Virginia Western Community College
MEC 132
Mechanics II - Strength of Materials for Engineering Technology

Revised: Fall 2017

Prerequisites
MEC 131

Course Description:
Teaches the concepts of stress and strain. Provides an analysis of stresses and deformations in loaded members, connectors, shafts, beams, columns, and combined combined stress.

Semester Credits: **3 Lecture Hours: 3 Lab/Recitation: Hours: 0**

Required Materials

Textbook:

Statics and Mechanics of Materials, 5th ed., Author: Hibbeler, Publisher: Pearson, ISBN# 9780134301006

Other Required Materials

1. Scientific calculator
2. Engineering graph paper for problem solving.

The following supplementary materials are available

1. Problem answer guide on reserve for checkout on second floor of LRC

2. Digital resources of how to solve specific problems related to Statics are available on BlackBoard.

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Mechanics and Machine Elements

Course Description

This course focuses on the study of the mechanical components that are included in a complex mechatronic system. It begins with an overview of Statics and Kinetics, which includes force system analysis, study of equilibrium, frames and machines, friction and effects of forces on the motion of objects among other basic topics.
The second part of the course focuses on Machine Elements, fundaments and classification of a variety of components expanding the material into calculations involving force, stress and wear analysis, as well as calculations to determine the different features from a particular component required in given a system. The course focuses on the employment of these techniques for supporting mechatronic systems and to ensure its proper function, correct possible defects that may interrupt the process and to plan preventive maintenance operations on them, observing and incorporating locally enforced and general safety standards. Course 5 of Level 2 provides a deeper insight into the principles behind the different components of the system. The course aims to form both high and low level mechatronic experts at production and development facilities.

Course Philosophy

This course is the fifth in a series of six courses which prepares students for certification as a Siemens Certified Mechatronic System Associate. The job profile for which the Level 2 Certification prepares students is that of a highly skilled technician, who has a well-rounded understanding of and can work with modules and components in complex mechatronic systems as well as be able to assess and analyze the system as a whole.
This course, as all courses within the Certification Program, is based upon a systems-oriented approach. Students learn about individual components and system characteristics within the context of an actual mechatronic system. In Course Five the students should already have been in contact with an actual mechatronic system. While they are learning with and on it, students understand clearly why they are learning the subject material. By viewing the system as a whole, learning retention is also increased, as the students experience the components in a holistic way, rather than in isolation.
Because the student is learning with and working on a real system he or she will be able to understand and analyze the technical specification of mechatronic systems, subsystems, modules and components. One of the very important things during the certification program is, that students are able to work as an effective member of a team and realize projects based on deriving and determining parameters for mechatronic systems and system elements.
Of great importance is that the student is able to transfer the knowledge learned to a new system and is able to quickly familiarize himself or herself with a new system.
This understanding leads to a better informed employee having sufficient knowledge to make well-informed decisions about the operation of the system with which he or she is working. After successfully finishing Course 5 the student will be able to make decisions to find the right machinery and material in and out of the actual mechatronic system which will fulfill the requested task best. The main idea of the current course is to deal with the structure of an actual system and to know how to work with it in a cost effective and safe manner, while following prescribed procedures.

Goals

At the end of this course, students should be prepared to:

1. Understand the role of mechanical components in complex mechatronic systems.
2. Apply this knowledge to ensure proper performance of the mechanical parts in the system
3. Understand troubleshooting, preventive maintenance and safety issues revolving around mechanical components within a mechatronic system.

Objectives

1. Understand and be able to resolve problems involving Statics and Kinetics principles such as:

- Force systems (2D and 3D);
- Moments of a force around a point and moment due to a force couple;
- Equilibrium of a rigid bodies, supports and equilibrium in space, including the use of free body diagrams;
- Frames and basic machines;
- Basic principles of friction applied to wedges;
- Effects of forces on translational and rotational motions of objects;
- The basics of mechanical work, energy, power and efficiency.

2. Trace and describe the flow of energy in a given mechatronic system or subsystem.
3. Describe the basic physical properties of mechanical components including materials, lubrication requirements and surface properties.
4. Carry out adjustments on mechanical components in a mechatronic system.
5. Explain the different classifications and roles of various mechanical components within a given system or module including:
- Bearings;
- Shafts and axles and perform rough calculations of force and stress;
- Gears, with basic force analysis and gear train calculations;
- Belts and chains and belt drive calculations;
- Shafts and couplings and shaft calculations;
- Clutches with multiple disc clutch calculations.

And make use of formulas and data sheets to determine the appropriate element for a given system.
6. Correctly localize, identify and document causes of malfunctions in mechanical components, based upon the use of applied formulas and technical documentation.
7. Correct malfunctions where possible, or correctly identify the expertise required to correct a malfunction.
8. Apply safety rules while working on the system.
9. Transfer the knowledge learned from one system to another system .

Topical Description

Week 1 **Introduction to class, review of Chapter 8 and Introduction to Chapter 9.**
Ch 8 – Area Moments of Inertia Sections 8-1 to 5.
Ch 9 - Simple Stresses Sections 9-1 to 3.

Week 2 **Ch 9 - Simple Stresses Sections 9-4 to 7.**

Week 3 **Ch 10 – Strains Sections 10-1 to 10-8.**

Week 4 **Ch 11 - Mechanical Properties of Materials Sections 11-1 to 8.**

Week 5 **Ch 12 - Torsion of Circular Shafts Sections 12-1 to 6.**

Week 6 **Ch 13 - Shear Forces and Bending Moment Diagrams Sections 13-1 to 9.**

Week 7 **Ch 14 - Stresses in Beams Sections 14-1 to 9.**

Week 8 **Ch 15 - Design of Beams for Strength Sections 15-1 to 5.**

Week 9 **Ch 16 - Deflection of Beams Sections 16-1 to 3.**

Week 10 **Ch 16 – Deflection of Beams Section 16-4.**

Ch 18 Combined Stresses Section 18 -1 to 2.

Week 11 **Ch 18 Combined Stresses Section 18 - 4 to 5.**

Week 12 **Ch 18 Combined Stresses Section 18 - 6 to 8.**

Week 13 **Ch 19 Columns Sections 19-1 to 4.**

Week 14 **Ch 19 Columns Sections 19-5 to 7.**

Week 15 **Ch 20 Connections Sections 20.1 – 6.**
Topics in machine and structure design.

Week 16 **Final Exam**

Mechanics and Machine Elements
Statics overview

- **Fundamentals**
  - **Definitions**
  - **Principal SI units**
- **Force systems**
  - **Forces on a plane**
  - **Forces in a space**
- **Moments and couples**
  - **Moment of a force about a point or axis**
  - **Moment of a couple**
- **Equilibrium of a rigid body**
  - **Equilibrium**
  - **Supports**
  - **Free body diagrams**
  - **Equilibrium in a space**
- **Centre of gravity and centroids**
  - **Centre of gravity**
  - **Centroids of areas, lines and bodies**
- **Frames and machines**
  - **Frames**
  - **Machines**
- **Friction**
  - **Basics of friction**
  - **Wedges**
- **Components**
  - **Registers**
  - **Flags**

Kinetics overview

- **Translation**
  - **Law of inertia**
  - **Principal of Dynamics**
  - **Acceleration on a horizontal plane**
  - **Acceleration on an Inclined Plane**
  - **Rope Acceleration**
  - **Inertia Force – D'Alembert's Priciple**

- **Momentum and Principle of Linear Momentum**
- **Total Momentum**

- **Rotation**
  - **Moment of Inertia and Acceleration Torque**
  - **D'Alembert's Principle for Rotation**
  - **Moment of Inertia of Composed Bodies**
  - **Centrifugal Forces**
- **Work, Energy and Efficiency**
  - **Mechanical Work**
  - **Energy**
  - **Mechanical power and degree of efficiency**
  - **Energy and Power by rotational movement**
  - **Work and Energy**
  - **Reduced Moment of Inertia**

Machine Elements

- **Bearings**
  - **Bearing types**
  - **Selecting of ball or roller bearings**
- **Shaftings**
  - **Axles**
  - **Shafts**
  - **Rough calculation of stressed shafts**
  - **Shaft-hub connecting elements**
  - **Timing diagrams**
- **Gears**
  - **Gear types**
  - **Gear geometry**
  - **Gear train calculation**
  - **Force analysis**
- **Flexible elements**
  - **Belt-drive calculation**
- **Shaft couplings**
  - **Coupling types and applications**
  - **Coupling calculation**
- **Clutches**
  - **Clutch types and applications**
  - **Multiple disc clutch calculation**

Notes to Instructors

1. Instructors should use Excel to demonstrate as many problem solutions as appropriate. In addition, online or downloadable software (MDSolids) can be used to supplement solution of problems. Autodesk® ForceEffect™ can be used to demonstrate analysis of static structures and machines.

2. The solution guide is available for student use in the reserve area of the LRC.

3. Concepts should be demonstrated as possible through the use of projects. A common type of project is a bridge building and analysis competition.

4. Industry standards and applications should be stressed. Failures in the analysis of engineering problems can be used to demonstrate the need for proper force determination. The Hyatt Walkway Failure: http://en.wikipedia.org/wiki/Hyatt_Regency_walkway_collapse

5. The final exam is worth 15-20% of the final grade.