ANNA UNIVERSITY, CHENNAI
NON-AUTONOMOUS AFFILIATED COLLEGES
REGULATIONS 2021
CHOICE BASED CREDIT SYSTEM

B.E. MATERIALS SCIENCE AND ENGINEERING

PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

I. To prepare students to excel in research and to succeed in the areas of materials science and metallurgical engineering.
II. To provide students with a solid foundation in mathematical, scientific and engineering fundamentals required to solve materials science and metallurgical engineering problems
III. To train students to have sound knowledge on the production, processing, characterization, structural properties correlation and application of all different engineering materials.
IV. To inculcate students with professional and ethical attitude, effective communication skills, teamwork skills and multidisciplinary approach.
V. To develop student with an academic excellence, leadership qualities, leading to life-long learning for a successful professional career

PROGRAM OUTCOMES (POs)

PO	Graduate Attribute
1	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2	**Problem analysis**: Identify, formulate, review research literature, and analyse complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modelling to complex engineering activities with an understanding of the limitations.
6	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and

norms of the engineering practice.

9 **Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.

10 **Communication:** Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.

11 **Project management and finance:** Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.

12 **Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PROGRAM SPECIFIC OUTCOMES (PSOs)

1. Graduates will have an ability to identify, analyse and provide solution to the problems related to Materials and metallurgical engineering
2. Graduates will have the ability to implement/use appropriate characterisation techniques, analytical skills, and latest/recent development in materials technology to solve engineering problems related to materials selection and design.
3. Graduates will be able to design and develop materials and processing techniques to meet the industry needs within the realistic constraints economic, environmental, social, ethical, health and safety, manufacturability and sustainability

PEO's – PO's & PSO's MAPPING:

PEO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
I.	3	2	2	2	2	1	1	1				2	3	2	2
II.	3	3	3	3	3							2	3	2	2
III.	3	3	3	3	3							2	3	2	2
IV.	2	2	1	1		3	3	3	3	3		2	2	1	1
V.	2	2	1	1		2	2	2	2	2	3	3	2	1	1

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REGULATIONS 2021
CHOICE BASED CREDIT SYSTEM
B. E. MATERIALS SCIENCE AND ENGINEERING
CURRICULUM FOR SEMESTERS I TO VIII AND SYLLABI FOR SEMESTERS III AND IV

SEMESTER I

SL. NO.	COURSE CODE	COURSE TITLE	CATE - GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	IP3151	Induction Programme	-	-	-	-	-	0
THEORY								
2.	HS3151	Professional English - I	HSMC	3	0	0	3	3
3.	MA3151	Matrices and Calculus	BSC	3	1	0	4	4
4.	PH3151	Engineering Physics	BSC	3	0	0	3	3
5.	CY3151	Engineering Chemistry	BSC	3	0	0	3	3
6.	GE3151	Problem Solving and Python Programming	ESC	3	0	0	3	3
7.	GE3152	அறிவியல் தமிழ் /Scientific Thoughts in Tamil	HSMC	1	0	0	1	1
PRACTICAL								
7	GE3171	Problem Solving and Python Programming Laboratory	ESC	0	0	4	4	2
8	BS3171	Physics and Chemistry Laboratory	BSC	0	0	4	4	2
9	GE3172	English Laboratory[$]	EEC	0	0	2	2	1
			TOTAL	**16**	**1**	**10**	**27**	**22**

SEMESTER II

SL. NO.	COURSE CODE	COURSE TITLE	CATE - GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
THEORY								
1.	HS3251	Professional English - II	HSMC	2	0	0	2	2
2.	MA3251	Statistics and Numerical Methods	BSC	3	1	0	4	4
3.	CY3202	Solid State Chemistry	BSC	3	0	0	3	3
4.	BE3251	Basic Electrical and Electronics Engineering	ESC	3	0	0	3	3
5.	GE3251	Engineering Graphics	ESC	2	0	4	6	4
6.	GE3252	தமிழர் மரபு /Heritage of Tamils	HSMC	1	0	0	1	1
7.		NCC Credit Course Level 1*	-	2	0	0	2	2
PRACTICAL								
8.	GE3271	Engineering Practices Laboratory	ESC	0	0	4	4	2
9.	BE3271	Basic Electrical and Electronics Engineering Laboratory	ESC	0	0	4	4	2
10.	GE3272	Communication Laboratory / Foreign Language [$]	EEC	0	0	4	4	2
			TOTAL	**14**	**1**	**16**	**31**	**23**

[#] **NCC Credit Course level 1 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA.**
[$] **Skill Based Course**

SEMESTER III

S. No.	Course Code	Course title	Cate Gory	Periods per week			Total contact periods	Credits
				L	T	P		
THEORY								
1.	MA3351	Transforms and Partial Differential Equations	BSC	3	1	0	4	4
2.	ML3301	Polymer Science and Engineering	ESC	3	0	0	3	3
3.	ML3302	Metallurgical Thermodynamics	PCC	4	0	0	4	4
4.	ML3391	Mechanics of Solids	ESC	3	0	0	3	3
5.	ME3351	Engineering Mechanics	ESC	3	0	0	3	3
6.	ML3303	Physical Metallurgy	PCC	3	0	0	3	3
PRACTICALS								
7.	ML3311	Microstructural Analysis Laboratory	PCC	0	0	4	4	2
8.	CE3312	Strength of Materials Laboratory	ESC	0	0	4	4	2
9.	GE3361	Professional Development $	EEC	0	0	2	2	1
			TOTAL	**19**	**1**	**10**	**30**	**25**

$ Skill Based Course

SEMESTER IV

S. No.	Course Code	Course title	Cate Gory	Periods per week			Total contact periods	Credits
				L	T	P		
THEORY								
1.	ML3401	Characterization of Materials	PCC	3	0	0	3	3
2.	ML3402	Iron and Steel Making	PCC	3	0	0	3	3
3.	ML3403	Mechanical Behavior of Materials	PCC	3	0	0	3	3
4.	ML3404	Heat Treatment of Metals and Alloys	PCC	3	0	0	3	3
5.	CE3391	Fluid Mechanics and Machinery	ESC	3	1	0	4	4
6.	GE3451	Environmental Sciences and Sustainability	BSC	2	0	0	2	2
7.		NCC Credit Course Level 2#		3	0	0	3	3#
PRACTICALS								
8.	ML3411	Materials Characterization Laboratory	PCC	0	0	4	4	2
9.	ML3412	Heat Treatment Laboratory	PCC	0	0	4	4	2
			TOTAL	**17**	**1**	**8**	**26**	**22**

 # NCC Credit Course level 2 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA

SEMESTER V

S. No.	Course Code	Course title	Cate Gory	Periods per week			Total contact periods	Credits
				L	T	P		
THEORY								
1.	ML3591	Metal and Powder Forming Techniques	PCC	3	0	0	3	3
2.	ML3501	Foundry Metallurgy	PCC	3	0	0	3	3
3.	ML3502	Non-Ferrous Metallurgy	PCC	3	0	0	3	3
4.		Professional Elective I	PEC	-	-	-	-	3
5.		Professional Elective II	PEC	-	-	-	-	3
6.		Professional Elective III	PEC	-	-	-	-	3
7.		Mandatory Course-I[&]	MC	3	0	0	3	0
PRACTICALS								
8.	ML3511	Summer Internship-I*	EEC	0	0	0	0	1
9.	ML3512	Metal and Powder Forming Laboratory	PCC	0	0	4	4	2
			TOTAL	-	-	-	-	**21**

***Two weeks Summer Internship carries one credit and it will be done during IV semester summer vacation and same will be evaluated in V semester.**

[&] Mandatory Course-I is a Non-credit Course (Student shall select one course from the list given under MC- I)

SEMESTER VI

S. No.	Course Code	Course title	Cate Gory	Periods per week			Total contact periods	Credits
				L	T	P		
THEORY								
1.	ML3601	Welding Technology	PCC	3	0	0	3	3
2.		Open Elective – I*	OEC	3	0	0	3	3
3.		Professional Elective IV	PEC	-	-	-	-	3
4.		Professional Elective V	PEC	-	-	-	-	3
5.		Professional Elective VI	PEC	-	-	-	-	3
6.		Professional Elective VII	PEC	-	-	-	-	3
7.		Mandatory Course-II**	AC	3	0	0	3	0
8.		NCC Credit Course Level 3***		3	0	0	3	3#
PRACTICALS								
9.	ML3611	Foundry and Welding Laboratory	PCC	0	0	4	4	2
			TOTAL	-	-	-	-	**20**

***Open Elective – I shall be chosen from the emerging technologies.**

[&] Mandatory Course-II is a Non-credit Course (Student shall select one course from the list given under MC- II)

[#] NCC Credit Course level 3 is offered for NCC students only. The grades earned by the students will be recorded in the Mark Sheet, however the same shall not be considered for the computation of CGPA

SEMESTER VII / VIII*

S. No.	Course Code	Course title	Cate Gory	Periods Per week			Total contact periods	Credits
				L	T	P		
THEORY								
1.	ML3701	Non-destructive Evaluation of Materials	PCC	3	0	0	3	3
2.	CME397	Surface Engineering	PCC	3	0	0	3	3
3.	GE3791	Human Values and Ethics	HSMC	2	0	0	2	2
4.		Elective – Management[#]	HSMC	3	0	0	3	3
5.		Open Elective – II**	OEC	3	0	0	3	3
6.		Open Elective – III***	OEC	3	0	0	3	3
7.		Open Elective – IV***	OEC	3	0	0	3	3
PRACTICALS								
8.	ML3711	Non-Destructive Testing Laboratory	PCC	0	0	4	4	2
9.	ML3712	Summer Internship-II*	EEC	0	0	0	0	1
			TOTAL	**20**	**0**	**4**	**24**	**23**

#Two weeks Summer Internship carries one credit and it will be done during VI semester summer vacation and same will be evaluated in VII semester.

***If students undergo internship in Semester VII, then the courses offered during semester VII will be offered during semester VIII.**

****Open Elective – II shall be chosen from the emerging technologies.**

*****Open Elective III and IV (Shall be chosen from the list of open electives offered by other Programmes).**

[#]**Elective – management shall be chosen from the Elective – Management Courses**

SEMESTER VIII / VII*

S. No.	Course Code	Course Title	Cate Gory	Periods per week			Total Contact Periods	Credits
				L	T	P		
PRACTICALS								
1.	ML3811	Project Work / Internship	EEC	0	0	20	20	10
			TOTAL	**0**	**0**	**20**	**20**	**10**

***If students undergo internship in Semester VII, then the courses offered during semester VII will be offered during semester VIII.**

TOTAL CREDITS = 166

ELECTIVE – MANAGEMENT COURSES

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PERWEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	GE3751	Principles of Management	HSMC	3	0	0	3	3
2.	GE3752	Total Quality Management	HSMC	3	0	0	3	3
3.	GE3753	Engineering Economics and Financial Accounting	HSMC	3	0	0	3	3
4.	GE3754	Human Resource Management	HSMC	3	0	0	3	3
5.	GE3755	Knowledge Management	HSMC	3	0	0	3	3
6.	GE3792	Industrial Management	HSMC	3	0	0	3	3

MANDATORY COURSES I

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MX3081	Introduction to Women and Gender Studies	MC	3	0	0	3	0
2.	MX3082	Elements of Literature	MC	3	0	0	3	0
3.	MX3083	Film Appreciation	MC	3	0	0	3	0
4.	MX3084	Disaster Management	MC	3	0	0	3	0

MANDATORY COURSES II

S. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	MX3085	Well Being with Traditional Practices (Yoga, Ayurveda and Siddha)	MC	3	0	0	3	0
2.	MX3086	History of Science and Technology in India	MC	3	0	0	3	0
3.	MX3087	Political and Economic Thought for a Humane Society	MC	3	0	0	3	0
4.	MX3088	State, Nation Building and Politics in India	MC	3	0	0	3	0
5.	MX3089	Industrial Safety	MC	3	0	0	3	0

PROFESSIONAL ELECTIVE COURSES: VERTICALS			
Vertical 1	**Vertical 2**	**Vertical 3**	**Vertical 4**
MECHANICAL BEHAVIOUR AND MATERIALS CHARACTERIZATION	**ADVANCED MATERIALS AND PROCESSING**	**MATERIALS FOR ELECTRICAL, ELECTRONIC AND MAGNETIC APPLICATIONS**	**DIVERSIFIED COURSES GROUP 1**
Fracture Mechanics and Failure Analysis	Fundamentals of Nanoscience	Smart Materials	Introduction to Transport Phenomena
Creep and Fatigue Behaviour of Materials	Metallurgy of Tool Materials and Special Steels	Energy Storage Devices	Materials Selection and design
Electron Microscopy	Automotive Materials	Fuel Cell Technology	Materials for Green Engineering
X-ray Diffraction and Associated Techniques	Additive Manufacturing	Semiconductors and optoelectronic Materials and Devices	Unconventional Machining Processes
Advanced Metallographic Techniques	Cryogenic Treatment of Materials	Advanced Materials Characterisation	Laser Processing of Materials
Finite Element Analysis	Nuclear Materials	Thin Film Technology	Making and Metallurgy of Stainless steels
Modelling and Simulation in Materials Engineering	Composite Materials	MEMS and Nanotechnology	Fuels, Furnaces and Refractories
Phase Transformations	Advanced Ceramics	Micro and Nano Fabrication	High Temperature Materials

Registration of Professional Elective Courses from Verticals:

Professional Elective Courses will be registered in Semesters V and VI. These courses are listed in groups called verticals that represent a particular area of specialisation / diversified group. Students are permitted to choose all the Professional Electives from a particular vertical or from different verticals. Further, only one Professional Elective course shall be chosen in a semester horizontally (row-wise). However, two courses are permitted from the same row, provided one course is enrolled in Semester V and another in semester VI.

The registration of courses for B.E./B.Tech (Honours) or Minor degree shall be done from Semester V to VIII. The procedure for registration of courses explained above shall be followed for the courses of B.E/B.Tech (Honours) or Minor degree also. For more details on B.E./B.Tech (Honours) or Minor degree refer to the Regulations 2021, Clause 4.10.

PROFESSIONAL ELECTIVE COURSES : VERTICALS

VERTICAL 1: MECHANICAL BEHAVIOUR AND MATERIALS CHARACTERIZATION

Sl. No.	Course code	Course title	Category	Periods Per week			Total Contact Periods	Credits
				L	T	P		
1.	ML3001	Fracture Mechanics and Failure Analysis	PEC	3	0	0	3	3
2.	ML3002	Creep and Fatigue Behaviour of Materials	PEC	3	0	0	3	3
3.	ML3003	Electron Microscopy	PEC	3	0	0	3	3
4.	ML3004	X-ray Diffraction and Associated Techniques	PEC	3	0	0	3	3
5.	ML3005	Advanced Metallographic Techniques	PEC	3	0	0	3	3
6.	CPR332	Finite Element Analysis	PEC	3	0	0	3	3
7.	ML3006	Modelling and Simulation in Materials Engineering	PEC	3	0	0	3	3
8.	ML3007	Phase Transformations	PEC	3	0	0	3	3

VERTICAL 2: ADVANCED MATERIALS AND PROCESSING

Sl. No.	Course Code	Course Title	Category	Periods Per Week			Total Contact Periods	Credits
				L	T	P		
1.	MLC331	Fundamentals of Nanoscience	PEC	3	0	0	3	3
2.	ML3008	Metallurgy of Tool Materials and Special Steels	PEC	3	0	0	3	3
3.	ML3009	Automotive Materials	PEC	3	0	0	3	3
4.	CME339	Additive Manufacturing	PEC	2	0	2	4	3
5.	ML3010	Cryogenic Treatment of Materials	PEC	3	0	0	3	3
6.	ML3011	Nuclear Materials	PEC	3	0	0	3	3
7.	ML3012	Composite Materials	PEC	3	0	0	3	3
8.	ML3013	Advanced Ceramics	PEC	3	0	0	3	3

VERTICAL 3: MATERIALS FOR ELECTRICAL, ELECTRONIC AND MAGNETIC APPLICATIONS

Sl. No.	Course Code	Course Title	Category	Periods Per week			Total Contact Periods	Credits
				L	T	P		
1.	ML3014	Smart Materials	PEC	3	0	0	3	3
2.	CME364	Energy Storage Devices	PEC	3	0	0	3	3
3.	ML3014	Fuel Cell Technology	PEC	3	0	0	3	3
4.	ML3015	Semiconductors and optoelectronic Materials and Devices	PEC	3	0	0	3	3
5.	ML3016	Advanced Materials Characterisation	PEC	3	0	0	3	3
6.	ML3017	Thin Film Technology	PEC	3	0	0	3	3
7.	ML3018	MEMS and Nanotechnology	PEC	3	0	0	3	3
8.	ML3019	Micro and Nano Fabrication	PEC	3	0	0	3	3

VERTICAL 4: DIVERSIFIED COURSES GROUP 1

Sl. No.	Course code	Course title	Category	Periods Per week			Total contact periods	Credits
				L	T	P		
1.	ML3020	Introduction to Transport Phenomena	PEC	3	0	0	3	3
2.	ML3021	Materials Selection and Design	PEC	3	0	0	3	3
3.	ML3022	Materials for Green Engineering	PEC	3	0	0	3	3
4.	CMF339	Unconventional Machining Processes	PEC	3	0	0	3	3
5.	ML3023	Laser Processing of Materials	PEC	3	0	0	3	3
6.	ML3024	Making and Metallurgy of Stainless steels	PEC	3	0	0	3	3
7.	ML3025	Fuels, Furnaces and Refractories	PEC	3	0	0	3	3
8.	CAS331	High Temperature Materials	PEC	3	0	0	3	3

OPEN ELECTIVES

(Students shall choose the open elective courses, such that the course contents are not similar to any other course contents/title under other course categories).

OPEN ELECTIVE I AND II

(EMERGING TECHNOLOGIES)

To be offered other than Faculty of Information and Communication Engineering

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OCS351	Artificial Intelligence and Machine Learning Fundamentals	OEC	2	0	2	4	3
2.	OCS352	IoT Concepts and Applications	OEC	2	0	2	4	3
3.	OCS353	Data Science Fundamentals	OEC	2	0	2	4	3
4.	OCS354	Augmented and Virtual Reality	OEC	2	0	2	4	3

OPEN ELECTIVES – III

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OHS351	English for Competitive Examinations	OEC	3	0	0	3	3
2.	OCE353	Lean Concepts, Tools And Practices	OEC	3	0	0	3	3
3.	OMG352	NGOs and Sustainable Development	OEC	3	0	0	3	3
4.	OMG353	Democracy and Good Governance	OEC	3	0	0	3	3
5.	OME353	Renewable Energy Technologies	OEC	3	0	0	3	3
6.	OME354	Applied Design Thinking	OEC	2	0	2	4	3
7.	OMF351	Reverse Engineering	OEC	3	0	0	3	3
8.	OMF353	Sustainable Manufacturing	OEC	3	0	0	3	3
9.	OAU351	Electric and Hybrid Vehicle	OEC	3	0	0	3	3
10.	OAS352	Space Engineering	OEC	3	0	0	3	3
11.	OIM351	Industrial Management	OEC	3	0	0	3	3
12.	OIE354	Quality Engineering	OEC	3	0	0	3	3
13.	OSF351	Fire Safety Engineering	OEC	3	0	0	3	3
14.	OMR351	Mechatronics	OEC	3	0	0	3	3
15.	ORA351	Foundation of Robotics	OEC	3	0	0	3	3

16.	OAE352	Fundamentals of Aeronautical engineering	OEC	3	0	0	3	3
17.	OGI351	Remote Sensing Concepts	OEC	3	0	0	3	3
18.	OAI351	Urban Agriculture	OEC	3	0	0	3	3
19.	OEN351	Drinking Water Supply and Treatment	OEC	3	0	0	3	3
20.	OEE352	Electric Vehicle technology	OEC	3	0	0	3	3
21.	OEI353	Introduction to PLC Programming	OEC	3	0	0	3	3
22.	OCH351	Nano Technology	OEC	3	0	0	3	3
23.	OCH352	Functional Materials	OEC	3	0	0	3	3
24.	OBT352	Biomedical Instrumentation	OEC	3	0	0	3	3
25.	OFD352	Traditional Indian Foods	OEC	3	0	0	3	3
26.	OFD353	Introduction to food processing	OEC	3	0	0	3	3
27.	OPY352	IPR for Pharma Industry	OEC	3	0	0	3	3
28.	OTT351	Basics of Textile Finishing	OEC	3	0	0	3	3
29.	OTT352	Industrial Engineering for Garment Industry	OEC	3	0	0	3	3
30.	OTT353	Basics of Textile Manufacture	OEC	3	0	0	3	3
31.	OPE351	Introduction to Petroleum Refining and Petrochemicals	OEC	3	0	0	3	3
32.	OPE352	Energy Conservation and Management	OEC	3	0	0	3	3
33.	OPT351	Basics of Plastics Processing	OEC	3	0	0	3	3
34.	OEC351	Signals and Systems	OEC	3	0	0	3	3
35.	OEC352	Fundamentals of Electronic Devices and Circuits	OEC	3	0	0	3	3
36.	OBM351	Foundation Skills in integrated product Development	OEC	3	0	0	3	3
37.	OBM352	Assistive Technology	OEC	3	0	0	3	3
38.	OMA352	Operations Research	OEC	3	0	0	3	3
39.	OMA353	Algebra and Number Theory	OEC	3	0	0	3	3
40.	OMA354	Linear Algebra	OEC	3	0	0	3	3

OPEN ELECTIVES – IV

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	OHS352	Project Report Writing	OEC	3	0	0	3	3
2.	OCE354	Basics of Integrated Water Resources Management	OEC	3	0	0	3	3
3.	OMA355	Advanced Numerical Methods	OEC	3	0	0	3	3
4.	OMA356	Random Processes	OEC	3	0	0	3	3
5.	OMA357	Queuing and Reliability Modelling	OEC	3	0	0	3	3
6.	OMG354	Production and Operations Management for Entrepreneurs	OEC	3	0	0	3	3
7.	OMG355	Multivariate Data Analysis	OEC	3	0	0	3	3
8.	OME352	Additive Manufacturing	OEC	3	0	0	3	3
9.	OME353	New Product Development	OEC	3	0	0	3	3
10.	OME355	Industrial Design & Rapid Prototyping Techniques	OEC	2	0	2	4	3
11.	OMF352	Micro and Precision Engineering	OEC	3	0	0	3	3
12.	OMF354	Cost Management of Engineering Projects	OEC	3	0	0	3	3
13.	OAU352	Batteries and Management system	OEC	3	0	0	3	3
14.	OAU353	Sensors and Actuators	OEC	3	0	0	3	3
15.	OAS353	Space Vehicles	OEC	3	0	0	3	3
16.	OIM352	Management Science	OEC	3	0	0	3	3
17.	OIM353	Production Planning and Control	OEC	3	0	0	3	3
18.	OIE353	Operations Management	OEC	3	0	0	3	3
19.	OSF352	Industrial Hygiene	OEC	3	0	0	3	3
20.	OSF353	Chemical Process Safety	OEC	3	0	0	3	3
21.	OMR352	Hydraulics and Pneumatics	OEC	3	0	0	3	3
22.	OMR353	Sensors	OEC	3	0	0	3	3
23.	ORA352	Foundation of Automation	OEC	3	0	0	3	3
24.	ORA353	Concepts in Mobile Robotics	OEC	3	0	0	3	3
25.	OMV351	Marine Propulsion	OEC	3	0	0	3	3
26.	OMV352	Marine Merchant Vehicles	OEC	3	0	0	3	3
27.	OMV353	Elements of Marine Engineering	OEC	3	0	0	3	3
28.	OAE353	Drone Technologies	OEC	3	0	0	3	3

29.	OGI352	Geographical Information System	OEC	3	0	0	3	3
30.	OAI352	Agriculture Entrepreneurship Development	OEC	3	0	0	3	3
31.	OEN352	Biodiversity Conservation	OEC	3	0	0	3	3
32.	OEE353	Introduction to control systems	OEC	3	0	0	3	3
33.	OEI354	Introduction to Industrial Automation Systems	OEC	3	0	0	3	3
34.	OCH353	Energy Technology	OEC	3	0	0	3	3
35.	OCH354	Surface Science	OEC	3	0	0	3	3
36.	OBT353	Environment and Agriculture	OEC	3	0	0	3	3
37.	OFD354	Fundamentals of Food Engineering	OEC	3	0	0	3	3
38.	OFD355	Food safety and Quality Regulations	OEC	3	0	0	3	3
39.	OPY353	Nutraceuticals	OEC	3	0	0	3	3
40.	OTT354	Basics of Dyeing and Printing	OEC	3	0	0	3	3
41.	OTT355	Fibre Science	OEC	3	0	0	3	3
42.	OTT356	Garment Manufacturing Technology	OEC	3	0	0	3	3
43.	OPE353	Industrial safety	OEC	3	0	0	3	3
44.	OPE354	Unit Operations in Petro Chemical Industries	OEC	3	0	0	3	3
45.	OPT352	Plastic Materials for Engineers	OEC	3	0	0	3	3
46.	OPT353	Properties and Testing of Plastics	OEC	3	0	0	3	3
47.	OEC353	VLSI Design	OEC	3	0	0	3	3
48.	OEC354	Industrial IoT and Industry 4.0	OEC	2	0	2	4	3
49.	OBM353	Wearable devices	OEC	3	0	0	3	3
50.	OBM354	Medical Informatics	OEC	3	0	0	3	3

SUMMARY

B.E. MATERIALS SCIENCE AND ENGINEERING										
S.No	Subject Area	Credits per Semester								Total Credits
		I	II	III	IV	V	VI	VII/VIII	VIII/VII	
1	HSMC	4	3					5		12
2	BSC	12	7	4	2					25
3	ESC	5	11	8	4					28
4	PCC			13	16	11	5	8		53
5	PEC					9	12			21
6	OEC						3	9		12
7	EEC	1	2			1		1	10	15
8	Non-Credit /(Mandatory)					√	√			
Total		22	23	25	22	21	20	23	10	166

ENROLLMENT FOR B.E. / B. TECH. (HONOURS) / MINOR DEGREE (OPTIONAL)

A student can also optionally register for additional courses (18 credits) and become eligible for the award of B.E. / B. Tech. (Honours) or Minor Degree.

For B.E. / B. Tech. (Honours), a student shall register for the additional courses (18 credits) from semester V onwards. These courses shall be from the same vertical or a combination of different verticals of the same programme of study only.

For minor degree, a student shall register for the additional courses (18 credits) from semester V onwards. All these courses have to be in a particular vertical from any one of the other programmes, Moreover, for minor degree the student can register for courses from any one of the following verticals also.

Complete details are available in clause 4.10 of Regulations 2021.

VERTICALS FOR MINOR DEGREE
(In addition to all the verticals of other programmes)

Vertical I	Vertical II	Vertical III	Vertical IV	Vertical V
Fintech and Block Chain	**Entrepreneurship**	**Public Administration**	**Business Data Analytics**	**Environment and Sustainability**
Financial Management	Foundations of Entrepreneruship	Principles of Public Administration	Statistics for Management	Sustainable infrastructure Development
Fundamentals of Investment	Team Building and Leadership Management for Business	Constitution of India	Datamining for Business Intelligence	Sustainable Agriculture and Environmental Management
Banking, Financial Services and Insurance	Creativity and Innovation in Entrepreneurship	Public Personnel Administration	Human Resource Analytics	Sustainable Bio Materials
Introduction to Blockchain and its Applications	Principles of Marketing Management for Business	Administrative Theories	Marketing and Social Media Web Analytics	Materials for Energy Sustainability
Fintech Personal Finance and Payments	Human Resource Management for Entrepreneurs	Indian Administrative System	Operation and Supply Chain Analytics	Green Technology
Introduction to Fintech	Financing New Business Ventures	Public Policy Administration	Financial Analytics	Environmental Quality Monitoring and Analysis
-	-	-	-	Integrated Energy Planning for Sustainable Development
-	-	-	-	Energy Efficiency for Sustainable Development

(Choice of courses for Minor degree is to be made from any one vertical of other programmes or from anyone of the following verticals)

VERTICAL 1: FINTECH AND BLOCK CHAIN

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG331	Financial Management	PEC	3	0	0	3	3
2.	CMG332	Fundamentals of Investment	PEC	3	0	0	3	3
3.	CMG333	Banking, Financial Services and Insurance	PEC	3	0	0	3	3
4.	CMG334	Introduction to Blockchain and its Applications	PEC	3	0	0	3	3
5.	CMG335	Fintech Personal Finance and Payments	PEC	3	0	0	3	3
6.	CMG336	Introduction to Fintech	PEC	3	0	0	3	3

VERTICAL 2: ENTREPRENERUSHIP

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG337	Foundations of Entrepreneruship	PEC	3	0	0	3	3
2.	CMG338	Team Building and Leadership Management for Business	PEC	3	0	0	3	3
3.	CMG339	Creativity and Innovation in Entrepreneurship	PEC	3	0	0	3	3
4.	CMG340	Principles of Marketing Management for Business	PEC	3	0	0	3	3
5.	CMG341	Human Resource Management for Entrepreneurs	PEC	3	0	0	3	3
6.	CMG342	Financing New Business Ventures	PEC	3	0	0	3	3

VERTICAL 3: PUBLIC ADMINISTRATION

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG343	Principles of Public Administration	PEC	3	0	0	3	3
2.	CMG344	Constitution of India	PEC	3	0	0	3	3
3.	CMG345	Public Personnel Administration	PEC	3	0	0	3	3
4.	CMG346	Administrative Theories	PEC	3	0	0	3	3
5.	CMG347	Indian Administrative System	PEC	3	0	0	3	3
6.	CMG348	Public Policy Administration	PEC	3	0	0	3	3

VERTICAL 4: BUSINESS DATA ANALYTICS

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CMG349	Statistics for Management	PEC	3	0	0	3	3
2.	CMG350	Datamining for Business Intelligence	PEC	3	0	0	3	3
3.	CMG351	Human Resource Analytics	PEC	3	0	0	3	3
4.	CMG352	Marketing and Social Media Web Analytics	PEC	3	0	0	3	3
5.	CMG353	Operation and Supply Chain Analytics	PEC	3	0	0	3	3
6.	CMG354	Financial Analytics	PEC	3	0	0	3	3

VERTICAL 5: ENVIRONMENT AND SUSTAINABILITY

SL. NO.	COURSE CODE	COURSE TITLE	CATE GORY	PERIODS PER WEEK			TOTAL CONTACT PERIODS	CREDITS
				L	T	P		
1.	CES331	Sustainable infrastructure Development	PEC	3	0	0	3	3
2.	CES332	Sustainable Agriculture and Environmental Management	PEC	3	0	0	3	3
3.	CES333	Sustainable Bio Materials	PEC	3	0	0	3	3
4.	CES334	Materials for Energy Sustainability	PEC	3	0	0	3	3
5.	CES335	Green Technology	PEC	3	0	0	3	3
6.	CES336	Environmental Quality Monitoring and Analysis	PEC	3	0	0	3	3
7.	CES337	Integrated Energy Planning for Sustainable Development	PEC	3	0	0	3	3
8.	CES338	Energy Efficiency for Sustainable Development	PEC	3	0	0	3	3

MA3351 TRANSFORMS AND PARTIAL DIFFERENTIAL EQUATIONS L T P C
3 1 0 4

COURSE OBJECTIVES:

- To introduce the basic concepts of PDE for solving standard partial differential equations.
- To introduce Fourier series analysis which is central to many applications in engineering apart from its use in solving boundary value problems.
- To acquaint the student with Fourier series techniques in solving heat flow problems used in various situations.
- To acquaint the student with Fourier transform techniques used in wide variety of situations.
- To introduce the effective mathematical tools for the solutions of partial differential equations that model several physical processes and to develop Z transform techniques for discrete time systems.

UNIT I PARTIAL DIFFERENTIAL EQUATIONS 9+3

Formation of partial differential equations –Solutions of standard types of first order partial differential equations - First order partial differential equations reducible to standard types-Lagrange's linear equation - Linear partial differential equations of second and higher order with constant coefficients of both homogeneous and non-homogeneous types.

UNIT II FOURIER SERIES 9+3

Dirichlet's conditions – General Fourier series – Odd and even functions – Half range sine series and cosine series – Root mean square value – Parseval's identity – Harmonic analysis.

UNIT III APPLICATIONS OF PARTIAL DIFFERENTIAL EQUATIONS 9+3

Classification of PDE – Method of separation of variables - Fourier series solutions of one-dimensional wave equation – One dimensional equation of heat conduction – Steady state solution of two-dimensional equation of heat conduction (Cartesian coordinates only).

UNIT IV FOURIER TRANSFORMS 9+3

Statement of Fourier integral theorem– Fourier transform pair – Fourier sine and cosine transforms – Properties – Transforms of simple functions – Convolution theorem – Parseval's identity.

UNIT V Z - TRANSFORMS AND DIFFERENCE EQUATIONS 9+3

Z-transforms - Elementary properties – Convergence of Z-transforms - – Initial and final value theorems - Inverse Z-transform using partial fraction and convolution theorem - Formation of difference equations – Solution of difference equations using Z - transforms.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon successful completion of the course, students should be able to:

- Understand how to solve the given standard partial differential equations.
- Solve differential equations using Fourier series analysis which plays a vital role in engineering applications.
- Appreciate the physical significance of Fourier series techniques in solving one and two dimensional heat flow problems and one dimensional wave equations.
- Understand the mathematical principles on transforms and partial differential equations would provide them the ability to formulate and solve some of the physical problems of engineering.
- Use the effective mathematical tools for the solutions of partial differential equations by using Z transform techniques for discrete time systems.

TEXT BOOKS:

1. Grewal B.S., "Higher Engineering Mathematics", 44thEdition, Khanna Publishers, New Delhi, 2018.
2. Kreyszig E, "Advanced Engineering Mathematics ", 10th Edition, John Wiley, New Delhi, India, 2016.

REFERENCES:

1. Andrews. L.C and Shivamoggi. B, "Integral Transforms for Engineers" SPIE Press, 1999.
2. Bali. N.P and Manish Goyal, "A Textbook of Engineering Mathematics", 10th Edition, Laxmi Publications Pvt. Ltd, 2015.
3. James. G., "Advanced Modern Engineering Mathematics", 4thEdition, Pearson Education, New Delhi, 2016.
4. Narayanan. S., Manicavachagom Pillay.T.K and Ramanaiah.G "Advanced Mathematics for Engineering Students", Vol. II & III, S.Viswanathan Publishers Pvt. Ltd, Chennai, 1998.
5. Ramana. B.V., "Higher Engineering Mathematics", McGraw Hill Education Pvt. Ltd, New Delhi, 2018.
6. Wylie. R.C. and Barrett . L.C., "Advanced Engineering Mathematics "Tata McGraw Hill Education Pvt. Ltd, 6th Edition, New Delhi, 2012.

ML3301	POLYMER SCIENCE AND ENGINEERING	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Understanding the basics of polymers, its formation and polymerization types.
2. Getting acquainted with the significance and the molecular weights of polymers.
3. Characterizing the polymers for their thermal behaviour and solution properties.
4. Gaining knowledge on the thermodynamics of polymer dissolution and the factors influencing them.
5. Identifying suitable polymer processing methods for polymer products.

UNIT I POLYMERS AND POLYMERIZATION 9

Fundamentals of Polymers – Monomers – Functionality - Classification – Polymerization types and techniques – Structure, property and applications of PE, PP, PVC, PMMA, PTFE, Polyamides, Polyesters, Polycarbonates and polyurethanes – Copolymers - Interfacial polymerization – Crosslinked polymers.

UNIT II MOLECULAR WEIGHTS OF POLYMERS 9

Number average and weight average molecular weights – Degree of polymerization – Molecular weight distribution – Polydispersity – Molecular weight determination-Methods – Viscometry - Gel Permeation Chromatography.

UNIT III TRANSITIONS IN POLYMERS 9

First and second order transitions – Glass transition, Tg– multiple transitions in polymers – experimental study – significance of transition temperatures. Crystallinity in polymers – effect of crystallization – factors affecting crystallization, crystal nucleation and growth – Relationship between Tg and Tm – Structure–Property relationship.

UNIT IV SOLUTION PROPERTIES OF POLYMERS 9

Size and shape of macromolecules – Solubility parameter – polymer/solvent interaction parameter – temperature – size and molecular weight. Solution properties of polymers. Importance of Rheology – Newtonian and Non-Newtonian flow behaviour – Polymer melts.

UNIT V POLYMER PROCESSING 9

Overview of Features of Single screw extruder –Tubular blown film process - Coextrusion. -Injection Moulding systems – Compression & Transfer Moulding - Blow Moulding – Rotational Moulding – Thermoforming – Vacuum forming -Calendering process – Fibre Spinning process –Structural Foam Moulding – Sandwich Moulding. - Reaction Injection Moulding & Reinforced Reaction Injection Moulding.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Describe the basics concepts and fundamental principles of polymers and polymerization.
2. Evaluate and determine the molecular weights of polymers.
3. Characterize and evaluate the thermal and solution properties of polymers.
4. Analyse the thermodynamics of polymer dissolution.
5. Produce tailor-made polymers to suit the demanding applications.

TEXT BOOKS

1. Bahadur and Sastry, “Principles of Polymer Science”, Narosa Publishing House, 2002.
2. Morton Jones D. H., “Polymer Processing”, Chapman & Hall, New York, 1995.

REFERENCES:

1. Billmayer Jr. and Fred. W., “Textbook of Polymer Science”, WileyTappers, 1965
2. Crawford R.J. Plastics Engineering (3rd Ed), Pergamon Press, London (1987)
3. Fried J. R., “Polymer Science and Technology”, Prentice Hall, 1995.
4. Gowarikar, “Polymer Science”, Johan Wiley and Sons, 1986.
5. Griskey G., “Polymer Process Engineering”, Chapman & Hall, New York, 1995.

	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	2			1		2					2	1	1	3
CO2	3	2	1		1		2					2	1	2	3
CO3	3	2	1		1		1					2	1	2	3
CO4	3	2	1		1		2	2	2			2	1	2	3
CO5	3	2	1	1	2		1	3	2			2	1	2	3
Avg	3	2	1	1	1.2		1.6	2.5	2			2	1	1.8	3

ML3302 METALLURGICAL THERMODYNAMICS

L	T	P	C
4	0	0	4

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Having an overview on the fundamental concepts in metallurgical thermodynamics
2. Gaining knowledge about the state functions such as internal energy, entropy and criteria of equilibrium.
3. Getting an insight to the auxiliary functions, heat capacities and thermodynamic potentials.
4. Knowing the essentials of thermodynamic behaviour of solutions,
5. Having an exposure on thermodynamics of electrochemical cells, surfaces and defects.

UNIT I FUNDAMENTAL CONCEPTS 9+3

Definition of thermodynamic terms; concept of states, systems and surroundings, Types of systems, equilibrium. Equation of states, extensive and intensive properties, homogeneous and heterogeneous, micro-macro systems. Phase diagrams and its classification, Internal energy, heat capacity, enthalpy, isothermal, and adiabatic processes.

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UNIT II INTERNAL ENERGY AND ENTROPY 9+3

First law of Thermodynamics: Relation between Heat and work, Internal energy and Enthalpy. The Second law of thermodynamics: Spontaneous process, Degree of measure of reversibility and irreversibility, Maximum work, criteria of equilibrium. Combined statement of first and second laws on thermodynamics. Statistical interpretation of entropy: Concept of microstate, most probable microstate, Thermal equilibrium, Boltzman equation, configurational entropy

UNIT III AUXILLARY FUNCTIONS AND THERMODYNAMIC POTENTIALS 9+3

Auxiliary functions: Helmholtz, Gibbs free energy, Maxwell's equation, Gibbs-Helmholtz equations. Concept of Third law, temperature dependence of entropy, Einstein's and Debye's concepts of heat capacity, relation between Cp and Cv, Nernst heat theorem, Consequences of third law, Hess's law, Le Chatelier's principle and Kirchoff's law. Zeroth law of thermodynamics and its applications. Thermodynamic potentials: Fugacity, Activity and Equilibrium constant. Clausius - Clayperon and Vant Hoff's equations.

UNIT IV THERMODYNAMICS OF SOLUTIONS 9+3

Solutions, Mole fraction, Dalton's law, partial molar quantities, ideal and non-ideal solutions, Henry's law, Gibbs - Duhem equation, regular solution, quasi-chemical approach to solution, statistical treatment. Change of standard state. Phase relations and phase rule, its applications. Ellingham diagram and its use. Free energy composition diagrams for binary alloy systems, determination of liquidus, solidus and solvus lines. Effect of pressure on phase transformation and phase equilibria.

UNIT V THERMODYNAMICS OF REACTIONS 9+3

Thermodynamics of electrochemical cells, solid electrolytes. Pourbaix diagrams. Thermodynamics of Surfaces: Adsorption isotherms, Effect of surface energy on pressure and phase transformation temperature. Thermodynamics of Defects in solids: Point defects, vacancies and interstitials in solid metals.

TOTAL: 60 PERIODS

	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
CO1	3	2			1		2					2	1	1	3
CO2	3	2	1		1		2					2	1	2	3
CO3	3	2	1		1		1					2	1	2	3
CO4	3	2	1		1		2					2	1	2	3

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Recognize the nature of the system and properties.
2. Explain the concept of internal energy, entropy and criteria for equilibrium.
3. Realize the importance of auxiliary functions and thermodynamic potentials
4. Apply the concepts of thermodynamics in the behaviour of solutions.
5. Outline the thermodynamic approaches towards electrochemical cells, surfaces and defects.

TEXT BOOKS:

1. David R Gaskell & David E Laughlin," Introduction to the Thermodynamics of materials", CRC press, Sixth edition, 2017.
2. Subir Kumar Bose & Sanat Kumar Roy, " Principles of Metallurgical Thermodynamics", Universities press, 2014.

REFERENCES:

1. Ahindra Ghosh, Textbook of Materials and Metallurgical Thermodynamics, Prentice hall of India, 2002.
2. Boris.S. Bokstein, Mikhail I. Mendelev, David J. Srolovitz," Thermodynamics and Kinetics in Materials science", Oxford University Press 2005.
3. Prasad, Krishna Kant, Ray, H. S. and Abraham, K. P., "Chemical and Metallurgical Thermodynamics", New Age International, 2012.
4. Shamsuddin M, " Physical Chemistry of Metallurgical process", John Wiley, 2016
5. Upadhyaya, G. S. and Dube, R. K., "Problems in Metallurgical Thermodynamics and Kinetics", Pergamon Press, London, 1977.

CO5	3	2	1	1	2		1					2	1	2	3
Avg	3	2	1	1	1.2		1.6					2	1	1.8	3

ML3391	MECHANICS OF SOLIDS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Applying the principle concepts behind stress, strain and deformation of solids for various engineering applications.
2. Analysing the transverse loading on beams and stresses in beam for various engineering applications.
3. Understanding the torsion principles on shafts and springs for various engineering applications.
4. Acquiring knowledge on the deflection of beams for various engineering applications.
5. Interpreting the thin and thick shells and principal stresses in beam for various engineering applications

UNIT I STRESS, STRAIN AND DEFORMATION OF SOLIDS 9

Rigid and Deformable bodies – Strength, Stiffness and Stability – Stresses and Strains: Tensile, Compressive and Shear – Material Behaviour- Elastic Vs Plastic – Response of Real Materials: Tensile Test, Compressive Test, Shear Test, Cyclic Tests - strain gauges and rosettes – Deformation of Statically determinate and Indeterminate bars of variable cross-section & Composite section under axial load – Thermal stress – Elastic constants – Plane Strain – Volumetric Strain.

UNIT II TRANSVERSE LOADING ON BEAMS AND STRESSES IN BEAM 9

Beams – types transverse loading on beams – Shear force and bending moment in beams – Cantilevers – Simply supported beams and over – hanging beams. Theory of simple bending– Bending stress distribution – Flitched beams – Shear stress distribution.

UNIT III TORSION 9

Torsion formulation stresses and deformation in circular and hollows shafts – Stepped shafts – Deflection in shafts fixed at the both ends – Stresses in helical springs – Deflection of helical springs, – Closed and Open Coiled helical springs – springs in series and parallel, carriage springs.

UNIT IV DEFLECTION OF BEAMS 9

Slope, Deflection and Radius of Curvature – Methods of Determination of Slope and Deflection- Double Integration method – Macaulay's method – Area moment Theorems for computation of slopes and deflections in beams - Conjugate beam and strain energy – Maxwell's reciprocal theorems.

UNIT V THICK & THIN SHELLS & PRINCIPAL STRESSES 9

Stresses in thin cylindrical shell due to internal pressure, circumferential and longitudinal stresses and deformation in thin cylinders – spherical shells subjected to internal pressure – Deformation in spherical shells – Lame's theory – Application of theories of failure – Stresses on inclined planes –principal stresses and principal planes – Mohr's circle of stress.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Apply the principle concepts behind stress, strain and deformation of solids for various engineering applications.
2. Analyse the transverse loading on beams and stresses in beam for various engineering applications.
3. Solve problems based on the torsion principles involved in shafts and springs for various engineering applications.
4. Interpret the results of the deflection of beams.
5. Analyse the thin and thick shells and principal stresses in beam for various engineering applications

TEXT BOOKS:

1. Egor P. Popov, Toader A. Balan., "Engineering Mechanics of Solids", Pearson India Education Services, 2018.
2. Ferdinand P. Beer, E. Russell Johnston, Jr., John T. DeWolf, David Mazurek "Mechanics of Materials", McGraw-Hill Education, 2015.

REFERENCES:

1. R. K. Bansal," A Textbook of Strength of Materials" Laxmi Publications 2010.
2. R. K. Rajput., "Strength of Materials", Shree Publishers, 2015.
3. Hibbeler, R.C., Mechanics of Materials, Pearson Education, 2018.
4. Subramanian R., Strength of Materials, oxford University Press, Oxford Higher Education Series,2010
5. Nash, W.A., "Theory and Problems in Strength of Materials", 6th Edition, Schaum Outline Series, McGraw-Hill Book Co, 2013.

	PO												PSO		
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**	**3**
CO1	3	3	3	1	1							1	3	2	1
CO2	3	3	3	2	2							1	3	2	1
CO3	3	3	3	2	2							1	3	2	1
CO4	3	3	3	2	2							1	3	2	1
CO5	3	3	3	2	2							1	3	2	1
Avg	3	3	3	1.8	1.8							1	3	2	1

ME3351 **ENGINEERING MECHANICS** **L** **T** **P** **C**
3 **0** **0** **3**

COURSE OBJECTIVES:

1 To Learn the use scalar and vector analytical techniques for analysing forces in statically determinate structures
2 To introduce the equilibrium of rigid bodies , vector methods and free body diagram
3 To study and understand the distributed forces, surface, loading on beam and intensity.
4 To learn the principles of friction, forces and to determine the apply the concepts of frictional forces at the contact surfaces of various engineering systems.
5 To develop basic dynamics concepts – force, momentum, work and energy;

UNIT – I STATICS OF PARTICLES **9**

Fundamental Concepts and Principles, Systems of Units, Method of Problem Solutions, Statics of Particles - Forces in a Plane, Resultant of Forces, Resolution of a Force into Components, Rectangular Components of a Force, Unit Vectors. Equilibrium of a Particle- Newton's First Law of Motion, Space and Free-Body Diagrams, Forces in Space, Equilibrium of a Particle in Space.

UNIT – II EQUILIBRIUM OF RIGID BODIES 9

Principle of Transmissibility, Equivalent Forces, Vector Product of Two Vectors, Moment of a Force about a Point, Varignon's Theorem, Rectangular Components of the Moment of a Force, Scalar Product of Two Vectors, Mixed Triple Product of Three Vectors, Moment of a Force about an Axis, Couple - Moment of a Couple, Equivalent Couples, Addition of Couples, Resolution of a Given Force into a Force -Couple system, Further Reduction of a System of Forces, Equilibrium in Two and Three Dimensions - Reactions at Supports and Connections.

UNIT III DISTRIBUTED FORCES 9

Centroids of lines and areas – symmetrical and unsymmetrical shapes, Determination of Centroids by Integration, Theorems of Pappus-Guldinus, Distributed Loads on Beams, Centre of Gravity of a Three-Dimensional Body, Centroid of a Volume, Composite Bodies, Determination of Centroids of Volumes by Integration. Moments of Inertia of Areas and Mass - Determination of the Moment of Inertia of an Area by Integration, Polar Moment of Inertia, Radius of Gyration of an Area, Parallel-Axis Theorem, Moments of Inertia of Composite Areas, Moments of Inertia of a Mass - Moments of Inertia of Thin Plates, Determination of the Moment of Inertia of a Three-Dimensional Body by Integration.

UNIT IV FRICTION 9

The Laws of Dry Friction, Coefficients of Friction, Angles of Friction, Wedge friction, Wheel Friction, Rolling Resistance, Ladder friction.

UNIT V DYNAMICS OF PARTICLES 9

Kinematics - Rectilinear Motion and Curvilinear Motion of Particles. Kinetics- Newton's Second Law of Motion -Equations of Motions, Dynamic Equilibrium, Energy and Momentum Methods - Work of a Force, Kinetic Energy of a Particle, Principle of Work and Energy, Principle of Impulse and Momentum, Impact of bodies.

TOTAL : 45 PERIODS

COURSE OUTCOMES:

At the end of the course the students would be able to

1. Illustrate the vector and scalar representation of forces and moments
2. Analyse the rigid body in equilibrium
3. Evaluate the properties of distributed forces
4. Determine the friction and the effects by the laws of friction
5. Calculate dynamic forces exerted in rigid body

TEXTBOOKS:

1. Beer Ferdinand P, Russel Johnston Jr., David F Mazurek, Philip J Cornwell, Sanjeev Sanghi, Vector Mechanics for Engineers: Statics and Dynamics, McGraw Higher Education., 12thEdition, 2019.
2. Vela Murali, "Engineering Mechanics-Statics and Dynamics", Oxford University Press, 2018.

REFERENCES:

1. Boresi P and Schmidt J, Engineering Mechanics: Statics and Dynamics, 1/e, Cengage learning, 2008.
2. Hibbeller, R.C., Engineering Mechanics: Statics, and Engineering Mechanics: Dynamics, 13th edition, Prentice Hall, 2013.
3. Irving H. Shames, Krishna Mohana Rao G, Engineering Mechanics – Statics and Dynamics, 4thEdition, Pearson Education Asia Pvt. Ltd., 2005.
4. Meriam J L and Kraige L G, Engineering Mechanics: Statics and Engineering Mechanics: Dynamics, 7th edition, Wiley student edition, 2013.
5. Timoshenko S, Young D H, Rao J V and Sukumar Pati, Engineering Mechanics, 5thEdition, McGraw Hill Higher Education, 2013.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	2	2	1	2							2	3	1	1
2	3	2	2	1	2							2	3	1	1
3	3	2	3	1	2							2	3	1	2
4	3	2	3	1	2							2	3	1	2
5	3	2	3	1	2							2	3	1	2
Low (1) ; Medium (2) ; High (3)															

ML3303 **PHYSICAL METALLURGY** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Acquiring a sound background in predicting the behaviour of a metallic material to a certain application.
2. Understanding the fundamental principles of Physical Metallurgy
3. Getting familiarized with the interpretation of phase diagrams.
4. Having an insight on the thermodynamics aspect of physical metallurgy
5. Gaining knowledge on the various strengthening mechanisms in materials

UNIT I STRUCTURE OF SOLIDS & SOLIDIFICATION OF PURE METALS 9

Atomic Bonding & Crystal Structure: Metallic bond, unit cell, atomic packing, interstitial sites, Miller indices, crystal orientation, stereographic projection.

Phase rule, Concept of Free Energy, Entropy, Surface Energy (grain boundary) & under cooling, Nucleation & Growth, homogeneous & heterogeneous nucleation, directional solidification. Mechanisms (slip & twin), critical resolved shear stress, single crystal tensile test (FCC), theoretical strength of ideal crystal.

UNIT II CRYSTAL IMPERFECTIONS AND DIFFUSION 9

Vacancy, interstitial, substitutional, free energy of mixing, dislocation (elementary concepts only), edge / screw dislocation, partial dislocation, stacking fault, dislocation lock, dislocation pile up, Hall Petch relation, grain boundary structure.

Elementary concepts of phenomenological & atomistic approaches in Diffusion

UNIT III SOLIDIFICATION OF BINARY ALLOYS 9

Limits of solubility, isomorphous system, lever rule, constitutional super cooling, effect of non-equilibrium cooling, eutectic, peritectic, eutectoid & peritectoid system, complex phase diagram, ternary diagram, structure of cast metal, segregation & porosity, iron-carbon diagram, steel & cast iron. Phase Diagrams of common commercial alloys: Cu-Ni, Ni-Cr, Al-Si, Al-Zn, Cu-Zn, Cu-Al, Ti-Al, Ti-V, interpretation of microstructure & properties.

UNIT IV COLD WORKING, ANNEALING AND PRECIPITATION 9

Recovery, recrystallization & grain growth, phenomenological & mechanistic approaches. Thermodynamics & kinetics of precipitation, precipitation hardening. Need for Heat treatments. Introduction to various Heat treatment processes.

UNIT V APPLICATIONS OF PHYSICAL METALLURGY 9

Strengthening mechanism, strength vs. toughness (ductility), thermo-mechanical processing, micro alloyed steel, ultra-high strength steel, superalloy, control of texture.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of the Course, the students will be able to

1. Recognize the basic nomenclature, microstructure, and associated terms with the appropriate structure / phenomena and differentiate between related structure / phenomena.
2. Perform simple calculations to quantify material properties and microstructural characteristics.
3. Interpret the effect of composition and microstructure on material properties.
4. Perform phase equilibrium calculation and construct phase diagram.
5. Discuss on the various strengthening mechanisms and thermal mechanical processing.

TEXT BOOKS

1. V. Raghavan, “Materials Science and Engineering”, Prentice –Hall of India Pvt. Ltd., 2015
2. William D. Callister, Jr., “Materials Science and Engineering an Introduction”, 9/e Edition, John Wiley & Sons, Inc., 2014.

REFERENCES:

1. Donald R. Askeland, Pradeep P. Phule, “The Science and Engineering of Materials”, 7th Edition, Thomson Learning, 2015.
2. F. N. Billmayer, “Test Book of polymer science”, John Wiley & Sons, New York, 1994.
3. Kingery, W. D., Bowen H. K. and Uhlmann, D. R., “Introduction to Ceramics”, 2nd Edition, John Wiley & Sons, New York, 1976.
4. Sidney H. Avner, “Introduction to Physical Metallurgy”, Tata Mc-Graw-Hill Inc,2/e, 1997.
5. Vijendra Singh, “Physical Metallurgy”, Standard Publishers Distributors, New Delhi,2012.
6. William F. Smith, “Structure and Properties of Engineering Alloys”, Mc-Graw-Hill Inc., U.S.A, 2nd edition, 1993.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	2	2	1								2	3	2	2
CO2	3	3	2	3	2							2	3	3	2
CO3	3	1	1	3	2							1	3	3	2
CO4	3	2	2	2								1	3	3	
CO5	3	2	3	1								2	3	1	3
Avg	3	2	2	2	2							1.6	3	2.4	2.25

ML3311 MICROSTRUCTURAL ANALYSIS LABORATORY

L	T	P	C
0	0	4	2

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Having hands on experience on the preparation of samples for microscopic examination.
2. Analysing the microstructure of plain carbon steels and its influence on the properties of materials
3. Interpreting the microstructure of the cast irons and its effect on the mechanical properties.
4. Distinguishing the microstructures of the different stainless steels and high-speed steels.
5. Examining the banded structures in steels, structure of welded joints and copper alloys.

LIST OF EXPERIMENTS

1. Mounting and preparation of metallurgical samples.
2. Study of metallurgical microscope and sample preparation.
3. Quantitative Metallography & image analysis.
4. Macro etching - cast, forged and welded components.
5. Electrolytic Etching and Polishing
6. Microscopic examination of cast irons - Gray, White, Malleable and Nodular types
7. Microscopic examination of Plain carbon steels (low carbon, medium carbon, high carbon steels).
8. Microscopic examination of Austenitic Stainless steels and High Speed Steels.
9. Microscopic examination of welded joints.
10. Microscopic examination of Copper alloys

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of the Course, the students will be able to:

1. Prepare the samples for microscopic examination
2. Recognize the microstructures of various ferrous and non- ferrous materials
3. Differentiate the different types of cast irons based on their morphology and analyse the effect of the processing on the microstructure.
4. Interpret the microstructures of various materials and also understand the effect of the various phase constituents on the properties of the materials
5. Perform a quantitative analysis on any given microstructure.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	3			1		3	1	2	1	2	1	1
CO2	3	3	3	3			1		3	1	2	1	2	1	1
CO3	3	3	3	3	3		1		3	1	2	1	2	3	1
CO4	2	3	3	3	3		1		3	1	2	2	2	3	1
CO5	1	3	3	3	3		1		3	1	2	1	3	3	1
Avg	2.4	3	3	3	3		1		3	1	2	1.2	2.2	2.2	1

CE3312 **STRENGTH OF MATERIALS LABORATORY** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

To study the mechanical properties of metals, wood and spring by testing in laboratory

LIST OF EXPERIMENTS

1. Tension test on mild steel rod
2. Torsion test on mild steel rod
3. Compression test on wood
4. Deflection test on metal beam
5. Double shear test on metal
6. Impact test on metal specimen (Izod and Charpy)
7. Hardness test on metal (Rockwell and Brinell Hardness)
8. Compression test on helical spring
9. Deflection test on carriage spring

TOTAL: 60 PERIODS

COURSE OUTCOMES:
On completion of the course, the student is expected to be able to

CO1 Determine the tensile and torsion properties of steel rod by testing
CO2 Determine the elastic modulus of a metal beam by conducting deflection test
CO3 Determine the shear strength and impact strength of metals.
CO4 Determine the hardness of various metals.
CO5 Determine the stiffness properties of helical and carriage spring.

CO – PO Mapping – STRENGTH OF MATERIALS LABORATORY

PO/PSO		Course Outcome					Overall Correlation of COs to POs
		CO1	CO2	CO3	CO4	CO5	
PROGRAM OUTCOMES(PO)							
PO1	Knowledge of Engineering Sciences	3	3	3	3	3	3
PO2	Problem analysis	2	2	2	2	2	2
PO3	Design / development of solutions	1	1	1	1	1	1
PO4	Investigation	3	3	3	3	3	3
PO5	Modern Tool Usage	3	3	3	3	3	3
PO6	Engineer and Society	1	1	1	1	1	1
PO7	Environment and Sustainability	1	1	1	1	1	1
PO8	Ethics	1	1	1	1	1	1
PO9	Individual and Team work	3	3	3	3	3	3
PO10	Communication	2	2	2	2	2	2
PO11	Project Management and Finance	1	1	1	1	1	1
PO12	Life Long Learning	2	2	2	2	2	2

ML3401	CHARACTERISATION OF MATERIALS	L	T	P	C
		3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Understanding the various techniques of structural characterization of materials.
2. Interpreting the microstructure, crystal structure and surface structure of materials.
3. on X-Ray diffraction techniques and analysis
4. To import knowledge on different electron microscopy techniques used for characterisation
5. To import knowledge on different electron microscopy techniques used for characterisation
6. To import knowledge on techniques of elemental chemical composition and structure of surface.

UNIT I METALLOGRAPHIC TECHNIQUES 9

Macro examination -applications, metallurgical microscope - construction and principle of working, specimen preparation, light material interaction – Rayleigh Scattering, Abbes theory; magnification, numerical aperture, resolving power, depth of focus, depth of field, different light sources; lenses aberrations and their remedial measures, Principles of microscopy -bright field , dark field, phase-contrast, polarization, differential interference contrast, high temperature microscopy; Quantitative metallography – Image analysis for grain size distribution and grain/precipitate shape.

UNIT II X-RAY DIFFRACTION TECHNIQUES 9

Reciprocal lattice, Stereographic projection, X-ray generation, absorption edges, characteristic and continuous spectrum, Bragg's law, Ewald's Sphere, Diffraction methods – Laue, rotating crystal and powder methods. Intensity of diffracted beams –structure factor calculations and other factors. Diffractometer – General features and optics, Counters - Proportional, Scintillating, Geiger counters and semiconductor based.

UNIT III ANALYSIS OF X-RAY DIFFRACTION 9

Line broadening-crystallite size, residual stress; Texture Analysis; Crystal structure determination-indexing -Phase identification- ASTM catalogue of Materials identification, quantitative phase estimation, Phase diagram determination, Precise lattice parameter calculation, Determination of residual stress – double angle diffraction.

UNIT IV ELECTRON MICROSCOPY 9

Electron specimen interaction; Construction and operation of Transmission electron microscope (TEM) – specimen preparation techniques- Diffraction mode and image mode, Sources of contrast-Selected Area Electron Diffraction, Zone axis, indexing ; Construction, modes of operation and sources of contrast of Scanning electron microscope(SEM), Electron probe micro analysis, Basics of Field ion microscopy (FIB), Scanning Tunnelling Microscope (STM) and Atomic Force Microscope(AFM).

UNIT V SURFACE ANALYSIS 9

X-ray emission spectroscopy - Energy Dispersive Spectroscopy- Wave Dispersive Spectroscopy-Ultraviolet Photo Electron Spectroscopy (UPS), X ray Photoelectron Spectroscopy (XPS), Auger Electron Spectroscopy (AES), Electron Energy Analysers, Secondary ion mass spectrometry - Quadrupole mass spectrometer ; Surface Structure -Unit meshes of five types of surface nets - diffraction from diperiodic structures - Low Energy Electron Diffraction (LEED)- Reflection High Energy Electron Diffraction (RHEED).

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of course, the student will be able to

1. Describe the principle of metallography and its application.
2. Explain the principle of XRD and its scope for metallurgical analysis.
3. Interpret and analyse the XRD results.
4. Discuss the various techniques of electron microscopy and their applications.
5. Describe the different techniques for the analysis of elemental chemical composition and structure of surface.

TEXT BOOKS:

1. Angelo, P.C., "Materials Characterisation", 1st Edition Cengage Publication, 2016.
2. Cullity, B. D., Stock, S.R. "Elements of X-ray diffraction", Pearson New International Edition, 3rd Edition, 2014

REFERENCES:

1. Brandon D. G, "Modern Techniques in Metallography", Von Nostrand Inc. NJ, USA, 1986.
2. D. A. Skoog, F. James Leary and T. A. Nieman, "Principles of Instrumental Analysis", 7th edition, Cengage Learning, 2017.
3. Thomas G., "Transmission electron microscopy of metals", John Wiley, 1996.
4. Whan R E (Ed), ASM Handbook, Volume 10, Materials Characterisation ", Nineth Edition, ASM international, USA, 1986.
5. Yang Leng, Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, Hong Kong University of Science and Technology, John Wiley & Sons (Asia) Pte Ltd. 2010.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO1 1	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	3	2	2		1					2	3	3	1
CO2	3	2	3	2	2		1					2	3	3	1
CO3	3	3	3	3	2							2	3	3	
CO4	3	2	3	2	2							2	3	3	
CO5	3	2	3	2	2							2	3	3	
Avg	3	2.2	3	2.2	2		1					2	3	3	1

ML3402 **IRON AND STEEL MAKING** **L T P C**
3 0 0 3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Acquiring the basic knowledge on the need for the beneficiation of iron ores and the different preliminary treatments given to the iron ores.
2. Discussing the various parts of blast furnace and the reactions that take place in the various zones of blast furnace
3. Understanding the principles and kinetics of pig iron production as well as steel making.
4. Getting insight on the various primary and secondary processes employed for making of steel
5. Producing the different types of steels by adopting the ladle metallurgy technique.

UNIT I RAW MATERIALS AND BURDEN PREPARATION 9

Iron ore classification, Indian iron ores, limestone and coking coal deposits, problems associated with Indian raw materials, Iron ore beneficiation and agglomeration, Briquetting, sintering, Nodulising and pelletizing, testing of burden materials, burden distribution on blast furnace performance.

UNIT II PRINCIPLES AND PROCESSES OF IRON MAKING 9

Blast furnace parts, construction and design aspects, ancillary equipment for charging, preheating the blast, hot blast stoves, gas cleaning, Blast furnace operation, irregularities and remedies, Blast furnace instrumentation and control of furnace Compositional control of metal and slag in blast furnace, modern trends in blast furnace practice.

Reduction of iron ores and oxides of iron by solid and gaseous reductions-thermodynamics and kinetics study of direct and indirect reduction, Gruner's theorem, blast furnace reactions. C-O and Fe-C-O equilibria, Rist diagrams, Ellingham diagram, material and heat balance- Sponge Iron making.

UNIT III PRINCIPLES OF STEEL MAKING 9

Development of steel making processes, physico-chemical principles and kinetic aspects of steel making, carbon boil, oxygen-transport mechanism, desulphurisation, dephosphorisation, Slag Theories, slag-functions, composition, properties and theories, raw materials for steelmaking and plant layout.

UNIT IV STEEL MAKING PROCESSES 9

Open Hearth process- constructional features, process types, operation, modified processes, Duplexing, pre-treatment of hot metal. Bessemer processes, Side Blown Converter, Top Blown processes-L. D, L.D.A.C., Bottom blown processes, combined blown processes, Rotating oxygen processes - Kaldo and Rotor, Modern trends in oxygen steel making processes-Electric Arc and Induction furnace-constructional features. Steel Classifications and Standards-National and International- Alloy Designation.

UNIT V LADLE METALLURGY 9

Production practice for plain carbon steels, stainless steels, tool steels and special steels, Secondary steel making processes, continuous steel casting process – Deoxidation and teeming practice. Principle, methods and their comparison, Killed, Rimmed and Capped steels, Degassing practices, ingot production, ingot defects and remedies. Recent trends in steel making technology.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon the completion of the course, the students will be able to:

1. Identify the suitable preliminary treatments to be given to the iron ore for the beneficiation of ores.
2. Discuss the construction of Blast furnace, its operation and the various reactions that takes place in the various zones of blast furnace.
3. Interpret the slag theories and slag functions in the steel making processes.
4. Compare the various steel making processes and analyse the advantages and limitations of the different processes.
5. Select the suitable secondary refining processes for producing a good quality steel.

TEXT BOOKS:

1. Dipak Mazumdar, "A First Course in Iron and Steel Making", Universities press – IIM, Series in Metallurgy and Materials Science, India, 2015.
2. Tupkary, R. H.&Tupkary V.R., "An Introduction to Modern Iron Making", Khanna Publishers, 4th edition, 2016 & "An Introduction to Modern Steel Making", Khanna Publishers, New Delhi, 2000.

REFERENCES:

1. Ahindra Ghosh and Amit chatterjee, "Iron Making and Steel Making – Theory and Practice", Prentice Hall of India Private Ltd., New Delhi 2008.
2. Biswas, A. K., "Principles of blast furnace iron making: theory and practice", SBA Publications, Kolkata, 1994.
3. Bashforth, G. R., "Manufacture of Iron and Steel", Vol. I, Chapman and Hall London, 1964.Bashforth, G. R., "Manufacture of Iron and Steel", Vol.2, 3rd Edition, Chapman & Hall, London, 1964.
4. "Making, Shaping and Treating of Steel", US Steel Corporation, 11th edition, 1994.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	3	3	3		1	1					2	3		
CO2	3	3	3	3	2	2	1					2	3	2	1
CO3	3	3	3	3	2	1	1					2	3		
CO4	3	3	3	3	2	1	1					2	3	2	1
CO5	3	3	3	3	2	1	1					2	3	2	1
Avg	3	3	3	3	2	1.2	1					2	3	2	1

ML3403 MECHANICAL BEHAVIOUR OF MATERIALS

L	T	P	C
3	0	0	3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Having an overview of elastic and plastic behaviour of materials
2. Getting enlightened with the different strengthening mechanisms.
3. Obtaining an insight into the types of fracture and mechanics of fracture.
4. Interpreting the fatigue behaviour of materials.
5. Having an insight on the high temperature behaviour of materials.

UNIT I ELASTIC AND PLASTIC BEHAVIOUR 9

Elastic behaviour of materials - Hooke's law, plastic behaviour: dislocation theory, Types of dislocations- Burger's vectors and dislocation loops, dislocations in the FCC, HCP and BCC lattice, stress fields and energies of dislocations, forces on and between dislocations, dislocation climb, intersections of dislocations, Jogs, dislocation sources, multiplication of dislocations, dislocation pile-ups, Slip and twinning. Methods of observing dislocations

UNIT II STRENGTHENING MECHANISMS 9

Elementary discussion of cold working, grain boundary strengthening. Solid solution strengthening, Martensitic strengthening, Precipitation strengthening, Particulate Strengthening, Dispersion strengthening, Fibre strengthening, Yield point phenomenon, strain aging and dynamic strain aging

UNIT III FRACTURE AND FRACTURE MECHANICS 9

Types of fracture, Basic mechanisms of ductile and brittle fracture, Griffith's theory of brittle fracture, Orowan's modification. Izod and Charpy Impacts tests, Ductile to Brittle Transition Temperature (DBTT), Factors affecting DBTT, Determination of DBTT. Fracture mechanics-Introduction, Modes of fracture, Stress intensity factor, Fracture toughness and Determination of KIC.

UNIT IV FATIGUE BEHAVIOUR AND TESTING 9

Fatigue: Stress cycles, S-N curves, Effect of mean stress, Factors affecting Fatigue, Structural changes accompanying fatigue, Cumulative damage- Miner law, HCF / LCF, creep- fatigue interactions, micro-mechanisms of fatigue crack initiation and growth, fatigue testing machines- Pari's Equation, Residual life prediction under Fatigue. Macro, Microstructural features of fatigue fracture.

UNIT V CREEP BEHAVIOUR AND TESTING 9

Creep curve, Stages in creep curve and explanation, Structural changes during creep, Creep mechanisms, Metallurgical factors affecting creep, High temperature alloys, Stress rupture testing, Creep testing machines, creep life prediction-Omega (Damage rate) method, Larson-Miller (parametric) method. Deformation Mechanism Maps according to Frost/Ashby, Super plasticity.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Identify the role of dislocations and the mechanisms of plastic deformation.
2. Explain the strengthening mechanisms of polycrystalline and composite materials.
3. Analyse the nature of fracture and its underlying mechanism.
4. Appraise the micro-mechanics, factors and life predictions of components under fatigue loading.
5. Assess the behaviour of materials under high temperature, metallurgical factors and life prediction of high temperature materials.

TEXT BOOKS:

1. Dieter, G. E., “Mechanical Metallurgy”, McGraw-Hill Co., SI Edition, 1995
2. Thomas H. Courtney, “ Mechanical Behaviour of Materials”, Waveland Press, 2nd edition, 2005

REFERENCES:

1. Bhargava A K & Sharma C P, “Mechanical behaviour and Testing of materials” PHI learning 2011.
2. Norman E Dowling, “Mechanical Behaviour of Materials, Pearson 2013.
3. Prashant Kumar, “Elements of Fracture Mechanics”, McGraw-Hill, 2009.
4. Shetty M N, Dislocations and mechanical behaviour of materials”, PHI learning 2013.
5. William Hosford., “Mechanical behaviour of Materials”, Cambridge University press, 2010.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
C01	3	3	2	2								1	3		
C02	3		2	2		2						1	3		
C03	3	2	3	3	3							1	3	2	
CO4	2	3	2	2			1					1	3	2	2
CO5	3	2	2	2	3		1					1	3	2	2
Avg	2.8	2.5	2.2	2.2	3	2	1					1	3	2	2

ML3404 HEAT TREATMENT OF METALS AND ALLOYS L T P C
3 0 0 3

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Having necessary background to design/select the necessary heat treatment for attaining the appropriate microstructure for the desired properties.
2. Getting a comprehensive understanding of the various transformation reactions associated with the changes in microstructures and properties that occur due to controlled heat treatment.
3. Understanding different case hardening techniques used in industries
4. Distinguishing the various Heat treatment furnaces, Quenching media and the heat treatment of some special alloys.
5. Getting an insight on the heat treatments employed for special alloys

UNIT I TRANSFORMATIONS IN STEELS 9

Allotropic changes in Iron, Iron-Iron carbide equilibrium diagram – transformations on heating and cooling - influence of alloying elements – general principles of heat treatment of steels – isothermal and continuous cooling transformations in steels – Time-Temperature-Transformation curves (TTT-diagrams), continuous cooling transformations – CCT-diagrams– effect of alloying additions on TTT diagrams, mechanism and kinetics of pearlitic, bainitic and martensitic transformations – habit plane – Bain distortion model

UNIT II HEAT TREATMENT PROCESSES 9

Annealing- Types, Normalising, Hardening & Quenching –Mechanisms-hardenability studies– Jominy end-quench test, Grossman's experiments, tempering – Hollomon& Jaffe tempering correlations, retained austenite, tempering – Stages – effects of alloying elements on tempering, austempering and martempering, precipitation hardening, thermo-mechanical treatment, intercritical heat treatment, sub-zero treatment – cryogenic quenching, patenting

UNIT III CASE HARDENING 9

Introduction, carburisation – principle – carbon potential – mechanism – application of Fick's law– depth of carburisation and its control – methods of carburising – heat treatment after carburizing – structure, properties and defects in carburising, nitriding – mechanism –- effect of microstructure – nitriding methods, ion-nitriding and nitro-carburising, boronising, chromising, cyaniding and carbonitriding, induction and flame hardening, Laser and Electron beam welding – principles – methods – operating variables, measurement of case depth.

UNIT IV FURNACES, ATMOSPHERE AND PROCESS CONTROL 9

Various heating atmosphere used for heat treatment, temperature and atmosphere control– carburising atmosphere and carbon potential measurement, Temperature Measurement Control devices – Nitriding gas atmospheres, quenching media and their characteristics, Stages of Quenching, polymer quenching, Various Heat Treatment furnaces- Roller and Mesh type continuous furnaces- fluidised bed furnaces, cryo-chamber, cryo-treatment of steels, sealed quench furnace, Vacuum furnace, Plasma equipment-Elements of Process control systems-PLC ,PID controllers and continuous monitoring systems.

UNIT V HEAT TREATMENT OF SPECIFIC ALLOYS 9

Heat treatment of special purpose steels – tool steels, high speed steels, maraging steels, HSLA steels and die steels, heat treatment of cast irons – gray cast irons, white cast irons and S.G. irons, austempering of S.G. Iron, heat treatment of non-ferrous alloys – aluminium alloys, copper alloys, nickel alloys and titanium alloys, defects in heat treated parts – causes and remedies.

TOTAL: 45 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Discuss the various transformation reactions associated with the changes in microstructures and properties that occur due to controlled heat treatment.
2. Explain the various heat treatment processes that can be applied for different ferrous and non-ferrous alloys.
3. Analyse the effect of various case hardening treatments on the metals and alloys.
4. Compare the various heat treatment furnaces, quenching media and furnace atmospheres.
5. Interpret the results of heat treatments on the various other non-ferrous materials, alloy steels and cast irons.

TEXT BOOKS:

1. Rajan, T. V., Sharma, C. P., Ashok Sharma., "Heat Treatment Principles and Techniques" Prentice-Hall of India Pvt. Ltd., New Delhi, 2011
2. Vijendra Singh, "Heat Treatment of Metals", Second edition, Standard Publishers Distributors New Delhi, 2012.
3.

REFERENCES:

1. ASM Hand book "Heat Treating", Vol.4., ASM International, 1999.
2. I. Novikov, "Theory of Heat Treatment of Metals", MIR Publishers, Moscow, 1978
3. Prabhudev. K. H. "Handbook of Heat Treatment of Steels", Tata McGraw-Hill, Publishing Co., New Delhi, 1988.
4. Sydney H. Avner, "Introduction to Physical Metallurgy", Tata McGraw Hill, New Delhi, 1997.

	PO1	PO 2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	2	2								2	3		
CO2	3	2	3	3	2		1					2	3	2	1
CO3	3	2	3	3	2		1					2	3	2	1
CO4	3	2	3	2	2	1	1					2	3	2	1
CO5	3	2	3	3	2		1					2	3	2	1
Av	3	2	2.8	2.6	2	1	1					2	3	2	1

Low (1) ; Medium (2) ; High (3)

CE3391 FLUID MECHANICS AND MACHINERY L T P C
3 1 0 4

COURSE OBJECTIVES:

1. To introduce the students about properties of the fluids, behaviour of fluids under static conditions.
2. To impart basic knowledge of the dynamics of fluids and boundary layer concept.
3. To expose to the applications of the conservation laws to a) flow measurements b) flow through pipes (both laminar and turbulent) and c) forces on pipe bends.
4. To exposure to the significance of boundary layer theory and its thicknesses.
5. To expose the students to basic principles of working of hydraulic machineries and to design Pelton wheel, Francis and Kaplan turbine, centrifugal and reciprocating pumps.

UNIT I FLUID PROPERTIES AND FLOW CHARACTERISTICS 10+3

Properties of fluids – Fluid statics - Pressure Measurements - Buoyancy and floatation - Flow characteristics - Eulerian and Lagrangian approach - Concept of control volume and system - Reynold's transportation theorem - Continuity equation, energy equation and momentum equation - Applications.

UNIT II FLOW THROUGH PIPES AND BOUNDARY LAYER 9+3

Reynold's Experiment - Laminar flow through circular conduits - Darcy Weisbach equation - friction factor - Moody diagram - Major and minor losses - Hydraulic and energy gradient lines - Pipes in series and parallel - Boundary layer concepts - Types of boundary layer thickness.

UNIT III DIMENSIONAL ANALYSIS AND MODEL STUDIES 8+3

Fundamental dimensions - Dimensional homogeneity - Rayleigh's method and Buckingham Pi theorem - Dimensionless parameters - Similitude and model studies - Distorted and undistorted models.

UNIT IV TURBINES 9+3

Impact of jets - Velocity triangles - Theory of rotodynamic machines - Classification of turbines - Working principles - Pelton wheel - Modern Francis turbine - Kaplan turbine - Work done - Efficiencies - Draft tube - Specific speed - Performance curves for turbines - Governing of turbines.

UNIT V PUMPS 9+3

Classification of pumps - Centrifugal pumps - Working principle - Heads and efficiencies– Velocity triangles - Work done by the impeller - Performance curves - Reciprocating pump working principle - Indicator diagram and its variations - Work saved by fitting air vessels - Rotary pumps.

TOTAL: 60 PERIODS

COURSE OUTCOMES:

On completion of the course, the student is expected to be able to

1. Understand the properties and behaviour in static conditions. Also to understand the conservation laws applicable to fluids and its application through fluid kinematics and dynamics
2. Estimate losses in pipelines for both laminar and turbulent conditions and analysis of pipes connected in series and parallel. Also to understand the concept of boundary layer and its thickness on the flat solid surface.
3. Formulate the relationship among the parameters involved in the given fluid phenomenon and to predict the performances of prototype by model studies
4. Explain the working principles of various turbines and design the various types of turbines.
5. Explain the working principles of centrifugal, reciprocating and rotary pumps and design the centrifugal and reciprocating pumps

TEXT BOOKS:

1. Modi P.N. and Seth, S.M. Hydraulics and Fluid Mechanics, Standard Book House, New Delhi, 22nd edition (2019)
2. Jain A. K. Fluid Mechanics including Hydraulic Machines, Khanna Publishers, New Delhi, 2014.
3. Kumar K. L., Engineering Fluid Mechanics, Eurasia Publishing House(p) Ltd. New Delhi, 2016.

REFERENCES:

1. Fox W.R. and McDonald A.T., Introduction to Fluid Mechanics John-Wiley and Sons, Singapore,
2011.
2. Pani B S, Fluid Mechanics: A Concise Introduction, Prentice Hall of India Private Ltd, 2016.
3. Cengel Y A and Cimbala J M, Fluid Mechanics, McGraw Hill Education Pvt. Ltd., 2014.
4. S K Som; Gautam Biswas and S Chakraborty, Introduction to Fluid Mechanics and Fluid Machines, Tata McGraw Hill Education Pvt. Ltd., 2012.
5. Streeter, V. L. and Wylie E. B., Fluid Mechanics, McGraw Hill Publishing Co., 2010.

CO	PO												PSO		
	1	2	3	4	5	6	7	8	9	10	11	12	1	2	3
1	3	3	2	2	1	2	2	1	2	1	1	2	3	2	3
2	3	3	3	2	1	2	2	1	2	1	1	2	3	2	3
3	3	3	3	3	1	2	2	1	2	1	1	2	3	3	3
4	3	3	3	3	1	2	2	1	2	1	1	3	3	2	2
5	3	3	3	3	1	2	2	1	2	1	1	3	3	2	2
Low (1) ; Medium (2) ; High (3)															

GE3451 ENVIRONMENTAL SCIENCE AND SUSTAINABILITY L T P C

2 0 0 2

COURSE OBJECTIVES:

1. To study the nature and its impacts on human life.
2. To study the environmental pollution, its types, control methods and protection acts
3. To provide the knowledge of about the energy management and energy resources
4. To study the concepts of Sustainability, global warming and Management
5. To study the Sustainability Practices and socio economical changes

UNIT I ENVIRONMENT AND BIODIVERSITY 9

Definition, scope and importance of environment – need for public awareness. Eco-system and Energy flow– ecological succession. Types of biodiversity: genetic, species and ecosystem diversity– values of biodiversity, India as a mega-diversity nation – hot-spots of biodiversity – threats to biodiversity: habitat loss, poaching of wildlife, man-wildlife conflicts – endangered and endemic species of India – conservation of biodiversity: In-situ and ex-situ.

UNIT II ENVIRONMENTAL POLLUTION 9

Causes, Effects and Preventive measures of Water, Soil, Air and Noise Pollutions. Solid, Hazardous and E-Waste management. Case studies on Occupational Health and Safety Management system (OHASMS). Environmental protection, Environmental protection acts.

UNIT III RENEWABLE SOURCES OF ENERGY 9

Energy management and conservation, New Energy Sources: Need of new sources. Different types new energy sources. Applications of- Hydrogen energy, Ocean energy resources, Tidal energy conversion. Concept, origin and power plants of geothermal energy.

UNIT IV SUSTAINABILITY AND MANAGEMENT 9

Development, GDP, Sustainability- concept, needs and challenges-economic, social and aspects of sustainability-from unsustainability to sustainability-millennium development goals, and protocols-Sustainable Development Goals-targets, indicators and intervention areas Climate change- Global, Regional and local environmental issues and possible solutions-case studies. Concept of Carbon Credit, Carbon Footprint. Environmental management in industry-A case study.

UNIT V SUSTAINABILITY PRACTICES 9

Zero waste and R concept, Circular economy, ISO 14000 Series, Material Life cycle assessment, Environmental Impact Assessment. Sustainable habitat: Green buildings, Green materials, Energy efficiency, Sustainable transports. Sustainable energy: Non-conventional Sources, Energy Cycles-carbon cycle, emission and sequestration, Green Engineering: Sustainable urbanization- Socio-economic and technological change.

TOTAL: 30 PERIODS

COURSE OUTCOMES:

At the end of the course the students would be able to

1.Understand the nature and its impacts on human life.
2.The students have the knowledge and awareness of Environmental Pollution.
3.Understanding of the energy sources and scientific concepts/principles behind them
4.Understand the concepts of the Sustainability and Management
5.Understand the Sustainability Practices and socio economical changes

TEXT BOOKS:

1. Anubha Kaushik and C. P. Kaushik's "Perspectives in Environmental Studies", 6th Edition, New Age International Publishers ,2018.
2. Benny Joseph, 'Environmental Science and Engineering', Tata McGraw-Hill, New Delhi, 2016.

REFERENCES:

1. R.K. Trivedi, 'Handbook of Environmental Laws, Rules, Guidelines, Compliances and Standards', Vol. I and II, Enviro Media. 38.
2. Cunningham, W.P. Cooper, T.H. Gorhani, 'Environmental Encyclopedia', Jaico Publ., House, Mumbai, 2001.
3. Dharmendra S. Sengar, 'Environmental law', Prentice hall of India PVT. LTD, New Delhi, 2007.
4. Rajagopalan, R, 'Environmental Studies-From Crisis to Cure', Oxford University Press, 2005.
5. Erach Bharucha "Textbook of Environmental Studies for Undergraduate Courses" Orient Blackswan Pvt. Ltd. 2013.

ML3411	MATERIAL CHARACTERIZATION LABORATORY	L	T	P	C
		0	0	4	2

COURSE OBJECTIVES:

The main learning objective of this course is to prepare the students for:

1. Gaining practical experience on handling sophisticated instruments.
2. Obtaining hands-on-practice for sample preparation.
3. Experiencing the procedure involved in the instrumentation methods.
4. Calibrating and standardizing the sensitive instruments.
5. Using the spectrometers, electron microscopes and thermal analysers for analysing the specimens.

LIST OF EXPERIMENTS:

1. Verification of Beer Lambert's law using Absorption Spectrophotometer.
2. Determination of concentration of metal ions using UV Visible spectrophotometer.
3. Determination of thermal coefficient using dilatometer.
4. Determination of conductivity using conductivity meter.
5. Identification of organic compounds using IR spectroscopy.
6. Quantitative analysis using column chromatography.
7. Qualitative identification of species using TLC.
8. Thermal degradation analysis using TGA
9. Thermal transition analysis using DSC.
10. Analysis of electron microscopic images

COURSE OUTCOMES:

Upon completion of the course , the students will be able to

1. Apply the theoretical principles and concepts of spectroscopy in characterization of materials.
2. Analyse and interpret the results obtained from the instrumental methods.
3. Demonstrate the use of suitable equipment to analyse the thermal behaviour of materials.
4. Examine the mixture of materials using chromatography technique.
5. Analyse and interpret the microstructural images obtained by electron microscopy.

TOTAL: 60 PERIODS

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	3	3	3	3	3				2	1	2	3	3	3	3
CO2	3	3	3	3	3				2	1	2	3	3	3	3
CO3	3	3	3	3	3				2	1	2	3	3	3	3
CO4	3	3	3	3	3				2	1	2	3	3	3	3
CO5	3	3	3	3	3				2	1	2	3	3	3	3
Avg	3	3	3	3	3				2	1	2	3	3	3	3

ML3412 **HEAT TREATMENT LABORATORY** **L T P C**
0 0 4 2

COURSE OBJECTIVES:

The main learning objective of this course is to prepare students for:

1. Performing heat treatment operations on the plain carbon steels
2. Interpreting the effect of quenching media and tempering temperature and time on the hardness of the steels
3. Enhancing the case hardness of the low carbon steels by carburizing treatment
4. Measuring the case depth of the case-hardened steels
5. Identifying the suitable heat treatment for non-ferrous materials.

LIST OF EXPERIMENTS:

1. Hardening and tempering of High carbon steels
2. Annealing and normalizing of hardened steels
3. Spheroidization annealing of high carbon steels
4. Effect of quenching media on hardening of steel
5. Effect of tempering temperature and time on tempering of steel
6. Effect of carbon percentage on the hardening of steel
7. Carburizing of low carbon steel
8. Case hardness depth measurements
9. Hardenability test – Jominy End Quench Test
10. Heat treatment of cast iron
11. Heat treatment of Stainless Steels and High speed steels
12. Heat treatment of non-ferrous alloys

TOTAL: 60 PERIODS

COURSE OUTCOMES:

Upon completion of this course, the students will be able to:

1. Perform various heat treatment processes on plain carbon steels and analyze the effect of the processes on steels.
2. Execute the case hardening effect on low carbon steel and to analyze the case depth measurements.
3. Interpret the effect of quenching media and the carbon percentage on the hardening of steel
4. Exemplify the effect of Jominy end quench test on the hardenability of steel.
5. Apply heat treatment on the various non-ferrous materials and analyze the effect of heat treatment on these materials.

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO11	PO12	PSO 1	PSO 2	PSO 3
CO1	3	2	3	2			1		2	1	1	2	3	2	2
CO2	3	2	3	2			1		2	1	1	2	3	2	2
CO3	3	3	2				1		2	1	1	2	3	2	1
CO4	3	3	3	2	2		1		2	1	1	2	3	2	2
CO5	3	2	3	1			1		2	1	1	2	3	2	1
Avg	3	2.4	2.8	1.75	2		1		2	1	1	2	3	2	3