GUJARAT TECHNOLOGICAL UNIVERSITY (GTU)

Competency-focused Outcome-based Green Curriculum-2021 (COGC-2021)
Semester-II/III

Course Title: Engineering Material
(Course Code: 4300020)

Diploma Programs in which this course is offered	Offered in
Automobile Engineering, Mechatronics (Load taken by Mechanical/Metallurgy dept.)	Sem 2nd
Mechanical Engineering, Fabrication Technology (Load taken by parent department)	Sem 3rd

1. RATIONALE

Due to globalization manufacturing sector experiencing a vital change over, where the emphasis is on reducing weight, fuel economy, ergonomically design and cost. It is essential to understand various material their composition, properties and applications.

Engineering Materials play an important role as the vital tool for solving the problems of material selection and application in the production and manufacturing of equipment/machines, devices, tools, etc. Therefore, an engineering diploma student must be conversant with the properties, composition and behavior of materials from the point of view of reliability and performance of the product.

Subject is concerned with the changes in structure and properties of matter. Many of the processes which are involved to bring out these changes, forms the basis of engineering activities. The study of basic concepts of material science and metallurgy will help the students understanding engineering subjects where the emphasis is laid on the application of these materials.

2. LIST OF COMPETENCIES

The course content should be taught and implemented with the aim to develop different types of skills so that students are able to acquire following competencies:

i. Compare Engineering materials based on properties, behavior and environmental effect for given engineering application.
ii. Examine microstructure and alloying elements of given engineering materials

3. COURSE OUTCOMES (Cos)

The practical exercises, the underpinning knowledge and the relevant soft skills associated with this competency are to be developed in the student to display the following Cos:

a) Compare appropriate material for manufacturing various components.

b) Explain appropriate heat treatment process for various components.
c) Describe various metal and its alloys based on composition and properties.
d) Understand classification and properties of non-metallic materials and composites,
e) Explain electrolysis, paints and powder material to improve surface properties.
f) Identify green material as an alternative of existing materials.

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	
3	0	2	4	30	70	25	25	150

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

5. SUGGESTED PRACTICAL/EXERCISES

The following practical outcomes (PrOs) that are the sub-components of the Cos. These PrOs need to be attained to achieve the Cos.

Sr. No.	Unit No.	Practical/Exercises	Approx. Hours.
1		Prepare report on- a) 1. Types of bonds, construction and characteristics of electrovalent, covalent, coordinate, hydrogen and metallic bond. b) Structure of solids 1.Concept of crystalline structure. 2. Structure of metal-unit cell, BCC, FCC and HCP with Examples of each.	4
1 OR 2			
2	I	1. State the criteria to identify any five (3metallic and 2 nonmetallic) materials from the selected set of material 2. List properties of each above identified materials. Also identify main alloy in elements and reasons to add them.	4

3	II	Analyze content of ferrous/nonferrous material using photo-spectrometer. (This may be covered during industrial visit).	4
3 OR 4			
4	II	1. Demonstrate/Study various heat treatment furnaces. 2. Study various Heat treatment processes Annealing, normalizing, carburizing, casehardening, hardening, tempering, spherodising, nitriding, tempering, stabilizing, etc. Methods, parameters and changes in properties 3.Types of quenching mediums, their properties and applications	4
5	II	Perform hardening process on ferrous material. Measure the hardness before and after hardening.	4
5 OR 6			
6	--	1. Prepare a report on metallurgical examination, its need and importance of microstructure. 2. Write steps for preparation of specimen for microscopic examination. 3. Examine the given specimen by use of metallurgical microscope.	4
7	III	Prepare ferrous micro specimens and examine them. Also prepare report on this. – Four specimens. (One of plain carbon steel, second of alloy steel, third of heat-treated steel and fourth of cast iron.)	4
8	III	Prepare non-ferrous micro specimens and examine them. Also prepare report on this. –Three specimens. (One of copper, second of brass and third of aluminum.)	4
9	IV	Prepare a report on various non-metallic material its classification, properties and application. At least four non-metallic materials.	4
10.	V	Prepare a report on different types of Electrolytes and Non-electrolytes and Industrial applications of electrolysis.	2

10 or 11			
11.	V	Prepare a report on different types of corrosion, identify reasons and suggest remedies for each type of corrosion.	2
12.	VI	Prepare a report on process equipment's and set up used for any two-powder coating process, its working principle and merits.	2

6. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

These major equipment with broad specifications for the PrOs is a guide to procure them by the administrators to usher in uniformity of practical in all institutions across the state.

1. Metallurgical Microscope.
2. Standard specimens.
3. Furnaces to perform heat treatment process.
4. Sorted/required quenching mediums.
5. Hardness tester-to check Rockwell hardness-scales A, B and C.
6. Other hardness testers like sceleroscope, etc.
7. Polishing machine to prepare specimens with necessary consumables.
8. Hand grinder – specifically to prepare specimens and for spark testing.
9. Other consumables.

7. AFFECTIVE DOMAIN OUTCOMES

The following sample Affective Domain Outcomes (ADOs) are embedded in many of the above-mentioned COs. More could be added to fulfil the development of this course competency.

a) Work as a leader/a team member.

b) Follow ethical practices.

c) Practice environmental friendly methods and processes. (Environment related)

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:

i. 'Valuing Level' in 1st year

ii. 'Organization Level' in 2nd year.

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 higher level UOs could be included by the course teacher to focus on attainment of COs and competency.

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit – I **Engineering Materials**	1a. Explain different types of bonds material, its construction and characteristics	1.1 Types of bonds, construction and characteristics of electrovalent, covalent, coordinate, hydrogen and metallic
	1b. Draw molecular arrangement in solids, liquid and gases	1.2 Intermolecular force of attraction 1.3 Molecular arrangement in solids, liquid and gases 1.4 Structure of solids i. Concept of crystalline structure. ii. Structure of metal-unit cell, BCC, FCC and HCP. iii. Examples and properties of metallic structures
	1c. Describe various properties of material	1.5 Physical, mechanical chemical, electrical, electromagnetic and thermal properties of Material.
Unit– II **Phase Diagrams**	2a. Explain the concept of equilibrium diagram. 2b. Plot cooling curves for pure metals and alloys. 2c. Explain effects of Cooling rate, grain size on materials properties.	2.1 Equilibrium diagrams. i. Concept, definition and need. ii. Alloys-major elements, reasons to add and important effect on material properties. iii. Cooling curve-concept and method to plot. 2.2 Solidification of metals i. Concept. ii. Crystal, grain, grain boundaries and dendritic solidification. iii. Effect of cooling rate on material properties.

	2c. Draw and Interpret TTT curves and Iron carbon diagram	2.3 Time Temperature Transformation curve-(TTT curve). i. Need and application. ii. Steps to construct TTT curve 2.4 Iron carbon equilibrium diagram. i. Concept, need & characteristics. ii. Definition of the terms used.
	2d. Improvement of Metal Properties using Different Heat Treatment Process	2.5 Heat treatment processes. i. Heat treatment processes. (Annealing, normalizing, carburizing, case hardening, hardening, tempering, spherodising, nitriding, tempering, stabilizing, etc.). Methods, parameters and changes in properties. ii. Types of quenching mediums, their properties and applications.
Unit– III **Metals And Its Alloys**	3a. Identify various ferrous metals and alloys based on composition and properties for prescribed application 3b. Test material for alloying elements content	3.1 Classification of metals. 3.2 Ferrous metals i. Classification. ii. Steels-types, composition, properties, applications. (For Plain carbon steel, alloy steel including stainless steel and cast iron.)
	3c. Compare various non-ferrous metals and alloys based on composition and properties for given application	3.3 Nonferrous metals i. Classification. ii. Types, composition, properties and applications. (For Copper, copper alloys, Aluminum and Aluminum alloys.)
Unit– IV **Non-Metallic Materials**	4a. Identify non-metallic material by judgment and lay-man tests 4b. Compare the non metallic material for given simple machine elements	4.1 Introduction and classification of non-metallic materials. 4.2 Classification of Polymers on basis of Thermal behavior (Thermoplastics & Thermosetting). 4.3 Properties and applications of polymers (like Polyethylene, Polypropylene, Polyvinyl chloride, Teflon, Polystyrene, Phenol formaldehyde, Acrylonitrile, Epoxy resin.) 4.4 Composites. i. Introduction of composite. ii. Characteristics of composites. iii. Constituents of composite. iv. Types and applications of composites.

		4.5 Other nonmetallic materials-types, properties and applications, (like rubber, ceramics, refectories, abrasives, adhesives, conductor, electronic circuits/components, insulators etc.).
Unit– V Electrolytes, oils, paints/ varnish and powder material	5a. Describe proper surface engineering process for specified application. 5b. Explain basic concept of powder metallurgy and corrosion.	5.1 Surface engineering processes: Coatings and surface treatments; Cleaning and mechanical finishing of surfaces; Organic coatings; Electroplating and Special metallic plating; Electro polishing and photo-etching; Conversion coatings: Oxide, phosphate and chromate coatings; Thin film coatings: PVD and CVD 5.2 Oils. i. Types and properties. ii. Designation methods as per BIS. iii. Applications in Mechanical engineering. 5.3 Paints and varnishes. i. Definition and classifications. ii. Surface preparation and coating methods using paints and varnishes. 5.4 Powder metallurgy. i. Basic concept of powder metallurgy and its applications, merits and demerits. 5.5 Corrosion-types and reasons.
Unit- VI Green material	6.a Understand importance of green material. 6.b Identify the parts which can be replaced by green material	6.1 Concept of green material 6.2 Sustainable and renewable material in mechanical and allied industries. 6.3 Need of advanced material in mechanical and automotive sector. (Electric vehicle, solar panels, battery etc)

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hrs.	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
I.	Engineering Materials.	06	4	2	2	8
II.	Phase diagrams.	10	6	4	6	16
III.	Metals and alloys.	08	6	4	4	14
IV.	Non-metallic materials.	07	2	4	6	12
V.	Electrolytes, oils, paints/ varnish and powder material	07	4	2	8	14
VI.	Green material	04	2	2	2	6
	Total	**42**	**24**	**18**	**28**	**70**

Legends: R=Remember, U=Understand, A=Apply and above (Revised Bloom's taxonomy)

Note: This specification table provides general guidelines to assist student for their learning and to teachers to teach and question paper designers/setters to formulate test items/questions to assess the attainment of the UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may slightly vary from above table.

10. SUGGESTED STUDENT ACTIVITIES

Other than the classroom and laboratory 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 and prepare reports of each activity. They should also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews:

a) Charts can be prepared.

b) Small report on any topic given by concern faculty.

c) Small groups of students can be formed for assigned work. Assigned work should be such that it covers market survey, team work, presentation, time management, quality development.

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

12. SUGGESTED MICRO-PROJECTS

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 are group-based. However, in the fifth and sixth semesters, it should be preferably being ***individually*** undertaken to build up the skill and confidence in every student to become problem solver so that she/he contributes to the projects of the industry. In special situations where groups have to 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 be about **14 - *16 (fourteen to 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:

Identify at least five metals used in laboratory and list the material of selected objects
Identify at least five nonmetals used in laboratory and list the material of selected objects
Identify at least three oils, greases used with their application
List different types of paints available in market for the metals with their specialty.

List the material used for manufacturing of the selected components.
Identify various heat treatment processes used for the manufacturing industries, which and why?
Study report on green material used in manufacturing industry
List different types of material for generation and storage of electricity from solar energy (Electric vehicle, solar panels and battery)
List different types of materials for manufacturing of conductor, electronic circuits/components, insulators

12. SUGGESTED LEARNING RESOURCES

S.No.	Author	Title of Books	Publication with place, year and ISBN
1.	GBS Narang	Materials science	Khanna Publishers, New Delhi, (2021),8195028721.
2.	R.K.Rajpoot	Materials science	S.K. Katariya and sons, Dariyaganj, New Delhi. (2013),8185749108
3.	R.S.Khurmi R.S.Sedha	Materials science	S. Chand, Ahmedabad, (2004), 8121901464
4	U.C. Jindal	Materials science and metallurgy	Pearson Education India, Ahmedabad, (2011) 9788131759110
5.	V. Raghavan	Materials science and Engineering	EEE Edition, Prentice Hill, New Delhi, (2015) 9788120350922
6.	R.B.Gupta	Material science and Engineering	Tech India publication, New Delhi, (2018),9351921077
7.	O.P.Khanna	Material science	Dhanpatrai publication, New Delhi, (2010), 8189928317
8.	Sidney Avner	Physical Metallurgy	Tata McGraw-Hill Education, Noida, (2017).0074630067

14. List of Software/Learning Websites

1. http://vimeo.com/32224002
2. http://www.substech.com/dokuwiki/doku.php?id=iron carbon_phase_diagram
3. http://www-g.eng.cam.ac.uk/mmg/teaching/typd/
4. http://www.ironcarbondiagram.com/

5. http://uk.ask.com/web?q=Who+Discovered+Carbon%3F&qsrc=14097&o=41647924&l=dir
6. http://www.youtube.com/watch?v=fHt0bOfj3T0&feature=related
7. http://www.youtube.com/watch?v=cN5YH0iEvTo
8. http://www.youtube.com/watch?v=m9l1tVXyFp8
9. http://www.youtube.com/watch?v=98lh5Q0M0cg
10. http://www.youtube.com/watch?v=KIyGr-1snMY
11. http://en.wikipedia.org/wiki/Materials_science
12. http://www.studyvilla.com/electrochem.asp

15. PO-COMPETENCY-CO MAPPING

Semester II/III	**Engineering Materials Course Code: 4300020**						
	POs						
Competency & Course Outcomes	**PO 1 Basic & Discipline specific knowledge**	**PO 2 Problem Analysis**	**PO 3 Design/ development of solutions**	**PO 4 Engineering Tools, Experimentation &Testing**	**PO 5 Engineering practices for society, sustainability & environment**	**PO 6 Project Management**	**PO 7 Life-long learning**
Compare Engineering materials based on properties, behavior and environmental effect for given engineering application.	3	1	1	2	1	1	3
Examine microstructure and alloying elements of given engineering materials	2	1	1	2		1	2
CO a) Compare appropriate material for manufacturing various components.	3	1	1	2		1	2
CO b) Explain appropriate heat treatment process for various components	2	1	1	2		1	2
CO c) Describe various metal and its alloys based on composition and properties.	2			1		1	3
CO d) Understand classification and properties of non-metallic materials and composites	3			1		1	3
CO e) Explain electrolysis, paints and powder material to improve surface properties	2					1	2

CO f) Identify green material as an alternative of existing materials	2				3	2	3

16. COURSE CURRICULUM DEVELOPMENT COMMITTEE

GTU Resource Persons

S. No	Name and Designation	Institute	Contact No.	Email
1	Prof. D. A. Dave (Retd. HOD Automobile)	Sir BPTI, Bhavnagar	9427182407	deven_a_dave@yahoo.co.in
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