GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-VI

Course Title: Surface Engineering
(Course Code: 4362106)

Diploma programmer in which this course is offered	Semester in which offered
Metallurgy Engineering	6th

1. RATIONALE

Surface engineering is a branch of materials science that focuses on modifying the outermost layer of solid materials to enhance their properties, functionality, lifespan and performance. It plays a pivotal role in various industries, including chemistry, mechanical engineering, and electrical engineering, particularly in semiconductor manufacturing. By employing a variety of techniques, such as coatings, films, and surface treatments, surface engineering enables the creation of improved properties that cannot be achieved solely by the bulk material. surface engineering is a transformative field that empowers engineers to design and manufacture materials with optimized properties for a wide range of applications.

2. COMPETENCY

The purpose of this course is to help the students to attain the following competency through various teaching learning experiences.

- **Apply advanced surface engineering principles for optimal material performance in diverse applications.**

3. COURSE OUTCOMES (COs)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with the identified competency are to be developed in the student for the achievement of the following COs:

1. Apply surface engineering knowledge to categorize and implement mechanical surface preparation methods for enhanced material properties.
2. Suggest surface coating and modification technique based on service requirements.
3. Characterize modified surfaces for enhanced performance across different applications.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P/2)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	T	P	C	CA	ESE	CA	ESE	
2	0	0	2	30	70	00	00	100

(*): Out of 30 marks under the theory CA, 10 marks are for assessment of the micro-project to facilitate integration of COs and the remaining 20 marks is the average of 2 tests to be taken during the semester for the assessing the attainment of the cognitive domain UOs required for the attainment of the COs.

Legends: ***L****-Lecture;* ***T****–Tutorial/Teacher Guided Theory Practice;* ***P*** *-Practical;* ***C*** *– Credit;* ***CA*** *- Continuous Assessment;* ***ESE*** *-End Semester Examination.*

5. SUGGESTED PRACTICAL EXERCISES: NA

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED: NA

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the abovementioned Cos. More could be added to fulfill the development of this course competency.

a) Promote teamwork and collaboration skills by engaging students in group projects or activities where they must work together to analyze, design, or present surface engineering concepts or applications.
b) Expand students' awareness of the diverse applications of surface engineering across different industries (e.g., aerospace, automotive, biomedical) and encourage them to appreciate the versatility of surface modification methods.
c) Encourage a desire for lifelong learning by demonstrating the dynamic nature of surface engineering. Highlight the need for staying updated with new technologies, materials, and processes in the field.
d) Cultivate problem-solving abilities by presenting students with real-world challenges related to surface engineering. Encourage them to brainstorm solutions, think critically, and apply theoretical knowledge to practical scenarios.
e) Participates in class discussion related to surface engineering methods.
f) Practice environment friendly methods and processes.
g) Be aware about the safety aspects during the surface treatment.

The ADOs are best developed through the laboratory/field-based exercises. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

h) i. 'Valuing Level' in 1st year
i) ii. 'Organization Level' in 2nd year
j) iii. 'Characterization Level' in 3rd year.

8. UNDERPINNING THEORY:

The major underpinning theory is given below based on the higher level UOs of Revised Bloom's taxonomy that are formulated for development of the COs and competency. If required, more such UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Subtopics
Unit -1 Introduction	**1.a** Understand surface characteristics, and real-world applications in various engineering field. **1.b** Categorize techniques used for modifying surfaces. **1.c** Describe various mechanical surface preparation methods.	**1.1** Introduction and Scope of surface engineering **1.2** Properties for surface engineering **1.3** Classify surface modification techniques **1.4** Mechanical surface preparation methods such as Sand Blasting, shot peening, shot blasting, Burnishing
Unit – II Surface Coating Techniques	**2.a** Understanding the principle, processes, and applications of various surface coating techniques. **2.b** Identify coating defects.	**2.1** Principle, processes, and applications of i. Electro plating ii. Electroless plating iii. Hot Dip galvanizing iv. Vapor deposition processes: PVD, CVD, IVD v. Sputtering and ion beam assisted deposition vi. Thermal Spraying **2.2** Coating defects
Unit – III Surface Modification Treatments	**3.a** Understand principle, mechanisms, and applications of various surface modification treatments. **3.b** Learn health, environmental, and safety aspects associated with surface modification techniques.	**3.1** Principle, mechanism, and applications of i. Anodizing ii. Carburizing iii. Nitriding iv. Carbonitriding and Laser nitriding v. Chromizing, vi. Boronizing vii. Flame hardening **3.2** Health, environmental issues and safety aspects in surface modification techniques.

Unit IV Characterization of Modified Surface	4.a Characterize properties of modified surface.	**4.1** Characterization of modified surface i.e. surface roughness, thickness, mechanical properties, metallography, wear behavior

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN:

Unit	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Introduction	05	6	4	2	12
II	Surface Coating Techniques	10	5	12	7	24
III	Surface Modification Treatments	08	4	8	8	20
IV	Characterization of Modified Surfaces	05	2	8	4	14
Total		**28**	**17**	**32**	**21**	**70**

Legends: R = Remember; U = Understand; A = Apply and above levels (Bloom's revised taxonomy)

Notes:

1. This specification table shall be treated as a general guideline for students and Teachers.
   The actual distribution of marks in the question paper may slightly vary from above Table.
2. Ask the questions from each topic as per marks weightage. Numerical questions are to be asked only if it is specified. Optional questions must be asked from the same topic.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom learning, following are the suggested student related co-curricular activities which can be undertaken to accelerate the attainment of the various outcomes in this course:

Students should conduct following activities in group

1. Analyze the treated surfaces using microscopy or other characterization methods
2. Assign students to investigate corrosion resistance by applying various coatings or treatments on metal samples.
3. Assign case studies that explore how surface engineering has been applied in specific industries.
4. Organize a debate or discussion around ethical considerations in surface engineering, such as environmental impact, health and safety concerns, or the balance between innovation and ethical use of surface modification.
5. Explore different surface characterization techniques like XRD, SEM, and XPS.

6. Organize field trips to companies or research facilities involved in surface engineering applications.

11. SUGGESTED SPECIAL INSTRUCTIONAL STRATEGIES (if any)

These are sample strategies, which the teacher can use to accelerate the attainment of the various outcomes in this course:

a. Massive open online courses (MOOCs) may be used to teach various topics/sub topics.
b. Guide student(s) in undertaking micro-projects
c. 'L' in section No. 4 means different types of teaching methods that are to be employed by teachers to develop the outcomes.
d. About 20% of the topics/sub-topics which are relatively simpler or descriptive in nature is to be given to the students for self-learning, but to be assessed using different assessment methods.
e. With respect to section No.10, teachers need to ensure to create opportunities and provisions for co-curricular activities.
f. Guide students on how to address issues on environment and sustainability using the knowledge of this course.

12. SUGGESTED PROJECT LIST (Micro Projects) If applicable

Only one micro-project is planned to be undertaken by a student that needs to be assigned to him/her in the beginning of the semester. In the first four semesters, the micro-project is group-based. However, in the fifth and sixth semesters, it should be preferably be individually undertaken to build up the skill and confidence in every student to become problem solver so that s/he contributes to the projects of the industry. In special situations where groups must be formed for micro-projects, the number of students in the group should not exceed three.

The micro-project could be industry application based, internet-based, workshop-based, laboratory-based, or field-based. Each micro-project should encompass two or more COs which are in fact, an integration of PrOs, UOs and ADOs. Each student will have to maintain dated work diary consisting of individual contribution in the project work and give a seminar presentation of it before submission. The total duration of the micro-project should not be less than 16 (sixteen) student engagement hours during the course. The student ought to submit micro-project by the end of the semester to develop the industry-oriented COs.

A suggestive list of micro-projects is given here. This has to match the competency and the COs. Similar micro-projects could be added by the concerned course teacher:

1) Compare the properties (such as hardness, wear resistance, corrosion resistance) of different surface coatings applied to a specific metal. Evaluate and analyze the effectiveness of each coating method.
2) Case studies highlighting the application of surface engineering in industries such as automotive, aerospace, biomedical, or electronics. Discuss the materials used, surface treatments applied, and resulting improvements.
3) Comparative study of different coating techniques (e.g., electroplating, thermal spraying) for wear resistance on mild steel.
4) Characterize the surface morphology of a material using Scanning Electron Microscopy (SEM).
5) Compare the corrosion resistance of different materials in a salt spray test.

6) Investigate the effect of surface modifications (e.g., galvanizing) on the corrosion rate of steel.

13. SUGGESTED LEARNING RESOURCES

Sr. No.	Title of Book	Author / Editor	Publication with place, year, and ISBN
1.	Surface Engineering for Corrosion and Wear Resistance	J. R. Davis	CRC Press, 1st Edition, 2001, ISBN: 9780871707000
2.	Surface Finishing Systems: Metal and Non-metal	R. J. Rudzki	ASM International, 1st Edition, 1984, ISBN: 9780904477078
3.	Surface Preparation and Finishes for Metal	J. A. Murphy	McGraw-Hill, 1st Edition, 1971, ISBN: 9780070595576
4.	ASM Handbook Volume 5: Surface Engineering	ASM International	ASM International, 10th Edition, 1994, ISBN: 9780871703842
5.	Surface Engineering for Wear Resistance	Budinski K. G.	Prentice Hall (1988)
6.	Advanced Surface Coatings: A Hand book of Surface Engineering	Mathews A.	Spinger (1991)
7.	Metallic and Ceramic Coatings	Hocking M.G.	John Wiley (1989).
8.	Surface Engineering Practice, Processes, Fundamentals and Applications in Corrosion and Wear	Strafford K.N., Datta P.K., and Gray J.S	Ellis Harwood (1990)

14. SOFTWARE/LEARNING WEBSITES

1) https://archive.nptel.ac.in/courses/112/107/112107248/
2) https://archive.nptel.ac.in/courses/113/105/113105086/
3) https://onlinecourses.nptel.ac.in/noc23_mm49/preview
4) https://www.youtube.com/watch?v=OxhCU_jBiOA
5) https://www.youtube.com/watch?v=iUeUZPkEFTg
6) https://www.youtube.com/watch?v=C0GINDPG8Ns&t=65s
7) https://www.youtube.com/watch?v=b8Ptfw39ea4
8) https://www.youtube.com/watch?v=DaK3qLIm8uM

15. PO-COMPETENCY-CO MAPPING:

Semester VI	**Surface Engineering (Course Code: 4362106)**						
	POs						
Competency & Course Outcomes	PO 1 Basic & Discipline specific knowledge	PO 2 Problem Analysis	PO 1 Design/ development of solutions	PO 1 Engineering Tools, Experimentation & Testing	PO 1 Engineering practices for society, sustainability & environment	PO 1 Project Management	PO 1 Life-long learning
Competency	**Apply advanced surface engineering principles for optimal material performance in diverse applications.**						
CO1: Apply surface engineering knowledge to categorize and implement mechanical surface preparation methods for enhanced material properties.	3	1	1	2	-	1	3
CO2: Suggest surface coating and modification technique based on service requirements.	3	2	3	2	2	3	3
CO3: Characterize modified surfaces for enhanced performance across different applications.	3	-	-	3	-	3	3

*Legend: '**3'** for high, '**2**' for medium, **'1'** for low and **'-'** for no correlation of each CO with PO.*

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

Sr. No.	**Name and Designation**	**Institute**	**Contact No.**	**Email**
1.	Dr. Naishadhkumar P. Patel	L. E. College (Diploma), Morbi	9727751178	naishadh.patel27@gmail.com
2.	Shailesh B. Rathwa	Government Polytechnic, Bhuj	9099749142	shailesh182011@gmail.com