BIRZEIT UNIVERSITY

Faculty of Engineering and Technology

Department of Mechanical and Mechatronics Engineering

ENMC 4421 - Design of Machine Elements, 4 Credit Hours.

Prerequisites: ENCE232 Statics, ENME2111 Mechanical Drawing

Instructors: Dr. Rashad Mustafa; **Office:** Aggad 323/2; **Email:** rimustafa@birzeit.edu

Textbook: Mechanics of Materials, 9th Edition, R.C. Hibbeler

Mechanical Engineering Design, 10th Edition, Joseph E. Shigley & Charles R. Mischke

References: Juvinall and Marshek: Fundamental of machine component design, 3rd Edition, Wiley

Norton: Machine Design, an integrated approach, Prentice Hall

Offered Semester: First Semester 2022-2023

ABET SOs:

(c) Ability to design a system, component, or process to meet desired needs.
(e) An ability to identify, formulate, and solve engineering problems.

Course Description:

Axial, bending and Torsion stresses, combined stresses, stress strain relations, Principal stress, and deflection by energy method, thermal stresses. Theories of failure for static loading, fatigue failure, Design of machine elements: shafts, screws, springs, welded joints and coupling.

Objectives:

At the end of this course the student must be able to: formulate and analyze stress and strain in machine elements, find the principals axial, bending, torsion and shear stresses, find deflection of elements by energy methods, apply theory of failure for static loading, fatigue failure, design of machine elements: Shafts, screws, springs, welded joints and coupling.

Learning Outcomes:

1. Ability to find the critical stressed section of a machine element. 2. Ability to analyze 2D and 3D stress state. 3. Ability to analyze strains and deflections. 4. Knowledge of various static failure criteria for different materials. 5. Ability to apply static failure criteria in the design and analysis of machine components. 6. Ability to analyze and design components with non-uniform cross-sections and combined loading. 7. Knowledge of fatigue failure and load-life relation. 8. Knowledge of various fatigue failure criteria. 9. Ability to apply fatigue failure criteria in the design and analyze of machine components under various loading conditions. 10. Ability to design and analyze permanent joints (riveted, welded, etc.) under concentric and eccentric loading conditions. 11. Ability to design and analyze reused joints (bolts, keys, pins, etc.) under various loading condition. 12. Ability to design and analyze power. 13. Ability to design and analyze shafts with different geometrical features under various loading conditions. 14. Understand spring terminology and different types of springs. 15. Ability to design and

analyze coil springs (compression, tension, torsion) under various loads. 16. Knowledge of standards for machine elements. 17. Understanding of safety and reliability concepts in the design of machine elements. 18. Ability to minimize the characteristic dimension of a machine element. 19. Ability to justify a design project in a formal report. 20. Ability to present the outcomes of the design in the form of engineering drawings.

Grading:	Participation	5%
	First Exam	20%
	Second Exam	25%
	Final Exam	40%
	Project	10%

Attendance: Students are required to attend all classes unless extraordinary circumstances occur, and must ask or inform the instructor. Any student who skips four classes including the first day will be dropped from the class. This includes late registration students. Any absences on exam days without informing the instructor beforehand or contacting next day will be unacceptable excuse even with a medical report.

Topics – Part 1		
Introduction to Mechanical Engineering Design		
Mechanics of Materials	Stress	Equilibrium of a deformable body
		Stress
		average normal stress in an axial loaded bar
		Average shear stress – Allowable stress design
		Strain
	Mechanical Properties of Materials	The stress strain diagram, Stress-Strain behavior of a ductile and brittle materials
		Hooke's low, Strain energy, Poisson's ratio
		The shear stress strain diagram
	Axial Load	Elastic Deformation of an axially loaded member
		The force method of analysis for axially loaded member, Thermal Stress
	Torsion	Torsion deformation of a circular shaft, The torsion formula, Power transmission
		Angle of twist
	Bending	Shear and Moment diagram, Graphical method for constructing shear and moment diagrams,
		Bending deformation of a straight member, Flexture formula
	Transverse shear	Shear in straight members, The shear formula
	Combined loading	State of stress caused by combined loadings
	Stress Transformation	Principles Stresses and Maximum in plane shear stresses
		Mohr's Circle – Plane stress
		Absolute Maximum Shear stress
	Energy Methods	Strain energy
		Castigliano's Theorem

Topics – Part 2		
Mechanical Design 1	Failures Resulting from Static Loading	Static Design requirements, Static strength
		Failure theories, Maximum-Normal-Stress theory, Maximum shear stress theory
		Distortion energy theory for ductile material
		Failure of ductile material
		Failure of brittle material
		Modification of the Mohr theory for brittle material, Coulomb-Mohr theory for ductile materials
	Fatigue failure resulting from variable loading	Fatigue Life Methods: The stress-life method, strain life method, linear-elastic fracture mechanics methods
		Endurance limit, fatigue strength
		Endurance limit modifying factors
		Stress concentration and notch sensitivity
		Characterizing fluctuating stresses, Fatigue Failure criteria for fluctuating stress
		Torsional fatigue strength under fluctuating stresses, Combination of loading modes
		Varying, fluctuating stresses, cumulative fatigue damage
		Surface fatigue strength
	Shafts and shaft components	Shaft materials, shaft layouts
		Shaft design for stress
		Deflection consideration
		Critical speed for shafts, Miscellaneous shaft components, Miscellaneous shaft components (Overview), limits and fits (overview)
	Screws, Fasteners, and the design of nonpermanent joints	The mechanics of power screws
	Welding, bonding, and the design of permanent joints	Welding symbols
		Stresses in welded joints in torsion and bending
		The strength of welded joints, Fatigue loading
	Mechanical springs	Helical springs, compression, tension and torsion springs, springs fatigue loading