GUJARAT TECHNOLOGICAL UNIVERSITY, AHMEDABAD, GUJARAT

COURSE CURRICULUM

Course Title: Material Science and Metallurgy
(Code: 3321902)

Diploma Programmes in which this course is offered	Semester in which offered
Mechanical Engineering**,** Automobile Engineering	Second Semester

1. RATIONALE

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

3. TEACHING AND EXAMINATION SCHEME

Teaching Scheme (In Hours)			Total Credits (L+T+P)	Examination Scheme				
				Theory Marks		Practical Marks		Total Marks
L	**T**	**P**	**C**	**ESE**	**PA**	**ESE**	**PA**	**150**
3	0	2	5	70	30	20	30	

Legends: L-Lecture; **T** – Tutorial/Teacher Guided Student Activity; **P** - Practical; **C** – Credit;; **ESE** - End Semester Examination; **PA** - Progressive Assessment.

Note: It is the responsibility of the institute heads that marks for **PA of theory** & **ESE and PA of practical** for each student are entered online into the GTU Portal at the end of each semester within the dates specified by GTU.

4. DETAILED COURSE CONTENT

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	1.2Intermolecular force of attraction 1.3Molecular 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, chemical, electrical, electromagnetic and thermal properties of material
	1d. Explain effects of cooling rate, grain size on materials properties	1.6Solidification of metals and digital transducers i.Concept. ii.Crystal, grain, grain boundaries and dendritic solidification. iii.Effect of cooling rate on material properties. iv.Effect of grain size on properties of metal
Unit– II **Phase Diagrams**	2a. Explain the concept of equilibrium diagram 2b. Plot cooling curves for pure metals and alloys	2.1Equilibrium diagrams. i.Concept, definition and need. ii.Solid solution-definition, properties and examples. iii. Alloys-major elements, reasons to add and important effect on material properties. iv.Cooling curve-concept and method to plot. v.Cooling curve for pure metals and alloys.
	2c. Draw and Interpret TTT curves and Iron carbon diagram	2.2 Time Temperature Transformation curve-(TTT curve). i.Need and application. ii.Steps to construct TTT curve 2.3 Iron carbon equilibrium diagram. i.Concept, need & characteristics. ii.Definition of the terms used. iii. Plotting fundamentals. iv.Interpretation.
	2d. Explain various heat treatment processes	2.4 Heat treatment processes. i.Types of furnaces. ii.Heat treatment processes.(Annealing, normalizing, carburizing, case hardening, hardening, tempering, spherodising, nitriding, tempering, stabilizing, etc.).Methods, parameters and changes in properties. iii.Types of quenching mediums, their properties and applications.

Unit	Major Learning Outcomes	Topics and Sub-topics
Unit– III Metallurgical Microscope	3a. Prepare specimens for microscopic examination 3b. Examine specimens using microscope	3.1 Metallographic examination and microstructures-need and importance 3.2 Principle & working of metallurgical microscope 3.3 Preparation of specimen for microscopic examinations
Unit– IV **Metals And Its Alloys**	4a. Identify various ferrous metals and alloys based on composition and properties for prescribed application 4b. Test material for alloying elements content 4c. Interpret material designations	4.1 Classification of metals. 4.2 Flow diagram for the production of iron and steel. 4.3 Ferrous metals i. Classification. ii. Steels-types, composition, properties, applications. (for Plain carbon steel, alloy steel including stainless steel and cast iron.) iii. Designation and coding methods according to BIS for plain & alloy steel and cast iron. iv. Designation and coding (as per BIS, ASME, EN, DIN,JIS)of plain & alloy steel and cast iron. v. Microstructure of mostly used ferrous materials-low carbon steel, alloy steel, cast iron.
	4d. Select various non-ferrous metals and alloys based on composition and properties for given application	4.4 Non ferrous metals i Classification. ii. Types, composition, properties and applications. (for Copper, copper alloys, Aluminum and Aluminum alloys.) iii. Designation and coding methods according to BIS . iv. Designation and coding (as per BIS, ASME, EN, DIN,JIS)of mostly used non ferrous materials. v. Microstructure of mostly used non ferrous materials-(Copper, Brass, Gunmetal, Aluminum).
Unit– V **Non Metallic Materials**	5a. Identify non-metallic material by judgment and lay-man tests 5b. Select the non metallic material for given simple machine elements	5.1 Introduction and classification of non metallic materials. 5.2 Classification of Polymers on basis of Thermal behavior (Thermoplastics & Thermosetting). 5.3 Properties and applications of polymers (like Polyethylene, Polypropylene, Polyvinyl chloride, Teflon, Polystyrene, Phenol formaldehyde, Acrylonitrile, Epoxy resin.) 5.4 Surface coating methods, setup, working parameters and applications using polymers. 5.5 Composites. i. Introduction of composite. ii. Characteristics of composites. iii. Constituents of composite. iv. Types and applications of composites. 5.6 Other non metallic materials-types, properties and applications.(like rubber, ceramics, refectories ,

Unit	Major Learning Outcomes	Topics and Sub-topics
		insulators, abrasives, adhesives, etc). 5.7 Designation and coding of important non metallic materials as per BIS.
Unit– VI **Electrolysis**	6a. Select proper electrolyte for specified application. 6b. Select proper electrolysis process for surface coating.	6.1 Introduction 6.2 Electrolytes and Non-electrolytes. i. Types of electrolytes. ii. Construction and working of electrochemical cell. iii. Standard conditions. iv. Standard hydrogen electrodes. v. Electrochemical series, galvanic series. vi. Faraday's Laws of Electrolysis. vii. Industrial applications of electrolysis. viii. Surface coating through electrolysis-setup and working. 6.3 Corrosion-types and reasons.
Unit- VII **Fluid And Powder Materials.**	7a. Select suitable cutting oil for given machining process 7b. Select suitable lubricants. 7c. Interpret designations of oils and paints. 7d. List areas of powder metallurgy applications.	7.1 Classification of fluid and powder materials. 7.2 Oils. i. Types and properties. ii. Designation methods as per BIS. iii. Applications in Mechanical engineering. 7.3 Paints and varnishes. i. Definition and classifications. ii. Surface preparation and coating methods using paints and varnishes. 7.4 Powder metallurgy. i. Basic concept of powder metallurgy and its applications, merits and demerits. ii. Manufacturing process of powder coating-setup, equipment used and working.

5. SUGGESTED SPECIFICATION TABLE WITH HOURS & MARKS (THEORY)

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total
I.	Engineering Materials.	05	4	2	2	8
II.	Phase diagrams.	10	6	4	8	18
III.	Metallurgical Microscope	03	3	2	0	5
IV.	Metals and alloys.	10	6	4	6	16
V.	Non metallic materials.	06	3	2	4	09
VI.	Electrolysis.	04	3	0	4	7
VII.	Fluid and powder materials.	04	3	0	4	7
	Total	**42**	**28**	**14**	**28**	**70**

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

Notes:

i) This specification table shall be treated as only general guideline for students and teachers. The actual distribution of marks in the question paper may vary from above table.

ii) If midsem test is part of continuous evaluation, unit numbers I, II, III and VII are to be considered. It is also compulsory for student to complete ex.no.1 to 4 to eligible for midsem test.

iii) Ask the questions from each topic as per marks weightage. Optional questions must be asked from the same topic. That is weightage of compulsory attendance part of questions will be equal to marks allotted to each topic.

6. SUGGESTED LIST OF PRACTICAL/EXERCISES

The practical/exercises should be properly designed and implemented with an attempt to develop different types of skills leading to the achievement of the above mentioned expected competencies.

S. No.	Unit No.	Practical/Exercises	Approx Hours. Required
1	I	a: State the criteria to identify any five (3 metallic and 2 non metallic) materials from the selected set of material b: List properties of each above identified materials. Also identify main alloying elements and reasons to add them.	2
2	II	Analyze content of ferrous/non ferrous material using photo spectrometer. (This may be covered during industrial visit).	2
3	II	a: Study various heat treatment furnaces. b: Perform hardening process on ferrous material. Measure the hardness before and after hardening.	4
4	III	Examine the given specimen by use of Metallurgical Microscope.	2
5	IV	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.)	8
6	IV	Prepare non-ferrous micro specimens and examine them. Also prepare report on this. – Three specimens.(One of copper, second of brass and third of aluminium.)	4
7	VI	Study corrosive materials to identify different types of corrosion of metals.	2
8	ALL	Visit one relevant industry which has specifically heat treatment processes facilities and photo spectrometer.	-
9	All	**PROBLEM BASED LEARNING:** Group of 4-5 students will identify and collect five machine / product components which are made from different engineering materials and which are also failed in their applications. Students will measure and sketch the components (free hand-orthographic views) with dimensions. Students in group will also discuss the reasons of failure and will note down the discussion and outcome.	2
10	All	**SCHOOL WITHIN SCHOOL:**	2

S. No.	Unit No.	Practical/Exercises	Approx Hours. Required
		a. Each student will explain at least one diagram (assigned by teacher-may be part of iron-carbon diagram, TTT curve for specific material, etc) to all batch colleagues. b. Each student will share experiences of the student activities he/she has carried out.	

NOTES:

1. It is compulsory to prepare log book of exercises. It is also required to get each exercise recorded in logbook, checked and duly dated signed by teacher.
2. Student activities are compulsory and are also required to be performed and noted in logbook.
3. Term work report includes term work, objects taken for identification for laboratory work, student activity; parts experimented in acid as student activity and log book along with student activities. Term work report is compulsory part to be submitted at the time of practical ESE.
4. Term work report must not include any photocopy/ies, printed manual/pages, lithos, etc. It must be hand written / hand drawn by student only.
5. For 20 marks ESE, students are to be assessed for competencies achieved. Students are to be asked to prepare specimens, interpret microstructure-iron-carbon diagram-TTT curves, identify materials, select proper materials, etc.

7. SUGGESTED LIST OF PROPOSED STUDENT ACTIVITIES

7.1 Select any five objects (3 metallic and 2 non metallic) which will be used in laboratory and list the material of selected objects.

7.2 Prepare the material list of given tools and commonly used items such as razor blade, knife, scissor, hacksaw blade, carpentry chisel, fix spanner, etc. Also give reason(s) for using such material and discuss your answers with the teacher.

7.3 Take dilute acid which is commonly used at our home for cleaning purpose and put one scrap iron piece and one non ferrous metal piece in it for minimum 12 hours. Take out these two pieces by following all safety norms/steps (without touching acid) and observe the changes. Discuss with your teacher.

7.4 Group of 3-5 students will visit institute's workshop and will identify at least 5 nonmetallic components for a given machine / assembly. Also list the material of identified machine / assembly components.

7.5 List at least three questions individually which you would like to ask for followings:

i. Comparison of iron and fiber reinforced plastic.
ii. Comparison for strength of wood and cast iron.
iii. Annealing-heat treatment process.
iv. Materials used for construction of any bike.
v. Materials used for construction of any home appliance, like mixer, washing machine, iron, etc.

7.6 Any other relevant activity added by teacher including preparing industrial visit report.

8. SUGGESTED LEARNING RESOURCES

A. List of Books

S.No.	Author	Title of Books	Publication/Year
1.	GBS Narang	Materials science	Khanna Publishers, New Delhi.
2.	R.K.Rajpoot	Materials science	Laxmi Publication, Dariya ganj, New Delhi.
3.	R.S.Khurmi, R.S.Sedha	Materials science	S.Chand
4	D.S.Nutt	Materials science and metallurgy	S.K.Katariya and sons, Delhi.
5.	V.Raghavan	Materials science and Engineering	EEE Edition, Prentice Hill, New Delhi.
6.	Sidney Avner	Physical Metallurgy	Tata McGraw-Hill Education (2011).

B. List of Major Equipment/ Instrument

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.

C. 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.aspx

9. COURSE CURRICULUM DEVELOPMENT COMMITTEE

Faculty Members from Polytechnic

- **Prof. Y. R. Joshi**, TPO, B&B Institute of Technology, Vallabhvidyanagar.
- **Prof. D. A. Dave**, Head of Automobile Engineering Department, Sir B.P.I., Bhavnagar.
- **Prof. A. M. Talsaniya**, Lecturer in Mechanical Engineering, Sir B.P.I., Bhavnagar.
- **Prof. R. B. Dhruv**, Lecturer in Mechanical Engineering, R.C.T.I., Ahmedabad.

Co-ordinator and Faculty Member from NITTTR Bhopal

- **Dr. K.K.Jain**, Professor and Head; Dept. of Mechanical Engg,
- **Dr. A.K.Sarathe**, Associate Professor; Dept. of Mechanical Engg,