COURSE OUTLINE

Faculty: Faculty of Chemical and Energy Engineering	
Subject & Code: Material Engineering (SETG 2363) Total Lecture Hours: 4 hours x 14 weeks	Semester: 1 Academic Session: 2024/2025

Lecturer	:	Dr. Zulhairun Abdul Karim
Room No.	:	N29a AMTEC
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Section	:	

Prerequisite	:	Statics (SKPG1243)
Synopsis	:	The first part of SKPG 1263 is introductory of Materials Engineering. Topics include classification of materials (metals, ceramics, polymers, composites and semiconductors); atomic bonds; crystal structure; crystalline defects and solid solutions; and phase diagrams. Main emphasis is on metals because metals are structurally the simplest to characterize and a sound knowledge of structure-property relation of metals can be extended to the study of ceramics and polymers. The second part of the course deals with Mechanics of Materials. Topics cover stress and deformation of members under axial loading, torsion in circular shafts, analysis and design of beams for bending, and stress transformation. Throughout the course, strong emphasis is placed on drawing a free-body diagram and selecting appropriate coordinate system using the correct sign convention.

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Course Learning Outcomes:

By the end of the course, students should be able to:

1) **describe** structure-property of traditional and modern engineering materials (metals, ceramics, polymers and composites) and **choose** class of materials for a given application (i.e. simple material selection)

2) **describe** types of atomic bonding (ionic, covalent, metallic, secondary) and **relate** bonding to materials properties.

3) **describe** and **compare** crystal structure and point defects in metals (FCC and BCC) and **draw** crystallographic direction and planar indices in isometric of cubic unit cells.

4) **describe and differentiate** eutectoid and eutectic phase diagrams of binary systems, perform simple calculations (lever rule) to quantify phase composition and fraction using phase diagram, and predict microstructure as function of temperature and composition.

5) **analyze** structural members under axial load and torsion and **determine** the corresponding internal force, stress and deformation.

6) **Solve** problem related to the location of centroid, moment of inertia and normal stress due to bending in a beam of given cross section

7) **Solve** the problem related to the shear force, bending moment diagrams of beams based on allowable normal stress.

8) **apply** Mohr's circle method to **determine** stress transformation at a point (principal stresses and planes, maximum shear stress, average normal stress)

9) **Function** effectively as an individual, and as a member or leader in diverse teams or multidisciplinary settings

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STUDENT LEARNING TIME

Teaching and Learning Activities	**Student Learning Time (Hours)**
1. Lecture -Tutorial	42 14
2. Independent Study - self learning - information search - library/internet search - reading - group/peer discussion	44
3. Assignment (5x) - self learning - group discussion - team working	15
Test (2x)	2
Final Exam (1x)	3
TOTAL HOURS	120

TEACHING METHODOLOGY

Lecture and discussion, co-operative learning (group discussion), independent study, individual/grouphomework assignment

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Week	Topic	Learning Outcomes
1	**Introduction to Materials Science and Engineering (Chapter 1)** • Classification of engineering materials • (sections 1.1-1.6)	*It is expected that students will be able to:* • **describe** structure-property of traditional and modern classes of materials (metals, ceramics,polymers, composite, semiconductor) • **perform** simple material selection
2	**Atomic Structure and Bonding (Chapter 2)** • Atomic structure and masses • Periodic Variations and Trends in Periodic Table • Primary Bonds • Secondary Bonds (Sections 2.1 – 2.6, omit 2.3)	*It is expected that students will be able to:* • **describe** structure of atom and various trends inPeriodic Table • **describe** types of primary and secondary bonding: • **relate** bond type and strength to electrical andmechanical properties of materials
3-4	**Crystal and Amorphous Structure in Materials (Chapter 3)** • The Space Lattice and Unit Cells • Crystal Systems and Bravais Lattices • Principal Metallic Crystal Structures • Atom Positions in Cubic Unit Cells • Directions in Cubic Unit Cells • Miller Indices for Crystallographic Planes in Cubic Unit Cells • Volume, Planar, and Linear Density Unit-Cell Calculations	*It is expected that students will be able to:* • **define** terms used to describe crystal structure • **draw** crystallographic directions and planes and **assign** corresponding Miller indices • **calculate**: -Coordination Number (CN) -Atomic Packing Factor (APF) -Density (mass, linear and planar)
5-6	**Solidification and Crystalline Imperfections & Thermally Activated Processes and Diffusion in Solids (Chapter 4 & 5)** • Solidification of Metals • Metallic Solid Solutions • Crystalline Imperfections - Point Defects - Line Defects (Dislocations) • Rate Processes in Solids • Atomic Diffusion in Solids • Industrial Applications of Diffusion Processes -Case Hardening of Steel by Gas Carburizing • Effect of Temperature on Diffusion in Solids	*It is expected that students will be able to:* • **define** and **describe** various forms of metallic solidsolutions (alloy) • **distinguish types of crystal defect** • **explain** role of point defects on mechanical andelectrical properties of crystalline materials • **describe** main diffusion mechanisms • **solve** non-steady state diffusion using Fick’ssecond law • **calculate** parameters that influence diffusionkinetics-*T,D,Q*

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7	**Phase Diagrams (Chapter 8)** • Phase Diagrams of Pure Substances • Gibb's Phase Rule • Binary phase diagram – binary isomorphous and binary eutectic • Lever Rule • Invariant Reactions	*It is expected that students will be able to:* • **describe** phase diagram of a material systemand **apply** Gibbs rule. • **describe** binary isomorphous and binaryeutectic phase diagrams • **draw** generic diagrams showing all phaseregions and relevant information • **determine** phase composition and phase fraction in the mixture using tie-line and leverrule • **describe** types of invariant reactions
7-8	**9. Engineering Alloys (Chapter 9)** • Fe-C phase diagram • Heat Treatment of Plain Carbon Steels	• **Interpret** Fe-C phase diagram - describe solid phases in Fe-C diagram - describe invariant reactions in Fe-C diagram - microstructure upon slow cooling - carry out phase analysis • **Describe** TTT diagram for eutectoid steel • **Identify** information found on TTT diagram foreutectoid steel • **Describe** the theory of heat treatment and useit to vary microstructure and physical properties • **Superpose** a variety of isothermal heat treatments on TTT diagram and explain themicrostructure • **Describe** types of heat treatment Appreciatethe relationship between microstructure and properties of steel
9	**Introduction: Concept of Stress** • Review of statics • Stresses in members of a structure • Normal stress in axial bars	*It is expected that students will be able to:* • **draw** free body diagrams (FBD) • **calculate** force, moment and reactions atsupport • **determine** internal force and stresses instructural member
10	**Axial Loading – Stress and Deformation** • Deformation under axial loading for **statically determinate** structures	*It is expected that students are able to:* • **calculate** normal stress and deformation ofuniform or multiple cross-section bars under axial load.
11	**Torsion in Circular Shaft** • Stress in Elastic Range – Solid and Hollow Shafts • Shaft Subjected to Multiple Torques • Shaft Deformation: Angle of Twist	*It is expected that students will be able to:* • **derive** elastic torsion formula • **draw** FBD and **calculate** shear stress and shaftdeformation for solid, hollow and stepped shaftsusing elastic torsion formula

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12	**Pure Bending** • Deformation in a symmetric member inpure bending • Stress in the elastic range	*It is expected that students will be able to:* • **determine** neutral axis or centroid • **calculate** moment of inertia of given crosssection • **calculate** normal stress due to bending
12-13	**Analysis and Design of Beam for Bending** • Shear Force (V) and Bending Moment (M) Diagrams • Using Relationships between w, V and M(graphical method) • Design of Prismatic Beam for Bending	*It is expected that students will be able to:* • **classify** types of beam • **draw** FBD and **calculate** beam support reactions of simple and overhang beams • **construct** V and M diagrams using segmentanalysis AND graphical method. • **determine** maximum bending moment |M| section modulus and maximum bending stress • **select** beam for bending based on given allowable normal stress or section modulus
13-14	**Transformation of Stress** • Transformation of plane stress – principalstresses and plane, maximum shear stress and stresses on rotated plane • Mohr's circle method for plane stress	*It is expected that students will be able to:* • **determine** principal stresses and plane, maximum shear stress and average normal stress using transformation equation AND usingMohr's circle method

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MAIN TEXTBOOKS

1. W.F. Smith and Javad Hashemi, Foundations of Materials Science and Engineering, 5th Ed. in SI Units, MGraw-Hill International, 2011.
2. F. P. Beer, E. R. Johnston, Jr. and J. T. DeWolfe, Mechanics of Materials, 6th Edition (SI Units), McGraw-Hill, 2008.

OTHER REFERENCES

1. R.C. Hibbeler, Mechanics of Materials, 8th Edition in SI Units, Pearson-Prentice-Hall, 2011
2. William D. Callister, Jr., Materials Science and Engineering: An Introduction 7th edition, John Wiley & Sons (Asia)
3. http://www.engin.umich.edu/students/ELRC/me211

GRADING

No.	Assessment	Number	% each	% total	Date
1	HW/Quizzes	4-5		10	As assigned by your lecturer
2	Test 1	1	20	20	Week 5/6
3	Test 2	1	20	20	Week 11/12
4	Final Exam	1	50	50	As scheduled
	OVERALL TOTAL			**100**	

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