 7. Stress Cycle Diagrams 8. Common Fatigue Fractures 9. Fatigue Strength Approximations 10. Fatigue Strength De-rating Factors: surface finish, size, reliability, temperature, Impact 11. Stress Concentrations 12. Surface Treatment and Corrosion 13. Fatigue Stresses 14. Mechanical Contacts **Design for Rigidity, Stability and Resistance to Wear** 15. Nomenclature 16. Design for Rigidity 17. Stability of Machines 18. Calculating Machine Columns

		19. Cylindrical Piston Rods 20. Friction and Wear Considerations in Machine Design 21. Sliding Friction 22. Rolling Friction 23. Types of Wear 24. Design for Wear Resistance
Week 4/5– 8 hours of lecture	**Chapter 6,7 and 8: Permanent Connections, Flexible Connections and Springs**	**<u>Permanent Connections</u>** 1. Nomenclature 2. Welding 3. Field of Application 4. Classification of Welding 5. Design of Weldments 6. Allowable Strength of Welds under steady load 7. Primary Welds: butt welds 8. Secondary Welds: fillet welds 9. Plug Welds 10. Fatigue Strength of Welds 11. Riveting 12. Fits **<u>Flexible Connections</u>** 13. Nomenclature 14. Function and Description 15. Screw Thread System 16. Material for Threaded Fasteners 17. Common Types of Threaded Fasteners 18. Nuts and Locking Devices 19. Pre-load, Fatigue and Resiliency 20. Stress Consideration for Threaded Fasteners 21. Torque and Tension Relationship 22. Other Load Conditions **<u>Springs</u>** 23. Nomenclature 24. Function and Description 25. Classification 26. Material 27. Load-Deflection Relationship 28. Energy Storage and Dissipation 29. Allowable Stress 30. Helical Compression Springs: nomenclature, design and computations 31. Spring Design Chart 32. Design Practices 33. Manufacturing Tolerances 34. Extension Coil Springs

		35. Torsion Coil Springs 36. Leaf Springs 37. Belleville Springs 38. Coupling of Springs
Week 6 – 2 hour Review Lab and 2 hour Term Test	**Review and Term Test**	
Week 7/8/9/10– 16 hours of lecture	**Chapter 9,10,11,12 and 13: Fundamentals of Transmission and Control of Power, Flexible Couplings, Belt Drives, Chain Drives, Spur and Helical Gears and Gears for Non-parallel Shafts**	**<u>Fundamentals of Transmission and Control of Power</u>** 1. Principles of Power Transmission 2. Mechanical Power Transmission 3. Hydraulic Power Transmission 4. Optimum Power 5. Mechanical Adjustable Speed Drives 6. Transverse Force due to Torque 7. Estimating Transverse and Overhung Loading **<u>Flexible Couplings</u>** 8. Function and Design 9. Classification and Standardization 10. Conditions of Misalignment and axial displacement 11. Flexible Couplings 12. Special Couplings 13. Overload Release Couplings 14. Fluid Couplings 15. Magnetic Couplings 16. Universal Couplings 17. Specification of Couplings **<u>Spur and Helical Gears</u>** 18. Nomenclature 19. Function and Design 20. Involute Gear Principles 21. The Mechanics of Involute Teeth 22. Standard Spur Gears 23. Standard Tooth Proportions of Spur Gears 24. Limitations of Spur Gears 25. Spur Gear Force Analysis 26. Spur Gear Stress Analysis 27. Gear Manufacture and Material 28. Modifications for Strength and Noise Abatement 29. Internal Gears 30. Helical Gears for Parallel Shafts 31. Helical Gear Analysis 32. Gear Drawings 33. Gear Trains for Power Transmission

		<u>Gears for Non Parallel Shafts</u> 34. Nomenclature 35. Bevel Gears 36. Hypoid Gears 37. Helical Gearing Worm Gearing 38. Worm Gearing Terminology and Kinematics 39. Thermal Ratings 40. Efficiency of Worm Gearing 41. Optimum Design 42. Applications
Week 11 – 2 hour Review Lab and 2 hour Term Test	**Review and Term Test**	
Week 12/13/14/15 16 Hours of Lecture	**Chapter 15/16/17 and 18: Axles and Shafts, Detachable Fastenings for Shaft and Hub, Sliding Bearings, Rolling Element Bearings**	**<u>Axles and Shafts</u>** 1. Nomenclature 2. Types of Axles and Shafts 3. Design Problems 4. Materials for Axles and Shafts 5. Design for Strength: basics, simple loading, combined loading 6. Hollow Shafts 7. Axial Loads 8. Design for Bending Rigidity 9. Design for Torsion Stiffness 10. Effects of Keyseats **<u>Sliding Bearings</u>** 11. Nomenclature 12. Function of Bearings 13. Choosing a Bearing Type 14. Bearing Loads 15. Lubricants 16. Lubrication Regimes 17. Selecting Bearings for Light Service 18. Lubrication of Journal Bearings for Severe Service 19. Journal Bearing Design Charts 20. Lubrication Flow in Pressure Fed Journal Bearings 21. Temperature Rise and Heat Balance for Pressure Fed Journal Bearings 22. Practical Choices of Design Parameters 23. A Journal Bearing Design Example **<u>Rolling Element Bearings</u>** 24. Nomenclature 25. Design and Characteristics

		26. Terminology and Classification 27. Standardization of Roller Bearings 28. Ball Bearings 29. Roller Bearings 30. Needle Bearings 31. Bearing Capacities 32. Bearing Life 33. Ball Bearing Selection from Vendor Catalogues 34. Additional Factors Affecting Bearing Life 35. Bearing Selection 36. Additional Information Available from Bearing Catalogue 37. Mounting of Roller Bearings 38. Lubrication
Week 11 – 2 hour Review Lab and Final Exam	**Review and Final Exam**	