COURSE OUTLINE: MCH609 - MACHINE DESIGN

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Course Code: Title	MCH609: MACHINE DESIGN
Program Number: Name	4043: MECH ENG. TECHNOLOGY
Department:	MECHANICAL TECHNIQUES PS
Academic Year:	2022-2023
Course Description:	In this course students learn how to design, select and integrate common machine elements found in mechanical devices and systems including shafts, bearings, springs, gears, cams, belts, and chains. Students will also analyze the performance of fasteners and welded joints in various loading conditions and be introduced to failure mechanisms.
Total Credits:	3
Hours/Week:	3
Total Hours:	42
Prerequisites:	MCH103
Corequisites:	There are no co-requisites for this course.
Substitutes:	MCH307
Vocational Learning Outcomes (VLO's) addressed in this course: **Please refer to program web page for a complete listing of program outcomes where applicable.**	**4043 - MECH ENG. TECHNOLOGY** VLO 1 Monitor compliance with current legislation, standards, regulations and guidelines. VLO 2 Plan, co-ordinate, implement and evaluate quality control and quality assurance procedures to meet organizational standards and requirements. VLO 4 Develop and apply sustainability best practices in workplaces. VLO 5 Use current and emerging technologies to implement mechanical engineering projects. VLO 6 Analyze and solve complex mechanical problems by applying mathematics and fundamentals of mechanical engineering. VLO 7 Prepare, analyze, evaluate and modify mechanical engineering drawings and other related technical documents. VLO 8 Design and analyze mechanical components, processes and systems by applying fundamentals of mechanical engineering. VLO 9 Design, manufacture and maintain mechanical components according to required specifications.
Essential Employability Skills (EES) addressed in this course:	EES 1 Communicate clearly, concisely and correctly in the written, spoken, and visual form that fulfills the purpose and meets the needs of the audience. EES 2 Respond to written, spoken, or visual messages in a manner that ensures effective communication. EES 3 Execute mathematical operations accurately.

	EES 4 Apply a systematic approach to solve problems. EES 5 Use a variety of thinking skills to anticipate and solve problems. EES 6 Locate, select, organize, and document information using appropriate technology and information systems. EES 7 Analyze, evaluate, and apply relevant information from a variety of sources. EES 8 Show respect for the diverse opinions, values, belief systems, and contributions of others. EES 9 Interact with others in groups or teams that contribute to effective working relationships and the achievement of goals. EES 10 Manage the use of time and other resources to complete projects. EES 11 Take responsibility for ones own actions, decisions, and consequences.
Course Evaluation:	Passing Grade: 50%, A minimum program GPA of 2.0 or higher where program specific standards exist is required for graduation.
Books and Required Resources:	Machine Elements in Mechanical Design by Mott, Vavrek, Wang Publisher: Pearson Education Inc. Edition: 6th ISBN: 978-0-13-444118-4

Course Outcomes and Learning Objectives:

Course Outcome 1	**Learning Objectives for Course Outcome 1**
1. Differentiate functional vs. design requirements and standards. Explore fundamental principles related to properties of materials and types of materials used in mechanical design	1.1 Recognize examples of mechanical systems 1.2 List what design skills are required to perform competent mechanical design 1.3 Describe importance of integrating machine elements into more comprehensive mechanical systems 1.4 Describe main elements of the product realization process 1.5 Write statements of functions and design requirements for mechanical devices 1.6 Establish a set of criteria for evaluating proposed designs 1.7 Become acquainted with section properties of commercially available structural shapes 1.8 State the types of material properties that are important to the design of mechanical devices and systems
Course Outcome 2	**Learning Objectives for Course Outcome 2**
2. Calculate normal and shear stress, deformation and stress concentrations. Analyse more complex loading situations, use of Mohr`s Circle, combined stress and stress transformation. Calculate stress ratios, static loading, cyclic loading and design factors	2.1 Review the principles of stress and deformation analysis 2.2 Interpret the nature of the stress at a point by drawing the stress element 2.3 Review the importance of flexural centre of beam cross section with regard to alignment of loads on beams 2.4 Use the principle of superposition 2.5 Properly apply stress concentration factors in stress analysis 2.6 Understand the general case of combined stress 2.7 Perform Stress Transformation mathematically and graphically 2.8 Use Mohr`s Circle for stress transformation

	2.9 Understand equivalent Stresses, Tresca Stress & Von Misses Stress 2.10 Understand different types of loading and stress ratio 2.11 Understand some different failure modes and theories 2.12 Understand design factors 2.13 Design Philosophy 2.14 Understand how to design for different types of loading scenarios.
Course Outcome 3	**Learning Objectives for Course Outcome 3**
3. Explore the kinematics of belt, chain drive systems, wire ropes, gears and gear trains. Calculate velocity ratios, forces, torque, power, stresses, bending moments, friction and efficiencies in gearing.	3.1 Describe the basic features of a belt drive system. 3.2 Describe the basic features of a chain drive system. 3.3 Describe several types of belt & chain drives. 3.4 Specify suitable types and sizes of belts and sheaves & chains & sprockets. 3.5 Specify the primary installation variables for belt drives & chain drives. 3.6 Describe basic types of commercially available wire rope, the preferred methods for applying them, and typical working loads. 3.7 Recognize & describe the main features of spur gears, helical gears, bevel gears, and worm/worm gears. 3.8 Describe the important operating characteristics of these various types of gears with regard to the similarities & differences among them and their general advantages and disadvantages. 3.9 Describe the involute-tooth form and discuss its relationship to the law of gearing. 3.10 Describe the basic functions of AGMA. 3.11 Define velocity ratio as it pertains to two gears operating together. 3.12 Specify appropriate numbers of teeth for a mating pair of gears to produce a given velocity ratio. 3.13 Define train value as it pertains to the overall speed ratio between the input and output shafts of a gear type speed reducer (or speed increaser) that uses more than two gears. 3.14 Compute the forces exerted on gear teeth as they rotate and transmit power. 3.15 Specify a suitable level of quality for gears according to the use to which they are to be put. 3.16 Use appropriate stress analyses to determine the relationships among the applied forces, the geometry of the gear teeth, the precision of the gear teeth, and other factors specific to a given application, in order to make final decisions about those variables. 3.17 Bending Stress in Gear Teeth. 3.18 Contact Stress in Gear Teeth. 3.19 Perform the analyses of the tendency for the contact stresses exerted on the surfaces of the teeth to cause pitting of the teeth, in order to determine an adequate hardness of the gear material that will provide an acceptable level of pitting resistance for the reducer.

	3.20 Understand Power-Transmitting Capacity. 3.21 Practical Considerations for Gears and Interfaces with other Elements. 3.22 Describe the geometry of helical gears and compute the dimensions of key features. 3.23 Compute the forces exerted by one helical gear on its mating gear. 3.24 Compute the stress due to bending in helical gear teeth and specify suitable materials to withstand such stress. 3.25 Design helical gears for surface durability. 3.26 Describe the geometry of bevel gears and compute the dimensions of key features. 3.27 Design and analyze bevel gear teeth for strength and surface durability. 3.28 Analyze the forces exerted by one bevel gear on another and show how those forces are transmitted to the shafts carrying the gears. 3.29 Describe the geometry of worms and worm gears. 3.30 Compute the forces created by a worm gear drive system and analyze their effect on the shafts carrying the worm and the worm gear. 3.31 Compute the efficiency of worm gear drives. 3.32 Design and analyze worm gear drives to be safe for bending strength and wear.
Course Outcome 4	**Learning Objectives for Course Outcome 4**
4. Design shafts considering rigidity, material and diameter. Explore types and applications of keys, couplings and seals.	4.1 Describe several kinds of keys. 4.2 Specify a suitable size key for a given size shaft. 4.3 Specify suitable materials for keys. 4.4 Complete the design of keys and the corresponding keyways and keyseats, giving their complete geometries. 4.5 Describe splines and determine their torque capacity. 4.6 Describe several alternate methods of fastening machine elements to shafts. 4.7 Describe rigid and flexible couplings. 4.8 Describe several types of flexible couplings. 4.9 Describe universal joints. 4.10 Describe retaining rings and other means of locating elements on shafts. 4.11 Specify suitable seals for shafts and other types of machine elements. 4.12 Propose reasonable geometries for shafts to carry a variety of types of power-transmitting elements, providing for the secure location of each element and the reliable transmission of power. 4.13 Compute the forces exerted on shafts by gears, belt sheaves, and chain sprockets. 4.14 Determine the torque distribution on shafts. 4.15 Prepare shearing force and bending moment diagrams for shafts in two planes. 4.16 Account for stress concentration factors commonly encountered in shaft design.

	4.17 Specify appropriate design stresses for shafts. 4.18 Apply the shaft design procedure shown in this chapter to determine the required diameter of shafts at any section to resist the combination of torsional shear stress and bending stress. 4.19 Specify reasonable final dimensions for shafts that satisfy strength requirements and installation considerations and that are compatible with the elements mounted on the shafts. 4.20 Consider the influence of shaft rigidity on its dynamic performance. 4.21 Define the terms tolerance, allowance, unilateral tolerance, and bilateral tolerance. 4.22 Describe the relationships among tolerances, production processes, and cost. 4.23 Specify basic sizes for dimensions according to a set of preferred sizes. 4.24 Use the ANSI Standard B4.1, Preferred Limits and Fits for Cylindrical Parts, and ANSI B4.2 Preferred Metric Limits and Fits to Specify tolerances, fits, and clearances. 4.25 Specify transitional, interference and force fits. 4.26 Compute the pressure created between parts subjected to interference fits and the resulting stresses in the mating members. 4.27 Specify appropriate geometric dimensions and tolerancing controls for mating parts
Course Outcome 5	**Learning Objectives for Course Outcome 5**
5. Determine the lifespan of a bearing based on loading and operational conditions and select the appropriate type of bearing for a given application.	5.1 Identify the types of rolling contact bearings that are commercially available, and select the appropriate type for a given applicaiton, considering the manner of loading and installation conditions. 5.2 Use the relationship between forces on bearings and the life expectancy for the bearings to determine critical bearing selection factors. 5.3 Use manufacturers` data for the performance of ball bearings to specify suitable bearings for a given application. 5.4 Recommend appropriate values for the design life of bearings. 5.5 Compute the equivalent load on a bearing corresponding to combinations of radial and thrust loads applied to it. 5.6 Specify mounting details for bearings that affect the design of the shaft onto which the bearing is to be seated and the housing into which it is to be installed. 5.7 Compute the equivalent loads on tapered roller bearings. 5.8 Describe the special design of thrust bearings. 5.9 Describe several types of commercially available mounted bearings and their application to machine design. 5.10 Understand certain practical considerations involved in the application of bearings, including lubrication, sealing, limiting speeds, bearing tolerance classes, and standards related to the manufacture and application of bearings. 5.11 Consider the effects of varying loads on the life

	expectancy of bearings. 5.12 Describe the three modes of operation of a plain surface bearing (boundary, mixed-film, and full-film hydrodynamic lubrication), and discuss the conditions under which each will normally occur. 5.13 Discuss the significance of the bearing parameter, n/p. 5.14 List the decisions that a bearing designer must make to completely define a plain surface bearing system. 5.15 List the materials often used for journals and bearings, and describe their important properties. 5.16 Define the pV factor and use it in the design of boundary-lubricated bearings. 5.17 Describe the operation of full-film hydrodynamically lubricated bearings. 5.18 Complete the design of full-film bearings, define the size of the journal and bearing, the diametral clearance, the bearing length, the minimum film thickness, the surface finish, the lubricant, and the resulting frictional performance of the bearing system. 5.19 Describe a hydrostatic bearing system and complete the basic design of such bearings. 5.20 Define tribology and discuss the essential characteristics of friction, lubrication, and wear as applied to machinery. 5.21 Describe the general nature of oils and greases and their effects on lubrication.
Course Outcome 6	**Learning Objectives for Course Outcome 6**
6. Differentiate between types of fasteners and how they work and examine the importance of bolt torque during installation.	6.1 Describe a bolt in comparison with a machine screw. 6.2 Name and describe nine styles of heads for bolts. 6.3 Name and describe six styles of heads for machine screws. 6.4 Describe sheet-metal screws and lag screws. 6.5 Describe six styles of set screws and their application. 6.6 Describe nine types of locking devices that restrain a nut from becoming loose on a bolt. 6.7 Use tables of data for various grades of steel materials used for bolts as published by the SAE International (SAE) and the ASTM International (ASTM), and for standard metric grades. 6.8 List at least 10 materials other than steel that are used for fasteners. 6.9 Use tables of data for standard screw threads in the American Standard and metric systems for dimensions and stress analysis. 6.10 Define proof load, clamping load, and tightening torque as applied to bolts and screws, and compute design values. 6.11 Compute the effect of adding an externally applied force on a bolted joint, including the final force on the bolts and the clamped members. 6.12 List and describe 16 different coating and finishing techniques that are used for metal fasteners. 6.13 Describe rivets, quick-operating fasteners, welding, brazing, and adhesives, and contrast them with bolts and

	screws for fastening applications. 6.14 Apply the principles of stress and deflection analysis to propose a reasonable and efficient shape for a structure or frame and for the components involved. 6.15 Specify materials that are well suited to the demands of a given design, given certain conditions of load, environment, fabrication requirements, safety, and esthetics. 6.16 Analyze eccentrically loaded bolted joints. 6.17 Design welded joints to carry many types of loading patterns.

Evaluation Process and Grading System:

Evaluation Type	Evaluation Weight
Assignments	25%
Term Tests	75%

Date: August 15, 2022

Addendum: Please refer to the course outline addendum on the Learning Management System for further information.