Program Name : **Diploma in Mechanical Engineering**

Program Code : **ME**

Semester : **Third**

Course Title : **Mechanical Engineering Materials**

Course Code : **22343**

1. RATIONALE

With the advances made in the field of material science millions of materials are now available to cater various need of mankind. These needs and service conditions dictate the properties to be developed in the materials therefore the subject mechanical engineering materials has attracted lot of attention. Materials like ferrous and non ferrous metals, polymer, ceramics and composites are widely used in verity of engineering applications. This course deals with these materials along with advance materials, their metallurgical considerations, heat treatment processes, structure property relationship and applications. This course will enable diploma engineering students to identify variety of material and their selection for various applications.

2. COMPETENCY

The aim of this course is to help the student to attain the following industry identified competency through various teaching learning experiences:

- **Use relevant mechanical engineering materials in different applications.**

3. COURSE OUTCOMES (COs)

The theory, practical experiences and relevant soft skills associated with this course are to be taught and implemented, so that the student demonstrates the following industry oriented COs associated with the above mentioned competency:

a. Identify properties of materials.
b. Select relevant ferrous materials for mechanical components.
c. Select relevant cast iron for the engineering application.
d. Use non-ferrous metals for mechanical components.
e. Suggest relevant advanced materials for mechanical components.
f. Select relevant heat treatment process.

4. TEACHING AND EXAMINATION SCHEME

Teaching Scheme			Credit (L+T+P)	Examination Scheme												
				Theory							Practical					
L	T	P		Paper Hrs.	ESE		PA		Total		ESE		PA		Total	
					Max	Min	Max	Min	Max	Min	Max	Min	Max	Min	Max	Min
3	-	2	5	2	70*#^	28	30*	00	100	40	25#	10	25	10	50	20

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

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

5. COURSE MAP (with sample COs, PrOs, UOs, ADOs and topics)

This course map illustrates an overview of the flow and linkages of the topics at various levels of outcomes (details in subsequent sections) to be attained by the student by the end of the course. in all domains of learning in terms of the industry/employer identified competency depicted at the centre of this map.

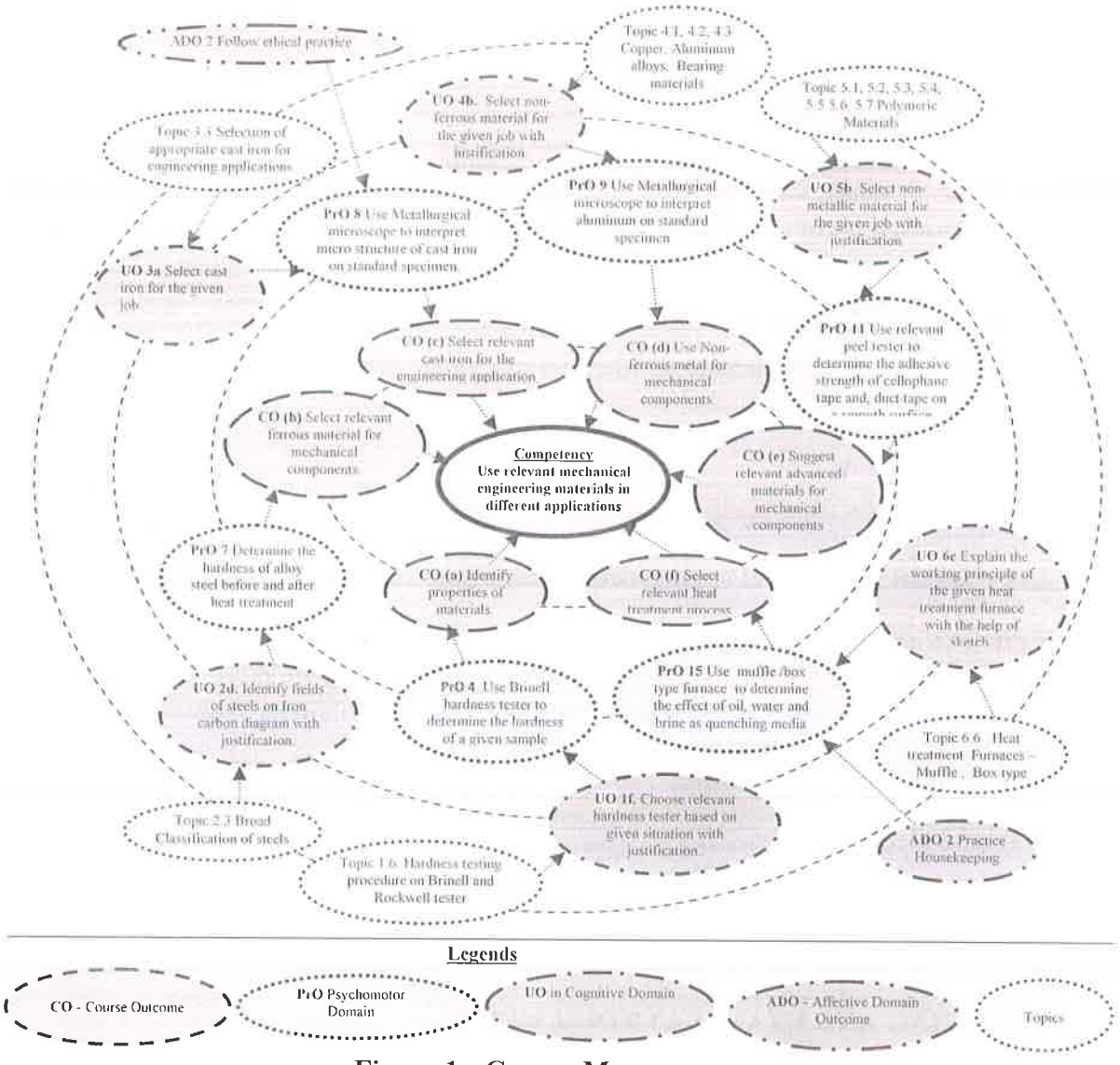

Figure 1 - Course Map

6. SUGGESTED PRACTICALS/ EXERCISES

The practicals in this section are PrOs (i.e. sub-components of the COs) to be developed and assessed in the student for the attainment of the competency.

S. No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
1	Prepare specimen of a given material for microscopic examination.	I	2*
2	Use metallurgical microscope to interpret micro structure of steels and alloy steels on standard specimen.	I	2
3	Use Brinell hardness tester to determine the hardness of a given	I	2*

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S. No	Practical Outcomes (PrOs)	Unit No.	Approx. Hrs. required
	sample.		
4	Use Rockwell Hardness tester to determine the hardness of given sample.	I	2*
5	Use relevant hardness tester to determine the hardness of mild steel before and after heat treatment.	II	2
6	Use relevant hardness tester to determine the hardness of alloy steel before and after heat treatment.	II	2*
7	Use Metallurgical microscope to interpret micro structure of cast iron on standard specimen.	III	2*
8	Use Metallurgical microscope to interpret aluminum on standard specimen.	IV	2
9	Use relevant hardness tester to determine the hardness of copper.	IV	2*
10	Use relevant peel tester to determine the adhesive strength of cellophane tape and, duct tape on a smooth surface.	V	2*
11	Perform flame test to identify different types of plastics.	V	2
12	Use High-temperature oven or electrical current to Identify behavior of the shape-memory alloy as a function with regards to temperature.	V	2*
13	Use relevant peel tester to determine the adhesive strength of scotch tape, electrical tape and masking tape on a smooth surface.	V	2
14	Use muffle /box type furnace to compare • the effect of ***oil*** as quenching media on the hardness of mild steel • the effect of ***water*** as quenching media on the hardness of mild steel • the effect of ***Brine*** as quenching media on the hardness of mild steel	VI	4*
	Total		**30**

Note

i. A suggestive list of PrOs is given in the above table. More such PrOs can be added to attain the COs and competency. A judicial mix of minimum 12 or more practical need to be performed, out of which, the practicals marked as '' are compulsory, so that the student reaches the 'Precision Level' of Dave's 'Psychomotor Domain Taxonomy' as generally required by the industry.*

ii. The 'Process' and 'Product' related skills associated with each PrO is to be assessed according to a suggested sample given below:

S. No.	Performance Indicators	Weightage in %
1.	Preparation of experimental set up	10
2.	Prepare sample using different operations	30
3.	Check the microstructure and hardness of the sample	30
4.	Follow Safety measures	10
5.	Observations and Recording	5
6.	Interpretation of result and Conclusion	5
7.	Answer to sample questions	5
8.	Submission of report in time	5

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S. No.	Performance Indicators	Weightage in %
	Total	**100**

The above PrOs also comprise of the following social skills/attitudes which are Affective Domain Outcomes (ADOs) that are best developed through the laboratory/field based experiences:

a. Follow safety practices.
b. Practice good housekeeping.
c. Demonstrate working as a leader/a team member.
d. Maintain tools and equipment.
e. Follow ethical Practices.

The ADOs are not specific to any one PrO, but are embedded in many PrOs. Hence, the acquisition of the ADOs takes place gradually in the student when s/he undertakes a series of practical experiences over a period of time. Moreover, the level of achievement of the ADOs according to Krathwohl's 'Affective Domain Taxonomy' should gradually increase as planned below:

- 'Valuing Level' in 1st year
- 'Organizing Level' in 2nd year
- 'Characterizing Level' in 3rd year.

7. MAJOR EQUIPMENT/ INSTRUMENTS REQUIRED

The major equipment with broad specification mentioned here will usher in uniformity in conduct of experiments, as well as aid to procure equipment by authorities concerned.

S. No.	Equipment Name with Broad Specifications	PrO. No.
1	Metallurgical Reflected light Microscope 6V, 30W halogen Light,200x magnification,191x126x100 mm specimen stage ,Size With 100 mm travel	1,2,3,4.
2	Slitting Machine- Slitting width- standard 300 mm or extensible, Slitting blade, Slitting each width at least 15 mm	2,3,4.
3	Polishing Machine Grinding/polishing disc diameter: 200mm. Rotation speed: 0-600 rpm	2,3,4
4	Digital Rockwell hardness tester- Easy-to-use Electronics Console Hi/Lo Tolerance Settings, Adjustable Time @ Load Average Test Group Results 2-9; Test Result Memory Capacity 5000 results, RS232 Output,- Average Range.	5,6,7
5	Digital Brinell Hardness Machine- Hardness range HBW<125	5,6,7
6	Laboratory box furnaces 1200°c	11,12,14
7	Peel Tester	10,13

8. UNDERPINNING THEORY COMPONENTS

The following topics are to be taught and assessed in order to develop the sample UOs given below for achieving the COs to attain the identified competency. More UOs could be added.

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Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Unit – I Basics of Engineering Materials	1a. Interpret crystal structure of the given material. 1b. Interpret the structure of specified materials at the given level. 1c. Identify microstructure of the given material with justification. 1d. Explain with sketches the procedure to prepare given sample. 1e. Explain with sketches procedure of hardness testing for the given tester. 1f. Choose relevant hardness tester based on the given situation with justification.	1.1 Classification of engineering materials, 1.2 Crystal structure, Unit cell and space lattice 1.3 Microstructure, types of microscopes 1.4 Sample preparation, etching process. types of etchant. 1.5 Properties of metals Physical Properties, Mechanical Properties. 1.6 Hardness testing procedure on Brinell and Rockwell tester
Unit – II Steel and its Alloys	2a. Interpret the given equilibrium diagram. 2b. Use the Iron –carbon equilibrium diagram for the given application. 2c. Identify the given phase diagrams and reactions with justification. 2d. Identify the given fields of steels on Iron carbon diagram with justification. 2e. Select relevant steel for the given application with justification.	2.1 Concept of phase, pure metal, alloy and solid solutions. 2.2 Iron Carbon Equilibrium diagram various phases i. Critical temperatures and significance ii. Reactions on Iron carbon equilibrium diagram 2.3 Broad Classification of steels, i. Plain carbon steels: Definition, Types and Properties, Compositions and applications of low, medium and high carbon steels. ii. Alloy Steels: Definition and Effects of alloying elements on properties of alloy steels. iii. Tool steels: Cold work tool steels, Hot work tool steels, High speed steels(HSS) iv. Stainless Steels: Types and Applications v. Spring Steels: Composition and Applications vi. Specifications of steels and their equivalents 2.4 Steels for following: Shafts, axles, Nuts, bolts, Levers, crank shafts, camshafts, Shear blades, agricultural equipments, house hold utensils, machine tool beds, car bodies, Antifriction bearings and gears.
Unit- III	3a. Select the relevant cast	3.1 Types of cast irons as white, gray,

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Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
Cast Iron	iron for the given job with justification. 3b. Interpret the given material designations. 3c. Identify the properties of the given composition of cast iron with justification.	nodular, malleable 3.2 Specifications of cast Iron. 3.3 Selection of appropriate cast iron for engineering applications. 3.4 Designation and coding (as per BIS, ASME, EN, DIN, JIS) of cast iron, plain and alloy steel.
Unit– IV Non-ferrous Metals and alloys	4a. Describe the properties and applications of the given copper alloy. 4b. Describe the properties and applications of the given aluminium alloy. 4c. Describe the properties and applications of the given bearing material 4d. Select relevant non-ferrous material for the specified application with justification.	4.1 Copper and its alloys - brasses, bronzes Chemical compositions, properties and Applications. 4.2 Aluminium alloys –Y-alloy, Hindalium, duralium with their composition and Applications. 4.3 Bearing materials like white metals (Sn based), aluminium bronzes, Porous, Self lubricating bearings.
Unit– V Non-metallic and Advanced Materials	5a. Distinguish between metallic and nonmetallic materials on the basis of given composition, properties and applications. 5b. Select relevant non-metallic material for the given job with justification. 5c. Select relevant composite material for the given job with justification. 5d. Suggest relevant alternative materials for the given job with justification.	5.1 Polymeric Materials i. Polymers- types, characteristics. ii. Properties and uses of Thermoplastics, Thermosetting Plastics and Rubbers. 5.2 Thermoplastic and Thermosetting Plastic materials 5.3 Characteristics and uses of ABS, Acrylics, Nylons and Vinyls,Epoxides, Melamines and Bakelites 5.4 Rubbers: Neoprene, Butadiene, Buna and Silicons – Properties and applications. 5.5 Ceramics –types of ceramics, properties and applications of glasses and refractories 5.6 Composite Materials - properties and applications of Laminated and Fibre reinforced materials 5.7 Advanced Engineering Materials - Properties and applications of Nano materials and smart materials.
Unit– VI Heat Treatment processes	6a. Describe with sketches the specified heat treatment processes. 6b. Select the relevant heat treatment process for the	6.1 Annealing: Purposes of annealing, Annealing temperature range, Types and applications 6.2 Normalizing: Purposes of Normalizing, Temperature range, Broad applications of

Unit	Unit Outcomes (UOs) (in cognitive domain)	Topics and Sub-topics
	given material with justification. 6c. Explain with sketches the working principle of the given heat treatment furnace. 6d. Suggest the relevant heat treatment process for the given situation with justification.	Normalizing 6.3 Hardening: Purposes of hardening, Hardening temperature range ,application 6.4 Tempering: Purpose of tempering. Types of tempering and its applications 6.5 Case hardening methods like Carburizing. Nitriding, and Cyaniding. 6.6 Heat treatment Furnaces – Muffle . Box type

***Note**: To attain the COs and competency, above listed UOs need to be undertaken to achieve the 'Application Level' and above of Bloom's 'Cognitive Domain Taxonomy'*

9. SUGGESTED SPECIFICATION TABLE FOR QUESTION PAPER DESIGN

Unit No.	Unit Title	Teaching Hours	Distribution of Theory Marks			
			R Level	U Level	A Level	Total Marks
I	Basics of Engineering Materials	06	02	04	04	10
II	Steel and its alloys	10	04	04	06	14
III	Cast Iron	08	02	04	04	10
IV	Non ferrous Metal and Alloys	08	02	04	04	10
V	Non Metallic and advanced Material	08	04	04	04	12
VI	Heat Treatment processes	08	04	06	04	14
Total		**48**	**18**	**26**	**26**	**70**

***Legends:** R=Remember, U=Understand, A=Apply and above (Bloom's Revised taxonomy)*
***Note**: This specification table provides general guidelines to assist student for their learning and to teachers to teach and assess students with respect to attainment of UOs. The actual distribution of marks at different taxonomy levels (of R, U and A) in the question paper may 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 about 5 pages for each activity, also collect/record physical evidences for their (student's) portfolio which will be useful for their placement interviews

a. Prepare journal based on practical performed in Material Testing laboratory .Journal consist of drawing, observations , required materials, tools, equipments, date of performance with teacher signature.
b. Prepare/Download a specifications of followings:
    i. Tools and equipment in material testing laboratory.
    ii. Machineries in material testing laboratory
a. Undertake a market survey of local dealers for tools, equipments; machineries and raw material prepare a report.
b. Visit any Industrial heat treatment shop and prepare a report consisting

i. Types of heat treatment process
ii. Types of furnaces
iii. Types of quenching mediums used
iv. Types of Testing equipments
v. Safety precautions observed.

c. Guide student(s) in undertaking micro-projects.

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. ***'L' in item No. 4*** does not mean only the traditional lecture method, but different types of teaching methods and media that are to be employed to develop the outcomes.
c. About ***15-20% of the topics/sub-topics*** which is relatively simpler or descriptive in nature is to be given to the students for ***self-directed learning*** and assess the development of the COs through classroom presentations (see implementation guideline for details).
d. With respect to item No.10, teachers need to ensure to create opportunities and provisions for ***co-curricular activities***.
e. Guide student(s) in undertaking micro-projects.
f. Arrange visit to nearby industries for understanding various Heat treatment processes.
g. Show video/animation films to explain functioning of various hardness testing and heat treatment processes.
h. Draw Iron Carbon charts.
i. Use different instructional strategies in classroom teaching.

12. SUGGESTED TITLES OF 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 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 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 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 are given here. Similar micro-projects could be added by the concerned faculty:

a. **Comparative study**: Comparative study of various materials used in previous and current generation components of mechanical engineering equipments like IC Engine, Compressor, turbine, pumps, refrigerator, water cooler, Lathe Machine, Milling Machine, Drilling Machine grinding machine (any one) with proper justifications.
b. **Experimentation:** Determine the hardness of different metallic components (min.5) and compare hardness and plot a bar chart indicating hardest and soft material in the given group

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c. **Experimentation:** Determine the microstructure of different metallic components (min.5) using metallurgical Microscope and compare their microstructure in the given group
d. **Collection:** Collect sample of various types of plastics, ceramics, composites used in day to day applications and prepare chart containing properties, applications of the samples.
e. Collect information related to Types, Properties and applications of smart materials from websites. Present the information in the form of Chart.

13. SUGGESTED LEARNING RESOURCES

S. No.	Title of Book	Author	Publication
1.	Engineering Material	Sharma, C. P.	PHI Learning, New Delhi 2015 ISBN 978-81-203-2448-0
2.	Engineering Materials	Agrawal, B. K.	McGraw Hill Education, New Delhi ISBN 978-00-745-1505-1
3.	Material Science and metallurgy	Kotgire, V. D.	Everest publishing House, New Delhi 2015; ISBN 81 86314 008
4.	Material Science and metallurgy	Khanna, O. P.	Dhanpat Rai and sons, New Delhi 2015; ISBN- 978-81-899-2831-5
5	Material Science for Polytechnic	Rajput, R. K.	S K Katariya and sons; New Delhi 2015; ISBN- 81-85749-10-8

14. SUGGESTED SOFTWARE/LEARNING WEBSITES

a. http://vimeo.com/32224002
b. http://www.substech.com/dokuwiki/doku.php?id=iron-carbon_phase_diagram
c. http://www-g.eng.cam.ac.uk/mmg/teaching/typd/
d. http://www.ironcarbondiagram.com/
e. http://www.youtube.com/watch?v=fHt0bOfj3T0andfeature=related
f. http://www.youtube.com/watch?v=cN5YH0iEvTo
g. http://www.youtube.com/watch?v=m9l1tVXyFp8
h. http://www.studyvilla.com/electrochem.aspx
i. http://www.sakshat.ac.in/

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