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COURSE PLAN

Academic Year 2019 – 20

Program:	B E – MECHANICAL
Semester :	III
Course Code:	18ME34
Course Title:	Material Science
Credit / L-T-P:	4 / 4-0-0
Total Contact Hours:	50
Course Plan Author:	K B Arun Kumar

Academic Evaluation and Monitoring Cell

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Note : Remove “Table of Content” before including in CP Book
Each Course Plan shall be printed and made into a book with cover page
Blooms Level in all sections match with A.2, only if you plan to teach / learn at higher levels

A. COURSE INFORMATION

1. Course Overview

Degree:	BE	Program:	ME
Year / Semester :	2/III	Academic Year:	2019-2020
Course Title:	Material Science	Course Code:	18ME34
Credit / L-T-P:	4/4-0-0	SEE Duration:	180 Minutes
Total Contact Hours:	50	SEE Marks:	60Marks
CIA Marks:	40	Assignment	1 / Module
Course Plan Author:	K B Arun Kumar	Sign	Dt:
Checked By:	Sagar H N	Sign	Dt:

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute. Identify 2 concepts per module as in G.

Module	Module Content	Teaching Hours	Module Concepts	Blooms Level
1	Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures,Atomic Diffusion: Phenomenon, Fick's Law s of diffusion; Factors affecting diffusion Mechanical Behavior: Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering and true strains, Linear and nonlinear elastic behavior and properties, Mechanical properties in plastic range. Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness, Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals Fracture: Type I, Type II and Type III,Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, Fatigue properties, S-N diagram, Fatigue testing. Creep: Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness	10	Crystal structure, mechanical behavior	L2 understand ,l3 apply
2	Concept of formation of alloys: Types of alloys, solid solutions, factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, Substitutional and interstitial solid solutions, Intermediate phases, Gibbs phase rule Effect of non-equilibrium cooling, Coring and Homogenization Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels. Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, Cast metal structures Solidification of Steels and Cast irons	10	Alloys, iron-carbon diagram	L2 understand
3	Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT)curves, Annealing: Recovery, Recrystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Martempering, Austempering, Concept of hardenability, Factors affecting it hardenability, surface hardening methods: carburizing, cyaniding, nitriding, flame hardening and induction hardening, Age hardening of aluminum-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron, Malleable iron, SG iron and steel	10	Heat treatment	L2 understand
4	Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites(MMCs), Ceramic Matrix Composites (CMCs) and Polymer Matrix Composites (PMCs), Particulate-reinforced and fiber reinforced composites, Fundamentals of production of composites, Processes for production of composites,Characterization of composites, Constitutive relations of composites, Determination of composite properties from component properties, Hybrid composites	10	Non-metals	L2 understand
5	Structure types and properties and applications of ceramics. Mechanical / Electrical behavior and processing of Ceramics. Plastics: Various types of polymers/plastics and their applications. Mechanical behaviors and processing of plastics,Failure of plastics. Brief description of other materials such as optical and thermal materials Smart materials – fiber optic materials, piezo-electrics, shape memory alloys Shape Memory Alloys – NitiInol, superelasticity, Biological applications ofsmart materials - materials used as implants in human Body, Selection of Materials, Performance of materials in service Residual life assessment – use of non-destructive testing, Economics, Environment and Sustainability	10	composites	L2 understand

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).

1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Module	Details	Available
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	
1,2,3,4,5	Smith, foundations of materials science engineering ,4th edition,McGraw Hill 2009	In Lib
B	Willam D Callister material science engineering and introduction Wiley 2006	In Lib
1,2,3,4,5	V ragavan material science and engineering PHI 2002	In Lib
C	Donald R Askland and pradeep p phule the science and engineering of materials ,cengage learing 4th Ed 2003	In Lib
C1	Kesttor praveen material science suggi publication	In Dept
C2	Nptel Videos	web
C3	➓ https://www.youtube.com/watch?v=5nBBUahtz-c&list=PLyAZSyX8Qy5C8ciqBBlypbx91j4nowUbL ➓ https://www.youtube.com/watch?v=UsT0CtabRYY ➓ https://www.youtube.com/watch?v=748_ME0p0Ag ➓ https://www.youtube.com/watch?v=VMH6qbED7pg	
C4		
C5		
C6		
C7		
C8		
C9		
C10		
D	**Software Tools for Design**	

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

Students must have learnt the following Courses / Topics with described Content . . .

SNo	Course Code	Course Name	Module / Topic / Description	Sem	Remarks	Blooms Level
1	1	15PHY12	Engineering physics	Physical geometry Of atoms	I	L2
2	2	18EME18/28	Elements of Mechanical Engineering	Material selection	I/II	L2

Note: If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.

Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1				

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs. Identify a max of 2 Concepts per Module. Write 1 CO per Concept.

#	Cos students should be able to...	Teach. Hours	Concept	Instr Method	Assessment Method	Blooms' Level
18ME34.1	Understand the micro structure of the material	04	Crystal structure	Lecture	Assignment ,IA ,unit test	L2 understand
18ME34.2	Apply the physiological process & mechanical behavior with in the material	06	Mechanical properties	Lecture	Assignment ,IA ,unit test	L3 apply
18ME34.3	Understand the characteristics and properties of alloys	05	Failure of materials	Lecture	Assignment ,IA ,unit test	L2 understand
18ME34.4	Study of alloys,steel and solidification	05	alloys,steel and solidification	Lecture & ppt	Assignment ,IA ,unit test	L2 apply
18ME34.5	Study of heat treatment process to obtained desired properties of alloys	05	Heat treatment	Lecture & ppt	Assignment ,IA ,unit test	L2 understand
18ME34.6	Understand the properties & potential of various materials & selection procedure	05	Ferrous	Lecture and ppt	Assignment ,IA ,unit test	L2 understand
18M34.7	Understand the process,preparation ,composition based on application & its properties to obtained their cumulative relation of composites	05	composites	Lecture and ppt	Assignment ,IA ,unit test	L2 understand
18M34.8	Understand the Processing ofcomposites	05	Processing ofcomposites	Lecture and ppt	Assignment ,IA ,unit test	L2 understand
18M34.9	Understand the properties and potentialities of Material	05	Material selection	Lecture and ppt	Assignment ,IA ,unit test	L2 understand
18M34.10	Understand the various available and Other Material	05	Other Material	Lecture and ppt	Assignment ,IA ,unit test	L2 understand

Note: Identify a max of 2 Concepts per Module. Write 1 CO per concept.

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level
1	Crystal structure predictions have been used to study organic molecules	CO1	L2
2	Materials used for the designing and manufacturing of any solid material	CO2	L3
3	Automotive. aircraft ,railroad electrical spring, tube pipe fitting	CO3	L2
4	Phase diagrams are useful to improve material behavior	CO4	L2
5	Heat treatment are useful to improve the mechanical properties	CO5	L2
6	Knife blades: brake fade ,ball bearing gas turbine engine	CO6	L2
7	Space craft,Aircraft Miscellaneous,Automobile parts	CO7	L2

4. Mapping Justification

Mapping		Justification	Mapping Level
CO	**PO**	**-**	**-**
CO1	PO1	Knowledge of microscope is required to understand the micro structure of material	L2
CO2	PO1	Knowledge of stress, strain is required to study the behavior of the material	L2
CO4	PO1	Knowledge of alloys is required to Understand the characteristics and	L2

		properties of alloys	
CO4	PO	Knowledge of iron and carbon and their alloys is required to study the iron-carbon diagram for different phases & comparison with metal and alloys	L2
CO5	PO1	engineering Knowledge is required to study the various heat treatment methods	L2
CO6	PO1	Knowledge of other material selection is required to study of properties of different material	L2
CO7	PO1	Basic knowledge of composites is required in engineering to study composite ,their properties and application	L2
CO8	PO1	Knowledge of composites and their properties and application	L2
CO9	PO1	Knowledge of Structure types and properties and applications of ceramics	L2
CO10	PO1	Knowledge of smart materials and applications of smart materials	L2

Note: Write justification for each CO-PO mapping.

4. Articulation Matrix

(CO – PO MAPPING)

-	-	Course Outcomes	Program Outcomes															
Modules	#	COs	PO1	PO 2	PO 3	PO4	PO5	PO 6	PO7	PO8	PO9	PO1 0	PO 11	PO 12	PSO 1	PS O2	PS O3	Lev el
1	18ME34.1	Understand the of micro structure the material	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
1	18ME34.2	Apply the physiological process & mechanical behaviour of the material	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	18ME34.3	Understand the characteristics and properties of alloys	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
2	18ME34.4	Study of iron-carbon diagram for different phases & comparison with metal and alloys	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	18ME34.5	Study of heat treatment process to obtained desired properties of alloys	x	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-
3	18ME34.6	Understand the properties & potential of various materials & selection procedure	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	18M34.7	Understand the process,preparation ,composition based	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
4	18M34.8	Understand the application & its properties to obtained their cumulative relation of composites	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
5	18M34.9	Understand the Structure types and properties and	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

		applications of ceramics																	
5	18M34.10	Knowledge of smart materials and applications of smart materials	x	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																	

5. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

SNo	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1					
2					
3					

Note: Write Gap topics from A.4 and add others also.

6. Content Beyond Syllabus

Modules	Gap Topic	Area	Actions Planned	Schedule Planned	Resources Person	PO Mapping
3						

Note: Anything not covered above is included here.

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation. Distinct assignment for each student. 1 Assignment per chapter per student. 1 seminar per test per student.

Module #	Title	Teaching Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Basics, Mechanical Behavior, Failure of Materials	10	2	-	-	1	1	2	CO1, CO2	L2, L3
2	Concept of formation of alloys:	10	2	-	-	1	1	2	CO3, CO4	L2, L3
3	Heat treating of metals:	10	-	2	-	1	1	2	CO5	L2
4	Ceramics:Plastics:Other materials	10	-	2	-	1	1	2	CO6	L2
5	Composite Materials	10	-	-	4	1	1	2	CO7	L2
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Evaluation	Weightage in Marks	CO	Levels
CIA Exam – 1	40	CO1,CO2,CO3	L2,
CIA Exam – 2	40	CO4, CO5	L2
CIA Exam – 3	40	CO6, CO7	L2

Assignment - 1	10	CO1,CO2,CO3	L2,
Assignment - 2	10	CO4, CO5	L2
Assignment - 3	10	CO6, CO7	L2
Seminar - 1		CO1,CO2,CO3	L2,
Seminar - 2		CO4, CO5	L2
Seminar - 3		CO6, CO7	L2
Other Activities – define – Slip test		CO1 to Co7	L2,
Final CIA Marks	**50**	**-**	**-**

D1. TEACHING PLAN - 1

Module - 1

Title:	Crystal Structure	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the microstore of the material	CO1	L2
2	Apply the physiological process & mechanical behavior with in the boundary limits,comparison with standards	CO2	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Introduction to Crystal Structure – Coordination number, atomic packing factor,	C01	L2
2	Simple Cubic, BCC, FCC and HCP Structures,	C01	L2
3	Atomic Diffusion: Phenomenon, Fick's Law s of diffusion; Factors affecting diffusion	C01	L2
4	Stress-strain diagrams showing ductile and brittle behavior of materials,	C01	L2
5	Engineering and true strains, Linear and nonlinear elastic behavior and properties,	C01	L2
6	Mechanical properties in plastic range. Stiffness, Yield strength, Offset Yield strength, Ductility,	C02	L2
7	Ultimate Tensile strength, Toughness, Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals	C02	L2
8	Fracture: Type I, Type II and Type III,	C02	L2
9	Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, Fatigue properties, S-N diagram, Fatigue testing.	C02	L2
10	Creep: Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness	C02	L2
c	**Application Areas**	**CO**	**Level**
1	Crystal structure predictions have been used to study organic molecules	CO1	L2
2	Materials used for the designing and manufacturing of any solid material	CO2	L2
d	**Review Questions**	-	-
1	Define APF. Calculate the APF for an ideally packed HCP unit cell.	CO1	L2
2	Classify the crystal defects. Explain point defect with neat sketches.	CO1	L2
3	With neat sketches explain surface defects briefly	CO1	L2
4	List the factors affecting diffusion. Explain them briefly	CO1	L2
5	list linear and non-linear elastic properties. Explain non-linear elastic properties.	CO2	L2
6	draw S-N curve and typical creep curve. Explain them briefly.	CO2	L2
7	With a neat creep curve, explain different stages of creep deformation.	CO2	L2

8	Explain the mechanisms of fatigue failure in engineering materials with necessary diagram.	CO2	L2
9	Define the following terms : i) Yield strength ii) Offset yield strength iii) Ductility iv) Ultimate strength v) Toughness.	CO2	L2
10	Compare Plastic deformation by slip and twinning	CO2	L2
11	Explain types of fatigue loading with examples	CO2	L2
e	**Experiences**	-	-
1			
2			

Module – 2

Title:	**Properties and Behaviour of materials**	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the characteristics and properties of alloys	CO3	L2
2	Study of iron-carbon diagram for different phases & comparison with metal and alloys	CO4	L2
b	***Course Schedule***	-	-
Class No	**Module Content Covered**	**CO**	**Level**
1	Concept of formation of alloys: Types of alloys	CO3	L2
2	solid solutions, factors affecting solid solubility (Hume Rothery rules)	CO3	L2
3	Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, Substitutional and interstitial solid solutions, Intermediate phases	CO3	L2
4	Gibbs phase rule Effect of non- equilibrium cooling, Coring	CO3	L2
5	Homogenization Iron-Carbon (Cementite) diagram	CO4	L3
6	description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel	CO4	L3
7	Solidification: Mechanism of solidification		
	Homogeneous and Heterogeneous nucleation	CO4	L2
8	Crystal growth, Cast metal structures	CO4	L2
9	Solidification of Steels and Cast irons	CO4	L2
c	Materials used for the designing and manufacturing of any solid material	CO3	L2
	Automotive. aircraft ,railroad electrical spring, tube pipe fitting	CO4	L2
d	**Review Questions**	-	L2
1	Explain the rules governs the formation of solid solution	CO3	L2
2	What are the different cast metal structures? Explain with neat sketches.	CO3	L2
3	explain Substitutional and Interstitial solid solutions. Discuss Hume — Rothary rules governing formation of solid solution	CO3	L2
4	State lever rule and Gibbs phase rule. Also explain Hume-Rothary rules for formation of solid solution	CO3	L2
5	Explain the Mechanism of solidification	CO3	L2
6	Draw Fe-Fe3C diagram. Explain the reactions in it.	CO4	L2
7	What is an invariant reaction in the Iron-Carbon phase diagram? Explain the Eutectic reaction and peritectic reaction.	CO4	L2
8	Two metals A and B have their melting points at 900°C and 800°C respectively. The alloy pair forms an eutectic at 600°C of composition 60% B. They have unlimited liquid solubilities. The solid solubility of A in B is 10% and that of B in A is 5% at eutectic temperature and remains constant till 0°C. Draw the phase diagram and label all the fields. Find the amount of liquid and solid phases in an alloy of 20% B at 650°C.	CO4	L2

9	two metals A and B have their melting points at 600°C and 400°C respectively. These metals do not form any compound or intermetallic phase. The maximum solubility in each other is 4% which remains the same until 0°C. An eutectic reaction occurs at 300°C for65% A.i) Draw the phase diagram and label all the phases and fields.ii) Find the temperature at which 20% A and 80% B starts and ends solidification.iii) Find the temperature at which the same alloy contain 50% liquid and 50,% solid.	CO4	L2
10	construct a phase diagram using the following data and label all the fields:Melting point of Ag = 961°C Melting point of Cu = 1083°C Eutectic temperature = 780°C Eutectic composition = 28% Cu. Max. solubility of Cu in Ag = 9% at 780°C Max. solubility of Cu in Ag = 2% at 0°C Max. solubility of Cu in Ag = 9% at 780°C Max. solubility of Cu in Ag = 0% at 0°C Determine the following:i) Solidification start and end of temperature for 30% Ag alloy.ii) Temperature at which a 15% Cu alloy has 50% liquid phase and 50% solid phase.iii) Percentage composition of liquid and solid phase in 20% Ag alloy at 900°C	CO4	L2
e	**Experiences**	-	-
1			
2			

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	18ME34	Sem:	III	Marks:	50	Time:	75 minutes		
Course:	Material Science								
-	-	**Note: Answer any 2 questions, each carry equal marks.**					**Marks**	**CO**	**Level**
1	a	Define APF?Determine the APF for FCC unit cell					CO1	L2	7
	b	State & explain Fick's laws of diffusion .also explain the factors affecting diffusion					CO1	L2	8
	c	Explain clearly the linear & non-linear elastic properties					CO2	L2	10
		OR							
2	a	Explain the plastic deformation by a) Slip b) Twinning					CO2	L2	8
	b	List the difference between ductile material & brittle material					CO2	L2	7
		A 0.2%C steel component is to be carburized at 920 ^{0}C . Calculate the time required to increase the carbon content to 0.4% at 0.5mm below the surface . Assume that the carbon content at the surface is 0.9%.Given $D_{920}c = 1.28x10^{-11}$ m^2/sec Error function z: 0.75, erf(z): 0.7112 z: 0.80, erf(z): 0.7421					CO1	L3	10
3	a	Explain the stages in ductile fracture					CO3	L2	8
	b	List the difference between ductile & brittle fracture					CO3	L2	8
	c	What is solidification? Explain the solidification of pure metal with cooling curve					CO4	L2	9
		OR							
	a	What is solid solution ? Explain the classification of solid solution					CO4	L2	8
4	b	Define fatigue behaviour of material ? With the help of neat sketch discuss the different types of stress cycles					CO3	L2	9
	c	Define creep & explain a typical creep curve					CO3	L2	8

b. Assignment -1

Model Assignment Questions

Crs Code:	18ME34	Sem:	III	Marks:	10	Time:	90 – 120 minutes
Course:	Material Science						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		What is a crystal imperfection? Give the list of crystal imperfections.	5	CO2	L2
2		Define atomic packing factor. Calculate the atomic packing factor for FCC.	5	CO2	L2
3		Copper has FCC structure and an atomic radius of 1.278 A . Calculate its density. Given mol. wt. = 63.54 g/mol.	5	CO2	L3
4		Explain the Brinell hardness & Rockwell Hardness with sketches & equations.	5	CO2	L2
5		with the help of neat sketches explain the different stages of ductile cup & cone fracture.	5	CO2	L2
6		What is fatigue? What are the factors affecting the fatigue life?	5	CO2	L2
7		What is Griffith's theory of brittle fracture? Explain and give the equation for critical stress for crack propagation.	5	CO2	L2
8		sketch any three types of Bravais lattices.	5	CO2	L2
9		Determine the relationship between atomic radius and lattice parameters in cubic systems[simple cubic, BCC and FCC.	6	CO2	L2
10		Illustrate the steady-state diffusion.	4	CO2	L2
11		When a 3000 kg load is applied to a 10 mm diameter ball in a Brinell test of a steel, an indentation of 3.1 mm is produced. Estimate the tensile strength of the steel.	6	CO2	L3
12		state the stages in the cup and cone fracture	5	CO2	L2
13		Explain how fatigue life can be enhanced.	4	CO2	L2
14		differentiate between edge and screw dislocations, with sketches.	6	CO2	L2
15		State and explain Fick's first law of diffusion.	5	CO2	L2
16		raw the stress-strain curve for the following materials : i) Mild steel ii) Copper iii) Cast iron	6	CO2	L2
17		cylindrical specimen of medium carbon steel, having an original diameter of 20 mm,when subjected to a tension test has a fracture strength of 450 MPa. If its final diameter at fracture is 12 mm, calculate the engineering stress, engineering strain and true stress.	7	CO2	L2
18		derive an expression for critical resolved shear stress for slip, with a sketch	7	CO2	L2
19		Define : i) Space lattice ; ii) Unit cell ; iii) Atomic packing factor.	6	CO2	L2
20		With a neat sketch, explain the plastic deformation of a single crystal, by slip.	5	CO2	L2
21		Differentiate between : i) Toughness and resilience ; ii) Ductility and brittleness.	6	CO2	L2
22		define creep. With a typical creep curve, explain the different stages of creep.	5	CO3	L2
23		Write note on ductile fracture.	4	CO2	L2
24		A zinc crystal is being pulled in tension with the normal to its basal plane at 60 ° to the tensile axis, and with a slip direction at 40 ° to the tensile axis.i) What is the resolved shear stress, T, acting in the slip direction when a tensile stress of 0.69 MPa is applied? ii) What tensile stress is necessary to reach the critical resolved shear stress, Tc , of 0.94 MPa?	7	CO2	L2
25		A copper rod of initial diameter 2mm fractures at a load of 110 kg. It's ductility is 75% reduction in area. Calculate the true stress at fracture.	7	CO2	L2

D2. TEACHING PLAN - 2

Module – 3

Title:	Introduction to heat treatment	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Study of heat treatment process to obtained desired properties of alloys	CO5	L2

b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Heat treating of metals: Time-Temperature-Transformation (TTT) curves,	CO5	L2
2	Continuous Cooling Transformation (CCT)curves,	CO5	L2
3	Annealing: Recovery, Recrystallization and Grain growth,	CO5	L2
4	Types of annealing, Normalizing, Hardening, Tempering, Martempering, Austempering	CO5	L2
5	Concept of hardenability, Factors affecting it hardenability	CO5	L2
6	surface hardening methods: carburizing, cyaniding, nitriding,	CO5	L2
7	flame hardening and induction hardening,	CO5	L2
8	Age hardening of aluminum-copper alloys and PH steels.	CO5	L2
9	Ferrous materials: Properties, Compositions	CO5	L2
10	uses of Grey cast iron, Malleable iron, SG iron and steel,	CO5	L2
d	**Review Questions**	-	-
1	Define heat treatment. Give its classification.	CO6	L2
2	Distinguish between Austempering and Martempering.	CO6	L2
3	Draw TIT diagram. Explain briefly.	CO6	L2
4	With neat sketch explain Jominy end quench test.	CO6	L2
5	Explain age hardening of A/-Cu alloys.	CO6	L2
6	Draw a neat labeled TTT diagram for eutectoid steel. Show a cooling curve for the formation of 100% marten site on it and explain the curve	CO6	L2
7	Differentiate clearly between Normalizing and Annealing. Discuss Spheroidising Annealing with applications.	CO6	L2
8	With a neat diagram, explain induction hardening process. Discuss the advantages,limitations and applications of the process.	CO6	L2
9	Discuss on various types of cast irons with necessary micro structures	CO6	L2
10	Explain composition, properties and uses of Gray cast Iron, white cast iron and S. G Iron	CO6	L2
e	**Experiences**	-	-
1			
2			
5			

Module – 4

Title:	**Composite Materials**	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the properties & potential of various materials & selection procedure	CO6	L2
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**
1	Structure types and properties and applications of ceramics.	CO6	L2
2	Mechanical / Electrical behavior and processing of Ceramics.	CO6	L2
3	Various types of polymers/plastics and their applications	CO6	L2
4	Mechanical behaviors and processing of plastics,Failure of plastics.	CO6	L2
5	Brief description of other materials such as optical and thermal materials Smart materials – fiber optic materials,	CO6	L2
6	Piezo- electrics, shape memory alloys Shape Memory Alloys – Nitinol, superelasticity	CO6	L2
7	Biological applications of smart materials - materials used as implants in human Body	CO6	L2

8	Selection of Materials, Performance of materials in service	CO6	L2
	Residual life assessment – use of non-destructive testing,	CO6	L2
c	**Application Areas**	**CO**	**Level**
	Knife blades: brake fade ,ball bearing gas turbine engine	CO6	L2
d	**Review Questions**	-	-
1	Define ceramic. Explain briefly the types of ceramics.	CO6	L2
2	List the applications and mechanical properties of ceramics.	CO6	L2
3	Define smart material. Explain briefly the types of smart materials	CO6	L2
4	Write a note on: I) Shape memory alloys ii)Piezo electric materials iii) Fiber optic materials iv) Use of non-destructive testing	CO6	L2
5	describe Shape memory alloys. Explain briefly the applications of shape memory alloys	CO6	L2
6	classify Ceramic materials. Explain the application and processing method of any one class.	CO6	L2
7	Write a note on mechanical properties of ceramics	CO6	L2
8	give classification of polymers. List the characteristics of polymers.	CO6	L2
9	differentiate between Thermo settling and Thermoplastic polymers. What are the advantages and disadvantages of plastic materials?	CO6	L2
10	With a neat sketch explain the processing of plastic by injection moulding method.	CO6	L2
e	**Experiences**	-	-

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	18ME34	Sem:	III	Marks:	50	Time:	75 minutes		
Course:	Material Science								
-	-	**Note: Answer any 2 questions, each carry equal marks.**					**Marks**	**CO**	**Level**
1	a	Draw the TTT diagram for hyper eutectoid steel.					5	L2	9
	b	What is annealing ? Explain any two type of annealing with neat sketch.					5	L2	8
	c	With a neat sketch ,explain flame and induction hardening.					6	L2	8
		OR							
2	a	Explain microstructure , composition and application of grey and malleable cast iron.					6	L2	10
	b	With a neat sketch explain, carburizing and nitriding process.					6	L2	8
	c	Differentiate between austempering & martempering.					5	L2	7
3	a	With a neat sketch ,explain injection moulding process.					7	L2	8
	b	Explain filament winding process with a neat sketch .					7	L2	8
		Write the classification and application of composites.					8	L2	9
		OR							
4	a	Derive the equation for young's modulus of FRP composite using iso-strain condition.					8	L2	9
	b	Calculate the tensile modulus of elasticity of unidirectional carbon fiber reinforced composite material which contain 62% by volume of carbon fiber in iso-strain ans iso -stress condition .take $E_{\textbf{carbon fiber}} = 3.86X\ 10^4 kgf/mm^2$ and $E_{\textbf{epoxy}} = 4.28X\ 10^2 kgf/mm^2$.					8	L2	8
	c	With a neat sketch ,explain pultrusion process.					7	L2	8

b. Assignment – 2

Model Assignment Questions							
Crs Code:	18ME34	Sem:	III	Marks:	10	Time:	90 – 120 minutes
Course:	Material Science						
Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.							

SNo	USN	Assignment Description	Marks	CO	Level
1		Explain the steps to contruct TTT diagram. Draw a labeled sketch of a TTT diagram for an eutectoid steel	7	CO3	L2
2		What are TTT cures	5	CO3	L2
3		Explain is the effect of alloying element of Fe-C diagram and CCT diagram	5	CO3	L2
4		Write notes on plain carbon steels applications and uses	5	CO3	L2
5		What are the different types cast irons	5	CO3	L2
6		Write a note on effects of alloying elements on cast iron	5	CO3	L2
7		How are ductile irons manufactured	4	CO3	L2
8		Explain structure and composition of Gray cast iron S.G iron and low carbon steel	7	CO3	L2
9		Give the various classifications of Gray cast iron	4	CO3	L2
10		Explain four important cooper based alloys giving their composition range and applications	5	CO3	L2
11		Draw the copper- zinc phase and show different types of brasses in it	6	CO3	L2
12		What is meant by modification of Al-Si alloys	5	CO3	L2
13		Explain the composition properties and applications of any three aluminum based alloys	6	CO3	L2
14		Write a note on AL-Cu alloys	5	CO3	L2L2
15		List the alloying elements and applications of magnesium based alloys	6	CO3	
16		Explain the composition properties and uses of any four non ferrous alloys	5	CO3	L2
17		Explain in detail the BIS classification of steel	6	CO3	L2
18		Write a note on i) tool steel ii) stainless steel iii) chrome steel	6	CO3	L2
19		Discuss the following with reference to their composites properties and applications I) structural ii) tool and die steel iii) brasses and bronzes	5	CO3	L2
20		Distinguish clearly between plain carbon steels and alloys stells	6	CO3	L2

D3. TEACHING PLAN - 3

Module – 5

Title:	**Smart Materials**	Appr Time:	10 Hrs
a	***Course Outcomes***	-	**Blooms**
-	The student should be able to:	-	**Level**
1	Understand the process,preparation ,composition based on application & its properties to obtained their cumulative relation of composites	CO7	L2
b	***Course Schedule***		
Class No	**Module Content Covered**	**CO**	**Level**

1	Composite materials - Definition, classification, types of matrix materials & reinforcements	CO7	L2
2	Metal Matrix Composites (MMCs), Ceramic Matrix Composites (CMCs)	CO7	L2
3	Polymer Matrix Composites (PMCs),	CO7	L2
4	Particulate-reinforced and fiber reinforced composites	CO7	L2
5	Fundamentals of production of composites,	CO7	L2
6	Processes for production of composites	CO7	L2
7	Characterization of composites,,	CO7	L2
8	Constitutive relations of composites	CO7	L2
9	Determination of composite properties from component properties,	CO7	L2
10	Hybrid composites	CO7	L2
c	**Application Areas**	**CO**	**Level**
1	Space craft,Aircraft Miscellaneous,Automobile parts	CO7	L2
d	**Review Questions**	-	-
1	Define composite. How do you classify composites?	CO7	L2
2	Explain the role of matrix and reinforcement in composite materials	CO7	L2
3	With flow chart explain the production of carbon fiber	CO7	L2
4	with a neat sketch explain pultrusion process	CO7	L2
5	List the advantages and application of composites	CO7	L2
6	classify the composite materials on matrix and reinforcement. List the roles of matrix,reinforcement and interface.	CO7	L2
7	With a neat figure, explain Injection moulding process for particulate reinforced polymer	CO7	L2
8	classify the composite materials on matrix and reinforcement. List the roles of matrix,reinforcement and interface	CO7	L2
9	under Iso stress condition, obtain an expression for Young's modulus of a fibre reinforced composites	CO7	L2
10	Explain the fundamentals of production of FRPs	CO7	L2
e	**Experiences**	-	-
1			
2			

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	18ME34	Sem:	III	Marks:	50	Time:	75 minutes
Course:	Material Science						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Define composite give its classification list the advantages and limitations of composite	8	CO7	L2
	b	With a neat sketch explain filament winding process. list the application of filament winding process	7	CO7	L2
		OR			
2	a	Derive an expression for the ratio of load shared between the fiber and matrix in a uni-directional composite material when loaded in the directions along the axis of fiber	8	CO7	L2
	b	Explain with neat sketch the production of metal matrix composite (MMC) by stir casting	7	CO7	L2
3	a	With a neat sketch explain of FRPs by any two method of open mould process.	6	CO7	L2
	b	What is the role of matrix ,reinforcement and interface in composite material	4	CO7	L2
	c	With a neat sketch explain injection moulding process for particulate reinforced polymers	5	CO7	L2
4		**OR**			

	a	With a neat sketch explain filament winding process	7	CO7	L2
	b	Discuss the application of Al-SiC composites	8	CO7	L2

b. Assignment – 3

Note: A distinct assignment to be assigned to each student.

Model Assignment Questions							
Crs Code:	18ME34	Sem:	III	Marks:	5	Time:	90 – 120 minutes
Course:	Material Science						

Note: Each student to answer 2-3 assignments. Each assignment carries equal mark.

SNo	USN	Assignment Description	Marks	CO	Level
1		What are the composites ex[plain how they are involved the quality	5	CO7	L2
2		Distinguish between an alloys and composite	6	CO7	L2
3		Clearly bring out the difference b/w alloys & composite materials from fundamentals	5	CO7	L2
4		Define composite material mention the advantages of composite material over traditional materials	6	CO7	L2
5		Why and how composites superior to conventional material	5	CO7	L2
6		What are the advantage & limitations of composites as compared to metals & polymers	5	CO7	L2
7		Classify composite material	5	CO7	L2
8		Write a note on different types of composite material & their applications	5	CO7	L2
9		Compare metal matrix composites with polymer matrix composites	5	CO7	L2
10		Write down i)MMCs ii)PMCs	5	CO7	L2
11		What are the main types of synthetic fiber used in FRPs	5	CO7	L2
12		Differentiate between thermosetting and thermoplastic polymers	6	CO7	L2
13		List the different methods of manufacturing FRP explain any two of them	5	CO7	L2
14		With neat sketch explain filament winding process	5	CO7	L2
15		Explain spray-up process	5	CO7	L2
16		Explain pultrusion process	5	CO7	L2
17		With neat sketch Explain stir casting process	5	CO7	L2
18		With neat sketch resin transfer moulding	5	CO7	L2
19		With neat sketch sheet moulding compound	5	CO7	L2
20		With neat sketch injection moulding	5	CO7	L2

F. EXAM PREPARATION

1. University Model Question Paper

Course:		Material Science					Month / Year	/2019	
Crs Code:		18ME34	Sem:	III	Marks:	80	Time:	180 minutes	
	Note	Answer all FIVE full questions. All questions carry equal marks.					**Marks**	**CO**	**Level**
1	a	Define APF. Calculate APF for HCP cell					6	CO2	L2
	b	With neat sketch explain surface defects briefly					7	CO2	L2
	c	With a help of stress-strain diagram ,briefly explain ductile behavior of engineering material					7	CO2	L2
		OR							

2	a	Define fracture. Explain types of fracture	6	CO2	L2
	b	What is stress relaxation? obtain an expression for stress relaxation	6	CO2	L2
	c	With S-N diagram explain fatigue behavior of material	8	CO2	L2
3	a	Define fracture. Explain types of fracture	6	CO2	L2
	b	What is stress relaxation? obtain an expression for stress relaxation	7	CO2	L2
	c	With S-N diagram explain fatigue behavior of material	7	CO2	L2
		OR			
4	a	Define creep with a neat creep curve, explain different stages of creep deformation	6	CO2	L2
	b	What are ceramics? Briefly explain the types of ceramics	6	CO2	L2
	c	Write a note on mechanical properties of ceramics	8	CO2	L2
5	a	State and explain lever and Gibbs phase rule. also explain Hume- rothary rules for formation for formation of solid solution	7	CO3	L2
	b	Two metals A and B have melting points at 900^0C and 800^0C. The alloy pair forms an eutectic at 600^0C of composition 60%B and 40%A. A and B have unlimited mutual liquid solubility. Their solid solubilites are as follows: 10% B in A at 600^0C and 5% B in A at 0^0C,8%A in B at 600^0C and 4%A in B at 0^0C, assume liquids, solidus, and solves lines to be straight, no solid state reactions other than solubility changes occur in the series i) Draw the phase diagram for series and label all the temperatures, compositions and fields ii) Find the room temperature structure of an alloy of composition 60%A and 40% B with respect to the number, type, extent and composition of the phases	8	CO4	L3
6	a	Draw the Iron-Carbon equilibrium diagram, Show all the phase. write the about all the different phases	8	CO4	L2
	b	Define homogeneous and heterogeneous nucleation .obtain an expression for critical radius of nucleation	7	CO4	L2
	c	With a neat sketch explain Induction hardening process, mention advantages and applications	8	CO4	L2
	d	Explain composition properties and uses of Gray cast iron, white cast iron and S.G iron	7	CO4	L2
		OR			
6	a	With a neat sketch explain Induction hardening process, mention advantages and applications	10	CO5	L2
	b	Explain composition properties and uses of Gray cast iron, white cast iron and S.G iron	10	CO5	L2
		OR			
7	a	What is mean by plastic? what are advantage, disadvantage and application of the plastic material	10	CO6	L2
	b	With a neat sketch explain filament winding process. list the application of filament winding process	10	CO6	L2
		OR			
8	a	Define composite give its classification list the advantages and limitations of composite	10	CO7	L2
	b	Explain with neat sketch the production of metal matrix composite (MMC) by stir casting	10	CO7	L2

2. SEE Important Questions

Course:		Material Science					Month / Year	/2019	
Crs Code:		18ME34	Sem:	III	Marks:	80	Time:	180 minutes	
	Note	Answer all FIVE full questions. All questions carry equal marks.					-	-	
Module	Qno.	Important Question					**Marks**	**CO**	**Year**
1	1	Define APF. Calculate the APF for an ideally packed HCP unit cell.					6	CO2	2017
	2	Classify the crystal defects. Explain point defect with neat sketches.					6	CO2	2016
	3	With the help of Stress — strain diagrams, briefly explain the ductile and brittle behavior of Engineering Materials					8	CO2	2016

2	1	With a neat creep curve, explain different stages of creep deformation.	6	CO2	2017
	2	Explain the mechanisms of fatigue failure in engineering materials with necessary diagram	6	CO2	2016
	3	List and explain the mechanical properties in elastic and plastic region.	8	CO2	2016
3	1	Draw Fe-Fe3C diagram. Explain the reactions in it.	8	CO3	2018
	2	Define homogeneous and heterogeneous nucleation. Obtain an expression for critical radius of nucleus.	6	CO4	2016
	3	Explain the effect of alloying elements to the steel.	6	CO4	2015
4	1	Draw a neat labeled TTT diagram for eutectoid steel. Show a cooling curve for the formation of 100% marten site on it and explain the curve.	8	CO5	2004
	2	Differentiate clearly between Normalizing and Annealing. Discuss Spheroidising Annealing with applications	6	CO5	2004
	3	Define ceramic. Explain briefly the types of ceramics.	6	CO6	2006
5	1	classify the composite materials on matrix and reinforcement. List the roles of matrix, reinforcement and interface.	8	CO7	2013
	2	With a neat figure, explain Injection moulding process for particulate reinforced polymers	6	CO7	2015
	3	list the advantages and limitations of composite materials. Mention any four applications of polymer matrix composite	6	CO7	2017

G. Content to Course Outcomes

1. TLPA Parameters

Table 1: TLPA – Example Course

Module- #	Course Content or Syllabus (Split module content into 2 parts which have similar concepts)	Content Teaching Hours	Blooms' Learning Levels for Content	Final Blooms' Level	Identified Action Verbs for Learning	Instruction Methods for Learning	Assessment Methods to Measure Learning
A	*B*	*C*	*D*	*E*	*F*	*G*	*H*
1 1	Introduction to Crystal Structure – Coordination number, atomic packing factor, Simple Cubic, BCC, FCC and HCP Structures,Atomic Diffusion: Phenomenon, Fick's Law s of diffusion; Factors affecting diffusion Mechanical Behavior: Stress-strain diagrams showing ductile and brittle behavior of materials, Engineering and true strains, Linear and nonlinear elastic behavior and properties, Mechanical properties in plastic range.	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment

	Stiffness, Yield strength, Offset Yield strength, Ductility, Ultimate Tensile strength, Toughness, Plastic deformation of single crystal by slip and twinning, Mechanisms of strengthening in metals						
2	Fracture: Type I, Type II and Type III,Fatigue: Types of fatigue loading with examples, Mechanism of fatigue, Fatigue properties, S-N diagram, Fatigue testing. Creep: Description of the phenomenon with examples, three stages of creep, creep properties, Stress relaxation. Concept of fracture toughness	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment
2	Concept of formation of alloys: Types of alloys, solid solutions, factors affecting solid solubility (Hume Rothery rules), Binary phase diagrams: Eutectic, and Eutectoid systems, Lever rule, Substitutional and interstitial solid solutions, Intermediate phases, Gibbs phase rule Effect of non- equilibrium cooling, Coring and Homogenization	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment
3	Iron-Carbon (Cementite) diagram: description of phases, Effect of common alloying elements in steel, Common alloy steels, Stainless steel, Tool steel, Specifications of steels. Solidification: Mechanism of solidification, Homogenous and Heterogeneous nucleation, Crystal growth, Cast metal structures Solidification of Steels and Cast irons	5	- L1 - L2	L2,L3	Understand	Lecture/Tutorial	Assignment
3	Heat treating of metals: Time-Temperature-Transformation (TTT) curves, Continuous Cooling Transformation (CCT)curves, Annealing: Recovery, Recrystallization and Grain growth, Types of annealing, Normalizing, Hardening, Tempering, Martempering, Austempering, Concept of hardenability	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment
3	Factors affecting it hardenability, surface hardening methods: carburizing, cyaniding, nitriding, flame hardening and induction hardening, Age hardening of aluminum-copper alloys and PH steels. Ferrous materials: Properties, Compositions and uses of Grey cast iron, Malleable iron, SG iron and steel	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment
4	Structure types and properties and applications of ceramics. Mechanical / Electrical behavior and processing of Ceramics. Plastics: Various types of polymers/plastics and their applications. Mechanical behaviors and processing of plastics,Failure of plastics. Brief description of other materials such as optical and thermal materials Smart materials – fiber optic materials, piezo-electrics,	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment
4	shape memory alloys Shape Memory Alloys – NitiInol, superelasticity, Biological applications ofsmart materials - materials used as implants in human Body, Selection of Materials, Performance of materials in service Residual life assessment – use of non-destructive testing, Economics, Environment and Sustainability	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment
5	Composite materials - Definition, classification, types of matrix materials & reinforcements, Metal Matrix Composites(MMCs), Ceramic Matrix	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment

	Composites (CMCs) and Polymer Matrix Composites (PMCs), Particulate-reinforced and fiber reinforced composites,						
5	Fundamentals of production of composites, Processes for production of composites,Characterization of composites, Constitutive relations of composites, Determination of composite properties from component properties, Hybrid composites	5	- L1 - L2	L2	Understand	Lecture/Tutorial	Assignment

2. Concepts and Outcomes:

Table 2: Concept to Outcome – Example Course

Module- #	Learning or Outcome from study of the Content or Syllabus	Identified Concepts from Content	Final Concept	Concept Justification (What all Learning Happened from the study of Content / Syllabus. A short word for learning or outcome)	CO Components (1.Action Verb, 2.Knowledge, 3.Condition / Methodology, 4.Benchmark)	Course Outcome **Student Should be able to ...**
A	*I*	*J*	*K*	*L*	*M*	*N*
1	Crystal Structure	- -	Crystal Structure	structure of the crystal for different materials	- Understand	Understand the Crystal Structure an its types
1	Mechanical Behavior	- -	Mechanical Behavior	Stress strain diagram of materials	- Understand	- Understand the properties of material and their behaviour
2	Failure of Materials	- -	Failure of Materials	Fracture	Understand	Understand the Fatigue and creep of a material
2	Alloys Steel and solidification	- -	Alloys Steel and solidification	Iron carbon diagram	Understand	Understand the type of alloys and iron carbon diagram and different phases
3	Heat treatment	- -	Heat treatment ,	Time-Temperature transformation(TTT)curves and Continous cooling transformation(CCT)curves	Understand	Understand the different type of curves
3	Heat treatment methods ferrous and non-ferrous alloys	- -	Heat treatment methods ferrous and non-ferrous alloys	Surface Hardening Flame Hardening ferrous and non-ferrous alloys	Understand	Understand the types of different heat treatment methods,properties and composition of ferrous materials
4	Composite materials	- -	Composite materials	Composite materials,classification,type of matrix and reinforcement	Understand	Understand the types of Composite materials
4	Production of Composite materials	- -	Production of Composite materials	Production of MMCs,CMCs,PMCs	Understand	Understand the types of Production of MMCs,CMCs,PMCs
5	Materials selection	- -	Materials selection	Ceramics, Plastics	Understand	Understand the types of Ceramics, Plastics processing
5	Other Material selection		Other Material selection	Smart Materials	Understand	Understand the types of Smart Materials and

						their application