ME 648 3(3,0,0)
Surface Engineering
Muhammad Farzik Ijaz, PhD

Instructor Contact Information:

Dr. Muhammad Farzik Ijaz
Mechanical Engineering Department, Bldg. 3, Rm 2C 46
King Saud University
Tel: +966 11 467 6650, Fax: +966 11 467 6652
Email: mijaz@ksu.edu.sa (preferred contact)
https://faculty.ksu.edu.sa/en/mijaz

Course Description:

This course provides an in-depth study of surface engineering principles, tribology, and surface modification techniques. Students will gain a strong understanding of surface topography, roughness parameters, contact mechanics, coatings, and thermochemical surface treatments. The course emphasizes both theoretical foundations and practical applications, including numerical modeling, measurement techniques, and problem-solving. Upon completion, students will be equipped to design, analyze, and enhance surface properties of engineering materials to improve wear resistance, corrosion protection, and mechanical performance in real-world applications.

Course Objectives:

By the ed of this course, students will be able to:

1. Understand the fundamentals of surface engineering and tribology.
2. Analyze surface topography and quantify surface roughness using standard parameters.
3. Apply contact mechanics and Hertzian stress theory to engineering components.
4. Evaluate and select appropriate surface coatings and thermochemical treatments.
5. Perform numerical calculations related to surface roughness, coating thickness, diffusion depth, and stress analysis.
6. Understand deposition techniques and property gradients in surface coatings

Course Learning Outcomes (CLOs):

CLO1: To identify and understands the fundamentals and applications of surface engineering.

CLO2: To measure, distinguish, and interpret surface topography and roughness parameters.

CLO3: To apply numerical methods to analyze surface roughness, coating thickness, and diffusion depth to improve material performance.

CLO4: To Analyze and evaluate surface stresses and contact mechanics problems in engineering components.

CLO5: To reveal the ability to integrate surface engineering and surface modification techniques for practical engineering solutions.

Course Topics:

Lectures	Topics	References
1. Introduction to Surface Engineering	Definition, importance, applications, historical trends	1. M. F. Ashby, Materials Selection in Mechanical Design, 5th Edition, 2016. 2. B. Bhushan, Modern Tribology Handbook, 2001.
2. Fundamentals of Tribology	Friction, wear, lubrication, wear mechanisms	1. J. Halling, Tribology of Engineering Plastics, 2013. 2. B. Bhushan, Principles and Applications of Tribology, 2013.
3. Surface Topography	Surface morphology, measurement techniques, profilometers, SEM, AFM	1. K. Holmberg & A. Matthews, Coatings Tribology, 2nd Edition, 2009.
4. Surface Roughness Parameters	Ra, Rq, Rz, other metrics, practical significance	1. B. Bhushan, Introduction to Tribology, 2013. 2. ISO 4287:1997, Surface Texture: Profile Method.
5. Numerical Problems on Surface Roughness	Calculations using profilometer data	1. B. Bhushan, Modern Tribology Handbook, Vol. 1, 2001.
6. Introduction to Coatings	Types: metallic, ceramic, polymeric; applications	1. K. Holmberg & A. Matthews, Coatings Tribology, 2009. 2. P. Martin, Surface Engineering, Elsevier, 2015.
7. Coating Thickness & Property Gradients	Thickness measurement, hardness/composition gradients	1. R. F. Bunshah, Handbook of Hard Coatings, 2nd Edition, 2001.
8. Numerical Modeling of Coatings	Stress distribution, adhesion modeling, FEA	1. K. Holmberg & A. Matthews, Coatings Tribology, 2009. 2. D. Dowson, History of Tribology, 1979.
9. Numerical Problems on Coating Thickness	Stress and failure calculations, thickness estimation	1. R. F. Bunshah, Handbook of Hard Coatings, 2001.
10. Thermochemical Surface Treatments	Carburizing, nitriding, boriding	1. K. Holmberg & A. Matthews, Coatings Tribology, 2009. 2. ASM Metals Handbook, Surface Engineering, Vol. 5, 2002.
11. Diffusion Theory	Fick's laws, temperature, concentration, time effects	1. H. Leidheiser, Corrosion Control by Surface Engineering, 2000.
12. Diffusion Depth Calculations	Estimation of hardened layer depth, numerical problem-solving	1. ASM Metals Handbook, Heat Treating, 1991.
13. Contact Mechanics	Elastic contact, deformation, stress analysis	1. K. L. Johnson, Contact Mechanics, Cambridge University Press, 1985.
14. Hertzian Contact Stress	Stress calculation, contact area estimation	1. K. L. Johnson, Contact Mechanics, 1985. 2. J. F. Archard, Wear and Contact of Solids, 1953.

Lectures	Topics	References
15. Deposition Techniques & Course Review	PVD, CVD, electroplating, thermal spraying	1. R. F. Bunshah, Handbook of Hard Coatings, 2001. 2. K. Holmberg & A. Matthews, Coatings Tribology, 2009.

Grading Policy

Homework [2*5] ---------- 10
Two Major Exams [15*2] ---------- 30
Project report and presentation---------- 20
Final Exam ---------- 40

Exam schedule: Closed book

Mid-term exam 1: 5th March, 2026.

Midterm exam 2: 11th May,2026.

Reference Texts:

Week	Topic	Suggested Free Reading (PDF)	Notes
1	Introduction to Surface Engineering	*Tribology and Surface Engineering*, Chapters 1-2 (MDPI PDF)	Overview of surface vs bulk, scope, applications
2	Fundamentals of Tribology	*Tribology and Surface Engineering*, Chapters 3-4	Friction, wear, lubrication, tribology basics
3	Surface Topography	*Tribology of Textured Surfaces*, Intro & Chapters 1-2 (MDPI PDF)	Surface texture, roughness, waviness, lay
4	Surface Roughness Parameters	*Tribology of Textured Surfaces*, Chapter 3	RMS roughness, (R_a, R_q, R_z)
5	Numerical Problems on Surface Roughness	*Tribology of Textured Surfaces*, Chapter 4	Examples and calculations
6	Introduction to Coatings	*Coatings Tribology*, Chapters 1-2 (MDPI PDF)	Coating types, functions, substrate interaction
7	Coating Thickness & Property Gradients	*Coatings Tribology*, Chapters 3-4	Thickness effects, property gradients, failure
8	Numerical Modeling of Coatings	*Coatings Tribology*, Chapter 5	Simulation, layered models
9	Numerical Problems on Coating Thickness	*Coatings Tribology*, Chapter 6	Practice examples
10	Thermochemical Surface Treatments	*Tribology and Surface Engineering*, Chapters 6-7	Carburizing, nitriding, carbonitriding
11	Diffusion Theory	*Tribology and Surface Engineering*, Chapter 8	Fick's laws, diffusion mechanisms

Week	Topic	Suggested Free Reading (PDF)	Notes
12	Diffusion Depth Calculations	*Tribology and Surface Engineering*, Chapter 9	Case depth calculations
13	Contact Mechanics	*Mechanical Tribology and Surface Technology*, Chapters 1-2 (MDPI PDF)	Contact area, real vs apparent, elastic contact
14	Hertzian Contact Stress	*Mechanical Tribology and Surface Technology*, Chapter 3	Stress distribution, numerical calculations
15	Deposition Techniques & Course Review	*Laser Surface Engineering for Tribology*, Chapters 1-2 (MDPI PDF)	Ion implantation, deposition parameters, revision