B.Tech.

in

METALLURGICAL AND MATERIALS ENGINEERING

FLEXIBLE CURRICULUM

(For students admitted from 2023-24 onwards)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA

(in tune with Instt guidelines (2022) for NEP and multiple exits)

(BoS BTech MME meeting July 25 2022)

(Senate meeting January 6 2023)

(approval: 59 / Senate / 2023 / 5 (i))

Vision, Mission of the Institute

Vision of the Institute

- To provide valuable resources for industry and society through excellence in technical education and research

Mission of the Institute

- To offer state-of-the-art undergraduate, postgraduate and doctoral programmes
- To generate new knowledge by engaging in cutting-edge research
- To undertake collaborative projects with academia and industries
- To develop human intellectual capability to its fullest potential

Vision, Mission of MME department

Vision of the Department MME

- To evolve into a globally recognized department in the frontier areas of Metallurgical and Materials Engineering

Mission of the Department MME

- To produce Metallurgical and Materials Engineering graduates having professional excellence
- To carry out quality research having social & industrial relevance
- To provide technical support to budding entrepreneurs and existing industries

Summary of Flexible curriculum

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirement Courses)	23	56	34.35
PC (Programme Core)	15**	49	30.06
Programme Electives (PE) / Open Electives (OE)	14$	42	25.76
Essential Laboratory Requirements (ELR)	08 (Maximum 2 per session up to 6th semester)	16	10
Total		**163**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honours (Optional)	Courses for 15 credits	15 Additional credits	-

**Minimum of 4 programme core courses shall be 4 credits each

$Out of 14 elective courses (PE/OE), the students should study at least eight programme elective courses (PE)

B.Tech. Curriculum Structure – Students admitted in 2023 – 2024

Semester I (July Session)

Sl. No.	COURSE	Credits	Category
1	English for Communication (Theory & Lab)	4	GIR
2	Matrices and Calculus	3	GIR
4	Chemistry (Non-Circuit)	3	GIR
5	Chemistry Lab (Non-Circuit)	2	GIR
6	Introduction to Metallurgical and Materials Engineering*	2	GIR
7	Basics of Electrical and Electronics Engineering	2	GIR
8	Engineering Graphics	3	GIR
	Total	**19**	

Semester II (January Session)

Sl. No.	COURSE	Credits	Category
1	Complex Analysis and Differential Equations	3	GIR
2	Physics (Non-Circuit)	3	GIR
3	Physics Lab (Non-Circuit)	2	GIR
4	Introduction to Computer Programming (Theory & lab) **(Non-Circuit)**	3	GIR
5	Basics of Civil Engineering (**Non-Circuit**)	2	GIR
6	Energy and Environmental Engineering	2	GIR
7	Engineering Practice	2	GIR
8	Metallurgical Thermodynamics and Kinetics	4	PC
	Total	**21**	

* Mandatary course, offered by Industrial Experts / Alumni

Semester III (July Session)

Sl. No.	COURSE	Credits	Category
1	Physical Metallurgy	4	PC
2	Engineering Mechanics and Strength of Materials	3	PC
3	Transport Phenomena	3	PC
4	Mechanical Behaviour and Testing of Materials	3	PC
5	Polymers, Composites and Ceramics	3	PC
6	Process Metallurgy Laboratory	2	ELR
7	Polymers, Composites and Ceramics Laboratory	2	ELR
8	Programme Elective	3	PE/OE
	Total	**23**	

Note: Department(s) to offer Minor (MI) Course and ONLINE Course (OC) to those willing students in addition to 23 credits.

Semester IV (January Session)

Sl. No.	COURSE	Credits	Category
1	Mathematics III	4	GIR
2	Iron Making and Steel Making	4	PC
3	Phase Transformation and Heat Treatment	3	PC
4	Material Characterization	3	PC
5	Metallography and Heat Treatment Laboratory	2	ELR
6	Materials Testing and Inspection Laboratory	2	ELR
7	Elective – II	3	PE/OE
8	Elective – III	3	PE/OE
	Total	**24**	

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 24 credits.

Semester V (July Session)

Sl. No.	COURSE	Credits	Category
1	Industrial Economics and Foreign Trades	3	GIR
2	Metal Casting Technology	3	PC
3	Materials Joining Technology	3	PC
4	Metal Forming Technology	4	PC
5	Foundry and Welding Laboratory	2	ELR
6	Metal Forming and Particulate Processing Laboratory	2	ELR
7	Professional Ethics (Non-Circuit)	3	GIR
8	Elective – IV	3	PE/OE
	Total	**23**	

Note: Department(s) to offer MI/PE/OE/OC and Honours course as 2/3 credits to those willing students in addition to 23 credits.

Semester VI (January Session)

Sl. No.	COURSE	Credits	Category
1	Industrial Lecture	1	GIR
2	Non-Ferrous Physical Metallurgy	3	PC
3	Electrical, Electronic and Magnetic Materials	3	PC
4	Corrosion and Surface Engineering	3	PC
5	Non-Ferrous Metallography and Characterization Laboratory	2	ELR
6	Corrosion and Surface Engineering Laboratory	2	ELR
7	Elective – V	3	PE/OE
8	Elective - VI	3	PE/OE
9	Elective - VII	3	PE/OE
	Total	**23**	

Note: Department(s) may offer Minor (MI) Course, ONLINE Course (OC) and Honours Course
(HO) to those willing students in addition to 23 credits

Semester VII (July Session)

Sl. No.	COURSE	Credits	Category
1	Summer Internship	2	GIR
2	Elective – VIII	3	PE/OE
3	Elective – IX	3	PE/OE
4	Elective – X	3	PE/OE
5	Elective – XI	3	PE/OE
	TOTAL	**14**	

Note: Department(s) may offer Minor (MI) Course, ONLINE Course (OC) and Honours Course
(HO) to those willing students in addition to 14 credits

Semester VIII (January Session)

Sl. No.	COURSE	Credits	Category
1	Comprehensive Viva Voce	1	GIR
2	Project Work$^{\$}$ / Equivalent no. of Electives	**6**	GIR
3	Elective – XII	3	PE/OE
4	Elective – XIII	3	PE/OE
5	Elective – XIV	3	PE/OE
	TOTAL	**16**	

Note: Department(s) may offer Minor (MI) Course, ONLINE Course (OC) and Honours Course (HO) to those willing students in addition to 10 credits
$^{\$}$Optional course

Semester	I	II	III	IV	V	VI	VII	VIII	Total
Credit	19	21	23	24	23	23	14	16	163

Note:

1. Curriculum should have 4 programme core courses shall be 4 credits each.
2. Out of 14 elective courses (PE/OE), the students should study **at least eight programme elective courses (PE).**
3. MI – Minor Degree: **15 credits over and above** the minimum credit as specified by the departments. The details of MINOR will be mentioned only in the transcript not in the Degree certificate.
4. HO – Honours Degree: **15 credits over and above** the minimum credit as specified by the departments (163). The project work is compulsory.

GIR COURSES

S.No.	Name of the Course	Number of Courses	Max. Credits
1.	Mathematics	**3**	**10**
2.	Physics	**1 Theory**	**3**
		1 Lab	**2**
3.	Chemistry	**1 Theory**	**3**
		1 Lab	**2**
4.	Industrial Economics and Foreign Trade	**1**	**3**
5.	English for Communication	**1 Theory**	**2**
		1 Lab	**2**
6.	Energy and Environmental Engineering	**1**	**2**
7.	Professional Ethics	**1**	**3**
8.	Engineering Graphics	**1**	**3**
9.	Engineering Practice	**1**	**2**
10.	Basic Engineering	**2**	**4**
11.	Introduction to computer Programming	**1**	**3**
12.	Branch Specific Course[#] (Introduction to the branch of study)	**1**	**2**
13.	Summer Internship	**1**	**2**
14.	Project work*	**1**	**6**
15.	Comprehensive viva	**1**	**1**
16.	Industrial Lecture	**1**	**1**
17.	NSS/NCC/NSO	**1**	**Compulsory Participation**
Total		**23**	**56**

[#]Offered by Industrial Experts / Alumni of NITT, *Optional course

I. GENERAL INSTITUTE REQUIREMENTS (Course and Course details)

1. MATHEMATICS

Sl.No.	Course Code	Course Title	Credits
1.	**MAIR11**	**Matrices and Calculus**	**3**
2.	**MAIR21**	**Complex Analysis and Differential Equations**	**3**
3.	**MAIRYY[$]**	**Partial Differential Equations And Numerical Methods**	**4**
Total			**10**

2. PHYSICS

Sl.No.	Course Code	Course Title	Credits
1.	**PHIR11**	**Physics**	**3**
2.	**PHIR12**	**Physics Lab**	**2**
Total			**5**

3. CHEMISTRY

Sl.No.	Course Code	Course Title	Credits
1.	**CHIR11**	**Chemistry**	**3**
2.	**CHIR12**	**Chemistry Lab**	**2**
Total			**5**

4. HUMANITIES

Sl.No.	Course Code	Course Title	Credits
1.	**HSIR13**	**Industrial Economics and Foreign Trade**	**3**
Total			**3**

5. COMMUNICATION

Sl.No.	Course Code	Course Title	Credits
1.	**HSIR11**	**English for Communication (Theory)**	**2**
2.	HSIRYY[$]	**English for Communication (Lab)**	**2**
Total			**4**

6. ENERGY AND ENVIRONMENTAL ENGINEERING

Sl.No.	Course Code	Course Title	Credits
1.	**ENIR11**	**Energy and Environmental Engineering**	**2**
Total			**2**

7. PROFESSIONAL ETHICS

Sl.No.	Course Code	Course Title	Credits
1.	HSIR14	**Professional Ethics**	**3**
Total			**3**

8. ENGINEERING GRAPHICS

Sl.No.	Course Code	Course Title	Credits
1.	**MEIR12**	**Engineering Graphics**	**3**
Total			**3**

9. ENGINEERING PRACTICE

Sl.No.	Course Code	Course Title	Credits
1.	**PRIR11**	**Engineering Practice**	**2**
Total			**2**

10. BASIC ENGINEERING

Sl. No.	Course Code	Course Title	Credits
1.	**CEIR11**	**Basics of Civil Engineering**	**2**
2.	**EEIR11**	**Basics of Electrical and Electronics Engineering**	**2**
Total			**4**

11. INTRODUCTION TO COMPUTER PROGRAMMING

Sl.No.	Course Code	Course Title	Credits
1.	**CSIR11**	**Introduction to Computer Programming (Theory and Lab)**	**3**
Total			**3**

12. BRANCH SPECIFIC COURSE

Sl.No.	Course Code	Course Title	Credits
1.	**MTIR15**	**Branch Specific Course – Introduction to MME**	**2**
Total			**2**

13. SUMMER INTERNSHIP[#]

Sl.No.	Course Code	Course Title	Credits
1.	**MTIR16**	**Internship / Industrial Training / Academic Attachment**	**2**
Total			**2**

The student should undergo industrial training/internship for a minimum period of two months during the summer vacation of 3rd year. Attachment with an academic institution within the country (IISc/IITs/NITs/IIITs and CFTIs) or university abroad is also permitted instead of industrial training.

[#] To be evaluated at the beginning of VII semester by assessing the report and seminar presentations.

14. INDUSTRIAL LECTURE

Sl.No.	Course Code	Course Title	Credits
1.	MTIR17	Industrial Lecture	1
Total			1

A course based on industrial lectures shall be offered for 1 credit. A minimum of five lectures of two hours duration by industry experts will be arranged by the Department. The evaluation methodology, will in general, be based on quizzes at the end of each lecture.

15. COMPREHENSIVE VIVA

Sl.No.	Course Code	Course Title	Credits
1.	MTIR18	Comprehensive viva	1
Total			1

16. PROJECT WORK (OPTIONAL COURSE)

Sl.No.	Course Code	Course Title	Credits
1.	MTIR19	Project Work (Optional)	6
Total			6

17. NSS /NCC/ NSO

Sl.No.	Course Code	Course Title	Credits
1.	SWIR11	NSS / NCC/ NSO	0
Total			0

[$] The last two digits YY to be allotted by the Department.

Programme Core Courses

Sl. No.	Course Code	Course Title	Credits				Pre requisites	Credits
			L	T	P	C		
1.	MTPC11	Metallurgical Thermodynamics and Kinetics	3	1	0	4	Nil	4
2.	MTPC12	Physical Metallurgy	3	1	0	4	Nil	4
3.	MTPC13	Engineering Mechanics and Strength of Materials	3	0	0	3	Nil	3
4.	MTPC14	Transport Phenomena	3	0	0	3	Nil	3
5.	MTPC15	Mechanical Behaviour and Testing of Materials	3	0	0	3	Nil	3
6.	MTPC16	Polymers, Composites and Ceramics	3	0	0	3	Nil	3
7.	MTPC17	Iron Making and Steel Making	3	1	0	4	MTPC11, MTPC14	4
8.	MTPC18	Phase Transformation and Heat Treatment	3	0	0	3	MTPC12	3
9.	MTPC19	Material Characterization	3	0	0	3	MTPC12	3
10.	MTPC20	Metal Casting Technology	3	0	0	3	Nil	3
11.	MTPC21	Materials Joining Technology	3	0	0	3	Nil	3
12.	MTPC22	Metal Forming Technology	3	1	0	4	MTPC15	4
13.	MTPC23	Non-Ferrous Physical Metallurgy	3	0	0	3	MTPC12	3
14.	MTPC24	Electrical, Electronic and Magnetic Materials	3	0	0	3	Nil	3
15.	MTPC25	Corrosion and Surface Engineering	3	0	0	3	Nil	3
Total								**49**

Programme Elective Courses (PE)

Sl.No.	Course Code	Course Title	Prerequisites	Credits
1.	MTPE11	Mineral Processing and Metallurgical analysis	Nil	3
2.	MTPE12	Non-ferrous Extractive Metallurgy	Nil	3
3.	MTPE13	Manufacturing Processes	Nil	3
4.	MTPE14	Non-destructiveTesting	Nil	3
5.	MTPE15	Welding Metallurgy	MTPC21	3
6.	MTPE16	Materials for extreme environments	Nil	3
7.	MTPE17	Thermodynamics of Solidification	MTPC11, MTPC20	3
8	MTPE18	Design aspects of Welding and Casting	MTPC20, MTPC21	3
9.	MTPE19	Alloy Development	Nil	3
10.	MTPE20	Ceramic Materials	Nil	3
11.	MTPE21	Ceramic Processing	MTPC16	3
12.	MTPE22	High Temperature Materials	MTPC12	3
13.	MTPE23	Emerging Materials	Nil	3
14.	MTPE24	Automotive Materials	Nil	3
15.	MTPE25	Metallurgical Failure Analysis	Nil	3
16.	MTPE26	Biomaterials	Nil	3
17.	MTPE27	Stainless steels and Advanced Ferrous Alloys	Nil	3
18.	MTPE28	Special Steels and Cast Irons	MTPC18	3
19.	MTPE29	Economics of Metal Production Processes	MTPC17	3
20.	MTPE30	Special Casting Techniques	MTPC20	3
21.	MTPE31	Particulate Technology	Nil	3
22.	MTPE32	Special Topics in Metal Forming	MTPC22	3
23.	MTPE33	Additive Manufacturing	Nil	3
24.	MTPE34	Computational Materials Science	Nil	3
25.	MTPE35	Materials for New and Renewable Energy	Nil	3
26	MTPE36	Fatigue,Creep and Fracture Mechanics	MTPC15	3

27	MTPE37	Metallurgical Waste Management	Nil	3
28	MTPE38	Instrumentation and Control Engineering	Nil	3
29	MTPE39	Sustainable Materials	Nil	3
30	MTPE40	Integrated Computational Materials Engineering	Nil	3
31	MTPE41	Green Manufacturing	Nil	3

Open Elective Courses (Offered by Dept. of MME)

Sl.No.	Course Code	Course Title	Prerequisites	Credits
1.	MTOE11	Nanomaterials and Applications	Nil	3
2.	MTOE12	Mathematical Techniques in Materials Research	Nil	3
3.	MTOE13	Design and Selection of Materials	Nil	3
4.	MTOE14	New Product Development	Nil	3
5.	MTOE15	Introduction to Quality Management	Nil	3
6.	MTOE16	Surface Engineering	Nil	3
7.	MTOE17	Process Modelling and Applications	Nil	3
8.	MTOE18	Intellectual Property Rights	Nil	3
9.	MTOE19	Business and Entrepreneurship for Engineers	Nil	3
10.	MTOE20	History of Metals and Alloys	Nil	3
11.	MTOE21	Artificial Intelligence in Materials Engineering	Nil	3
12.	MTOE22	Materials in Indian Medicines	Nil	3
13.	MTOE23	Semiconductors Manufacturing	Nil	3

Essential Programme Laboratory Requirements (ELR)

Sl.No.	Course Code	Course Title	Pre-/Co-requisites	Credits
1.	MTLR30	Process Metallurgy Laboratory	Nil	2
2.	MTLR31	Polymers, Composites and Ceramics Laboratory	MTPC14	2

3.	MTLR32	Metallography and Heat Treatment Laboratory	MTPC15	2
4.	MTLR33	Materials Testing and Inspection Laboratory	MTPC17	2
5.	MTLR34	Foundry and Welding Laboratory	MTPC19, MTPC20	2
6.	MTLR35	Metal Forming and Particulate Processing Laboratory	MTPC21	2
7.	MTLR36	Non-Ferrous Metallography and Characterization Laboratory	MTPC22, MTPC23	2
8.	MTLR37	Corrosion and Surface Engineering Laboratory	MTPC24	2
Total				**16**

Minor Courses (MI)

Sl. No.	Course Code	Course Title	Prerequisites	Credits
1.	MTMI11	Materials Technology	Nil	3
2.	MTMI12	Fundamentals of Metallurgy	Nil	3
3.	MTMI13	Physical Metallurgy and Heat Treatment	Nil	3
4.	MTMI14	Deformation Processing	Nil	3
5.	MTMI15	Manufacturing Methods	Nil	3
6.	MTMI16	Testing and Evaluation of Materials	Nil	3
7.	MTMI17	Non-Metallic Materials	Nil	3

Advanced Level Courses for B.Tech. (Honours)

Sl.No.	Course Code	Course Title	Prerequisites	Credits
1.	MTHO11	Advanced Thermodynamics of Materials	MTPC11	4
2.	MTHO12	Crystallography	MTPC12	3
3.	MTHO13	Aerospace Materials	Nil	4

4.	MTHO14	Ladle Metallurgy and Continuous Casting of steels	MTPC17	4
5.	MTHO15	Recent Trends in Nano materials	Nil	4
6.	MTHO16	Advanced Solidification Processing	MTPC20	3
7.	MTHO17	Recent Developments in Welding Processes	MTPC21	3
8.	MTHO18	Recent Developments in Forming Processes	MTPC22	4
9.	MTHO19	Atomic Scale Modeling of Materials	Nil	3
10.	MTHO20	Metallurgy of Intermetallic Materials	Nil	4
11.	MTHO21	Phasefield Modelling	Nil	4

No.	**Programme Educational Objectives (PEO)**
I.	Choose their careers as practicing Metallurgical and Materials Engineers in traditional Metallurgical and Materials industries as well as in expanding areas of materials, environmental and energy-related industries.
II.	Engage in post-baccalaureate study and make timely progress toward an advanced degree in Metallurgical and Materials Engineering or a related technical discipline or business.
III.	Function effectively in the complex modern work environment with the ability to assume professional leadership roles.

No.	**Programme Outcomes (PO)**
PO1	**Engineering Knowledge:** Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2	**Problem Analysis:** Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3	**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.
PO4	**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.

PO5	**Modern Tool Usage:** Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6	**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.
PO7	**Environment and Sustain ability:** Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8	**Ethics:** Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9	**Individual and Team Work:** Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10	**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.
PO11	**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.
PO12	**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.

Course Code	:	HSIR11
Course Title	:	English for Communication (Theory & Lab)
Number of Credits		2 + 2

LTPC Breakup	:	L	T	P	Contact hours	C
		2	0	2	4	4

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

The primary objective is to develop in the under-graduate students of engineering a level of competence in English required for independent and effective communication for academic and social needs.

Course Content

Theory

Language and communication-reading strategies: skimming, scanning, inferring, predicting and responding to content – Guessing from context – Note making – Vocabulary extension - speed reading practice – use of extensive reading texts.

Analytical and critical reading practice- critical, creative and lateral thinking- language and thinking – thinking process and language development.

Effective writing practice – Vocabulary expansion - Effective sentences: role of acceptability, appropriateness, brevity & clarity in writing – Cohesion & coherence in writing –Writing of definitions, descriptions - Paragraph writing.

Reciprocal relationship between reading and writing –thinking and writing - Argument Writing practice – Perspectives in writing –professional writing - Narrative writing.

Lab

Listening process & practice – Exposure to recorded & structured talks, class room lectures – Problems in comprehension & retention – Note-taking practice – Listening tests- Importance of listening in the corporate world.

Barriers to listening: Physical & psychological – Steps to overcome them – Purposive listening practice – Active listening and anticipating the speaker – Use of technology to improve the skill.

Fluency & accuracy in speech –Improving self-expression – Tonal variations – Listener oriented speaking -Group discussion practice – Interpersonal Conversation -Developing persuasive speaking skills.

Barriers to speaking – Building self-confidence & fluency – Conversation practice- Improving responding capacity - Extempore speech practice – Speech assessment.

Reference Books

1	M. Ashraf Rizvi, *Effective Technical Communication*, Tata McGraw-Hill, New Delhi, 2005.
2	Strunk, William, and E B. White, *The Elements of Style*. Boston: Allyn and Bacon, Pearson Edition, 1999.
3	Garner, Bryan A, *HBR Guide to Better Business Writing*, Harvard Business Review Press, Boston, Massachusetts, 2013.

Course Outcomes

At the end of the course, students will be able to

CO1	Express themselves in a meaningful manner to different levels of people in their academic and social domains

Course Code	**:**	MAIR11
Course Title	**:**	Matrices and Calculus
Number of Credits		3

LTPC Breakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

Course Learning Objectives

- Introduce eigen value and eigen vectors and its properties.
- Determine canonical form of given quadratic form.
- Discuss the convergence of infinite series.
- Analyze and discuss the extrema of the functions of several variables.
- Evaluate the multiple integrals and apply in solving problems.
- Introduce vector differential operator for vector function and important theorems on vector functions to solve engineering problems

Course Content

Eigenvalues and eigenvectors; Diagonalization of matrices; Cayley-Hamilton Theorem. Quadratic form.
Sequence and series: Convergence of sequence. Infinite Series-Tests for Convergence-Integral test, comparison test, Ratio test, Root test, Raabe's test, Logarithmic test, and Leibnitz's test; Power series.
Functions of two variables: Limit, continuity and partial derivatives; Total derivative, Jacobian, Taylor series, Maxima, minima and saddle points; Method of Lagrange multipliers; Double and triple integrals, change of variables, multiple integral in cylindrical and spherical coordinates.
Gradient, divergence and curl; Line and surface integrals; Green's theorem, Stokes theorem and Gauss divergence theorem (without proofs).

Reference Books

1	Dennis Zill, Warren S. Wright, Michael R. Cullen, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2011
2	Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, 2019.
3	Jerrold E. Marsden, Anthony Tromba, *Vector Calculus*, W. H. Freeman, 2003
4	Strauss M.J, G.L. Bradley and K.J. Smith, *Multivariable calculus*, Prentice Hall, 2002.
5	Ward Cheney, David Kincaid, *Linear Algebra: Theory and Applications*, Jones & Bartlett Publishers, 2012.

Course Outcomes

At the end of the course, students will be able to

CO1	Compute eigenvalues and eigenvectors of the given matrix.
CO2	Transform given quadratic form into canonical form.
CO3	Discuss the convergence of infinite series by applying various test.
CO4	Compute partial derivatives of function of several variables
CO5	Write taylor's series for functions with two variables.
CO6	Evaluate multiple integral and its applications in finding area, volume.
CO7	Compute the dot product of vectors, lengths of vectors, and angles between vectors.

CO8	Perform gradient, div, curl operator on vector functions and give physical interpretations.

Course Code	:	CHIR11					
Course Title	:	Chemistry					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course code)	:	Nil					
Course Type	:	GIR					

Course Learning Objectives

To introduce the student's basic principles of Electrochemistry and Corrosion. They will be familiar with phase rule & its applications. Students will know about the essential requirements of water and its importance in day-to-day life. To provide students with a brief outline of the types and applications of polymers. Finally, students will be equipped with the usage of spectroscopy in industrial applications.

Course Content

Electrochemistry and Corrosion

Cell EMF- its measurement and applications - concentration cell - electrode electrolyte concentration cell - concentration cell with and without transference - Dry corrosion and wet corrosion, mechanisms, types of corrosion, Differential metal corrosion, differential aeration corrosion, intergranular, Passivity, Pitting, Polarization - Chemical conversion coatings and organic coatings- Paints, enamels.

Phase rule

Definition of terms – phase- components- degree of freedom- derivation of Gibbs phase rule – one component system – H_2O, CO_2, Sulfur – Two-component system – Eutectic systems – reduced phase rule - Pb-Ag system – Compound Formation with congruent melting – Zn- Mg Alloy system- Copper-nickel alloy system - systems with incongruent melting – Na_2SO_4- H_2O system and simple three-component systems.

Water

Sources, Hard & soft water, Estimation of hardness by EDTA method, Scale & Sludge- Caustic embrittlement - softening of water, zeolite process & demineralization by ion exchangers, boiler feed water, internal treatment methods-specifications for drinking water, BIS & WHO standards, treatment of water for domestic use, desalination - Reverse osmosis & Electrodialysis.

Spectroscopy

Interaction of electromagnetic radiation with matter, Electronic spectroscopy - Theory of electronic transitions, instrumentation, Beers Lambert law, Woodward FIESER rule, applications. IR spectroscopy - Fundamentals, Instrumentation, and applications, Raman spectroscopy – Fundamentals and applications.

Polymers and Composites

Concept of macromolecules- Tacticity- Classification of Polymers- Types of PolymerizationMechanism- - Ziegler Natta Polymerization - Effect of Polymer structure on properties - important addition and condensation polymers –synthesis and properties – Molecular mass determination of polymers- Static and dynamic methods, Light scattering- Rubbers – Vulcanization – Synthetic rubbers – Conducting polymers- Composite materials

Reference Books

1	P.C. Jain, M. Jain, *Engineering Chemistry*, Dhanpat Rai Publishing Company, New Delhi, 2005.
2	P. Atkins, J.D. Paula, *Physical Chemistry*, Oxford University Press, 2002.

3	B.R. Puri, L.R. Sharma, M.S. Pathania, *Principles of Physical Chemistry*, Vishal Publishing Company, 2008
4	F.W. Billmayer, *Textbook of Polymer Science*, 3rd Edison, Wiley. N.Y. 1991.
5	S.S. Darer, S.S. Umare, *A Text Book of Engineering Chemistry*, S. Chand Publishing, 2011.

Course Outcomes	
At the end of the course, students will be able to	
CO1	Understand the principles of electrochemistry and corrosion
CO2	Explain the phase rule and appreciate the applications of phase rule
CO3	Students will be familiarized with the importance of polymer and its application in industries.
CO4	A brief introduction in the area of water, spectroscopy will be very useful for the students in future endeavour

Course Code	**:**	CHIR12
Course Title	**:**	Chemistry Lab
Number of Credits		2

LTPC Breakup	**:**	L	T	P	Contact hours	C
		0	0	2	2	2

Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

Course Learning Objectives

The chemistry laboratory course will consist of experiments illustrating the principles of chemistry relevant to the study of science and engineering.

Course Content

1. Estimation of carbonate, non-carbonate and total hardness in the given water sample.
2. Estimation of dissolved oxygen in the given water sample.
3. Determination of the percentage of Fe in the given steel sample.
4. Estimation of Fe3+ by spectrophotometer.
5. Corrosion rate by polarization technique
6. Conductometric titration
7. Potentiometric titration
8. pH-metric titration
9. Percentage purity of bleaching powder
10. Determination of molecular weight of the polymer by Viscometry
11. Study of three component system.
12. Demonstration experiments using Advanced Spectroscopic Techniques, (UV-Vis, FTIR, Raman)

Reference Books

1	Laboratory Manual, Department of Chemistry, National Institute of Technology, Tiruchirappalli.
2	S.K. Bhasin, S. Rani, *Laboratory Manual on Engineering Chemistry*, Dhanpat Rai Publishing Company, New Delhi, 2011

Course Outcomes

CO1	The students will learn how to estimate various components from the corresponding bulk

Course Code	:	MTIR15
Course Title	:	Introduction to Metallurgical and Materials Engineering
Number of Credits		2
LTPC Breakup	:	L: 2, T: 0, P: 0, Contact hours: 2, C: 2
Prerequisites (Course code)	:	
Course Type	:	GIR

Course Learning Objectives

To develop an understanding of the basic knowledge of Metallurgical and Materials Engineering and gain knowledge on overview of developments in the field of materials over periods ; to become familiar with the metals and materials industry.

Course Content

Historical perspective, scope of materials science and of materials engineering – Role of metals in civilization and in wars – rise and fall of emperors who conquered world- Metallurgy and materials of India – Damascus sword – Delhi iron Pillar etc.

Metals and Materials – Classification – Properties – Mechanical, electrical, thermal, magnetic, optical, decorative and its applications. Illustrative examples of practical uses of materials.

Modern materials – Bio and Nano materials.

Role of metals and materials in aerospace and telecommunication, Role of metals and materials in Indian medicines – Siddha, Ayurveda, etc.

Reference Books

1	Rajput R.K. "Engineering Materials and Metallurgy" S. Chand & Co., New Delhi. 2006
2	Transaction of Indian Institute of Metals, Special issue on Nonferrous materials – Heritage of India. Vol.59, No.6, 2006.
3	Pooler and F.J. Owens, Introduction to nano technology, Wiley student edition, 2003.
4	Sujata V Bhat, Bio Materials, Narosa Publishing House, New Delhi, 2004.
5	Ravisankar B and Angelo P.C., Periodic table of elements, Mahi Publications, 2019

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Define engineering materials technology and understand each stage of the materials cycle, material selection criteria			1,2
CO2	Understand the impact of Metallurgical and Materials Engineering solutions in a global, economic, environmental, and societal context			1,3,6
CO3	Become familiar with the science behind the development of metals and materials			1
CO4	Become familiar with current trends / developments and the prevailing industrial scenario in metals and materials			1,12

Course Code	:	EEIR11
Course Title	:	Basic Electrical and Electronics Engineering
Number of Credits		2

LTPC Breakup	:	L	T	P	Contact hours	C
		2	0	0	2	2

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

- This course aims to equip the students with a basic understanding of Electrical circuits and machines for specific types of applications.
- The course gives a comprehensive exposure to house wiring.
- This course also equips students with an ability to understand basics of analogue and digital electronics.

Course Content

DC & AC Circuits: Current, voltage, power, Kirchhoff's Laws - circuit elements R, L and C, phasor diagram, impedance, real and reactive power in single phase circuits.

DC & AC Machines: DC Motor, Induction motor, Synchronous motor, Synchronous generator and Transformers- construction, principle of operation, types and applications.

House wiring & safety: Single phase and three phase system – phase, neutral and earth, basic house wring - tools and components, different types of wiring – staircase, florescent lamp and ceiling fan, basic safety measures at home and industry.

Analog Electronics: semiconductor devices – p-n junction diode, Zener diode, BJT, operational amplifier – principle of operation and applications – Introduction to UPS.

Digital Electronics: Introduction to numbers systems, basic Boolean laws, reduction of Boolean expressions and implementation with logic gates.

Reference Books

1	Hughes revised by Mckenzie Smith with John Hilcy and Keith Brown, Electrical and Electronics Technology, 8th Edition, Pearson, 2012.
2	R.J. Smith, R.C. Dorf, Circuits Devices and Systems, 5th Edition, John Wiley and sons, 2001.
3	P. S. Dhogal, Basic Electrical Engineering – Vol. I & II, 42nd Reprint, McGraw Hill, 2012.
4	Malvino, A. P., Leach D. P. and Gowtham Sha, Digital Principles and Applications, 6th Edition, Tata McGraw Hill, 2007.
5	Vincent Del Toro, Electrical Engineering Fundamental, Prentice Hall India, 2002.

Course Outcomes

CO1	The students shall develop an intuitive understanding of the circuit analysis, basic concepts of electrical machines, house wiring and basics of electronics and be able to apply them in practical situation.

Course Code	:	MEIR12
Course Title	:	Engineering Graphics
Number of Credits		3

LTPC Breakup	:	L	T	P	Contact hours	C
		0	0	3	3	3

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

1. Irrespective of engineering discipline, it has become mandatory to know the basics of Engineering Graphics. The student is expected to possess the efficient drafting skill depending on the operational function in order to perform day to day activity.
2. Provide neat structure of industrial drawing.
3. Enables the knowledge about position of the component and its forms Interpretation of technical graphics assemblies.
4. Preparation of machine components and related parts

Course Content

Fundamentals Drawing standard - BIS, dimensioning, lettering, type of lines, scaling conventions.

Orthographic projection Introduction to orthographic projection, drawing orthographic views of objects from their isometric views - Orthographic projections of points lying in four quadrants.

Orthographic projection of lines parallel and inclined to one or both planes Orthographic projection of planes inclined to one or both planes. Projections of simple solids – axis perpendicular to HP, axis perpendicular to VP and axis inclined to one and both planes.

Sectioning of solids Section planes perpendicular to one plane and parallel or inclined to other plane.

Intersection of surfaces Intersection of cylinder & cylinder, intersection of cylinder & cone, and intersection of prisms.

Development of surfaces Development of prisms, pyramids and cylindrical & conical surfaces. Isometric and perspective projection Isometric projection and isometric views of different planes and simple solids, introduction to perspective projection.

Reference Books

1	Bhatt, N. D. and Panchal, V.M, Engineering Drawing, Charotar Publishing House, 2010.
2	Ken Morling, Geometric and Engineering Drawing, 3rd Edition, Elsevier, 2010
3	Jolhe, D. A., Engineering drawing, Tata McGraw Hill, 2008
4	Shah, M. B. and Rana, B. C., Engineering Drawing, Pearson Education, 2009
5	K.V. Natarajan, *A text book of Engineering Graphics*, Dhanalakshmi Publishers,

Course Outcomes

CO1	At the end of the course student will be able to visualize the engineering components. A number of chosen problems will be solved to illustrate the concepts clearly.

Course Code	:	MAIR21
Course Title	:	Complex Analysis and Differential Equations
Number of Credits		3

LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

The course presents

- An introduction to analytic functions and power series.
- Various Cauchy's theorems and its applications in evaluation of integral.
- Various approach to find general solution of the ordinary differential equations
- Laplace transform techniques to find solution of differential equations Partial differential equations and methods to find solution.

Course Content

Analytic functions; Cauchy-Riemann equations; Line integral, Cauchy's integral theorem and integral formula (without proof); Taylor's series and Laurent series; Residue theorem (without proof) and its applications.

Higher order linear differential equations with constant coefficients; Second order linear differential equations with variable coefficients; Method of variation of parameters; Cauchy Euler equation; Power series solutions; Legendre polynomials, Bessel functions of the first kind and their properties.

Laplace Transform of Standard functions, derivatives and integrals – Inverse Laplace transform – Convolution theorem – Periodic functions – Application to ordinary differential equation.

Formation of partial differential equations by eliminating arbitrary constants and functions – solution of first order partial differential equations – four standard types – Lagrange's equation. Method of separation of variables.

Reference Books

1	James Ward Brown, Ruel Vance Churchill, Complex Variables and Applications, McGraw-Hill Higher Education, 2004
2	Dennis Zill, Warren S. Wright, Michael R. Cullen, Advanced Engineering Mathematics, Jones & Bartlett Learning, 2011
3	Erwin Kreyszig, *Advanced Engineering Mathematics*, John Wiley & Sons, 2019.
4	William E. Boyce, Richard C. DiPrima, Douglas B. Meade, *Elementary Differential Equations and Boundary Value Problems*, Wiley, 2017.
5	Ian N. Sneddon, *Elements of Partial Differential Equations*, Courier Corporation, 2013

Course Outcomes

At the end of the course, students will be able to

CO1	Understand analytic functions discuss its properties
CO2	Obtain series representation of analytic functions
CO3	Evaluate various integrals by using Cauchy's residue theorem
CO4	Classify singularities and derive Laurent series expansion

CO5	Find the solutions of first and some higher order ordinary differential equations
CO6	Apply properties of special functions in discussion the solution of ODE.
CO7	Find Laplace transform of a given function and its inverse Laplace transform.
CO8	Find solution of first order partial differential equations

Course Code	**:**	PHIR11					
Course Title	**:**	Physics					
Number of Credits		3					
LTPC Breakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course code)	**:**	Nil					
Course Type	**:**	GIR					

Course Learning Objectives

- To introduce the notions of light matter interaction, fabrication of lasers, light propagation in waveguides, applications of lasers and optical fibers to engineering students.
- To comprehend and explain the concepts of matter waves, wave functions and its interpretation to understand the matter at atomic scale.
- To teach the fundamentals of nuclear forces, models and classification of matter.
- To impart knowledge about the basics of conductors, superconductors, nanomaterials and their applications in science, engineering and technology.

Course Content

Lasers: Introduction to Laser-characteristics of Lasers-spontaneous and stimulated emissions – Einstein's coefficients – population inversion and lasing action – laser systems: He-Ne Laser, semiconductor laser-applications.
Fiber Optics: Snell's law-optical fiber – principle and construction – acceptance cone - numerical aperture –types of fibers - fiber optic communication principle – fiber optic sensors.

Quantum Mechanics: Inadequacy of classical mechanics-black body radiation, photoelectric effect- wave and particle duality of radiation – de Broglie concept of matter waves – electron diffraction – Heisenberg's uncertainty principle – Schrodinger's wave equation – eigen values and eigen functions – superposition principle – interpretation of wave function – particle confined in one dimensional infinite square well potential.
Nuclear and Particle Physics: Nuclear properties and forces - Nuclear models - Shell model - Nuclear reaction - Radioactivity - types and half-life. Fundamental forces - Particle physics - classification of matter - quark model.
Physics of Advanced Materials: Conductors: classical free electron theory (Lorentz –Drude theory) – electrical conductivity. Superconductors: definition – Meissner effect – type I & II superconductors – BCS theory (qualitative). Nanomaterials: introduction and properties – synthesis – top-down and bottom-up approach – applications.

Reference Books

1	William T. Silfvast, Laser Fundamentals, 2nd Edition, Cambridge University press, New York, 2004.
2	D. Halliday, R. Resnick and J. Walker, Fundamentals of Physics, 6th Edition, John Wiley and Sons, New York, 2001.
3	Arthur Beiser, Concepts of Modern Physics, Tata McGraw-Hill, New Delhi, 2010.
4	R. Shankar, Fundamentals of Physics, Yale University Press, New Haven and London, 2014.
5	R. Shankar, Fundamentals of Physics II, Yale University Press, New Haven and London, 2016.
6	C.P. Poole and F.J. Owens, Introduction to Nanotechnology, Wiley, New Delhi, 2007.
7	Charles Kittel, Introduction to Solid State Physics, 8th Edition, John Wiley & Sons, NJ, USA, 2005.

Course Outcomes

At the end of the course, students will be able to

CO1	know principle, construction and working of lasers and their applications in various science and engineering.
CO2	explain light propagation in optical fibers, types and their applications.
CO3	experience and appreciate the behaviour of matter at atomic scale, and to impart knowledge in solving problems in modern science and engineering.
CO4	understand the role of nuclear and particle physics in applications like radioactivity and nuclear reactions.
CO5	recognize, choose and apply knowledge to develop materials for specific applications for common needs

Course Code	**:**	PHIR12
Course Title	**:**	Physics Lab
Number of Credits		2

LTPC Breakup	**:**	L	T	P	Contact hours	C
		0	0	2	2	2

Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

Course Learning Objectives

- To introduce the spirit of experiments to verify physics concepts such as reflection, refraction, diffraction and interference on light matter interaction.
- To perform experiments to estimate the materials properties and to check their suitability in science and engineering.
- To familiarize physics concepts and to design instruments and experimental set up for better and accurate measurements.
- To teach and apply knowledge to measure and verify the values of certain constants in physics.

Course Content

1. Determination of rigidity modulus of a metallic wire
2. Conversion of galvanometer into ammeter and voltmeter
3. Wavelength of laser using diffraction grating
4. Dispersive power of a prism – Spectrometer
5. Radius of curvature of lens-Newton's Rings
6. Numerical aperture of an optical fiber
7. Field along the axis of a Circular coil
8. Wavelength of white light – Spectrometer
9. Calibration of Voltmeter – Potentiometer
10. Thickness of a thin wire – Air Wedge
11. Specific rotation of a liquid – Half Shade Polarimeter
12. Photoelectric effect – Planck's constant

Reference Books

1	Physics Laboratory Manual, Department of Physics, National Institute of Technology Tiruchirappalli, 2018.
2	R.K. Shukla, Anchal Srivastava, Practical Physics, New age international, 2011.
3	C.L Arora, B.Sc. Practical Physics, S. Chand & Co., 2012.

Course Outcomes

At the end of the course, students will be able to

CO1	Know how to calibrate a galvanometer and convert it into a current and voltmeters.
CO2	To make experimental setup to verify certain physics concepts of wave and particle nature of light.
CO3	Understand the light propagation in fibers, light matter interaction and use of lasers in science and engineering.
CO4	Acquire knowledge, estimate and suggest materials for engineering applications.

Course Code	:	CSIR11
Course Title	:	Introduction to Computer Programming
Number of Credits		3

LTPC Breakup	:	L	T	P	Contact hours	C
		2	0	2	4	3

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

To learn the fundamentals of computers.
To learn the problem solving techniques using algorithms and procedures
To read, write and execute simple Python Programs
To learn and use Python data structures – lists, tuples and dictionaries

Course Content

Introduction to computers – Computer Organization – Characteristics – Hardware and Software – Modes of operation – Types of programming languages – Developing a program. Algorithms – Characteristics – Flowcharts.

Data types; variables, assignments; immutable variables; numerical types; arithmetic operators and expressions; comments; understanding error messages; Conditions, Boolean logic, logical operators; ranges; Control statements: if-else, loops (for, while); short-circuit (lazy) evaluation. Strings and text files; manipulating files and directories, OS and SYS modules; text files: reading/writing text and numbers from/to a file; creating and reading a formatted file (csv or tab separated). String manipulations: subscript operator, indexing, slicing a string; strings and number system: converting strings to numbers and vice versa. Binary, octal, hexadecimal numbers

Lists, tuples, and dictionaries; basic list operators, replacing, inserting, removing an element; searching and sorting lists; dictionary literals, adding and removing keys, accessing and replacing values; traversing dictionaries.

Design with functions: hiding redundancy, complexity; arguments and return values; formal vs actual arguments, named arguments- Program structure and design- Recursive functions – Introduction to classes and OOP.

List of Programs

1. Programs using sequential constructs
2. Programs using selection constructs
3. Programs using Iterative constructs
4. Programs using nested for loops
5. Programs using lists
6. Programs using tuples and dictionaries
7. Simple Python functions
8. File input and output
9. Sorting and searching programs
10. Recursion

Reference Books

1	Kenneth A. Lambert, Fundamentals of Python: First Programs, CENGAGE Learning, 2012.
2	Guido van Rossum and Fred L. Drake Jr, An Introduction to Python – Revised and updated for Python 3.2, Network Theory Ltd., 2011.
3	Thareja R, Python Programming using Problem Solving Approach, Oxford University Press, 2017
4	Allen B. Downey, Think Python: How to Think Like a Computer Scientist, 2nd edition, Updated for Python 3, Shroff/O'Reilly Publishers, 2016.

5	John V Guttag, *Introduction to Computation and Programming Using Python*, Revised and expanded Edition, MIT Press, 2013.
Course Outcomes	
At the end of the course, students will be able to	
CO1	Write algorithms for problems
CO2	Use syntax and semantics of Python programming language for problem solving
CO3	Code a given logic in Python language
CO4	Appreciate and apply appropriate Data structures available in Python language for solving problems

Course Code	:	CEIR11
Course Title	:	Basics of Civil Engineering
Number of Credits		2

LTPC Breakup	:	L	T	P	Contact hours	C
		2	0	0	2	2

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

- To give an overview of the fundamentals of the Civil Engineering fields to the students of all branches of Engineering.
- To realize the importance of the Civil Engineering Profession in fulfilling societal needs.

Course Content

Properties and uses of construction materials - stones, bricks, cement, concrete and steel.

Site selection for buildings - Component of building - Foundation- Shallow and deep foundations - Brick and stone masonry - Plastering - Lintels, beams and columns - Roofs.

Roads-Classification of Rural and urban Roads- Pavement Materials-Traffic signs and road Marking-Traffic Signals.

Surveying - Classification-Chain Survey-Ranging-Compass Survey-exhibition of different survey equipment.

Sources of Water - Dams- Water Supply-Quality of Water-Wastewater Treatment – Sea Water Intrusion – Recharge of Ground Water.

Reference Books

1	Punmia, B.C, Ashok Kumar Jain, Arun Kumar Jain, Basic Civil Engineering, Lakshmi Publishers, 2012.
2	Satheesh Gopi, Basic Civil Engineering, Pearson Publishers, 2009.
3	Rangwala, S.C, Building materials, Charotar Publishing House, Pvt. Limited, Edition 27, 2009.
4	Palanichamy,M.S, Basic Civil Engineering, Tata McGraw Hill, 2000.
5	Lecture notes prepared by Department of Civil Engineering, NITT.

Course Outcomes

At the end of the course, students will be able to

CO1	The students will gain knowledge on site selection, construction materials, components of buildings, roads and water resources
CO2	A basic appreciation of multidisciplinary approach when involved in Civil Related Projects.

Course Code	:	ENIR12
Course Title	:	Energy and Environmental Engineering
Number of Credits		2

LTPC Breakup	:	L	T	P	Contact hours	C
		2	0	0	2	2

Prerequisites (Course code)	:	Nil
Course Type	:	GIR

Course Learning Objectives

- To teach the principal renewable energy systems.
- To explore the environmental impact of various energy sources and also the effects of different types of pollutants.

Course Content

Present Energy resources in India and its sustainability - Different type of conventional Power Plant--Energy Demand Scenario in India-Advantage and Disadvantage of conventional Power Plants – Conventional vs Non-conventional power generation.
Basics of Solar Energy- Solar Thermal Energy- Solar Photovoltaic- Advantages and Disadvantages-Environmental impacts and safety.
Power and energy from wind turbines- India's wind energy potential- Types of wind turbines Offshore Wind energy- Environmental benefits and impacts.
Biomass Resources-Biomass conversion Technologies- Feedstock preprocessing and treatment methods- Bioenergy program in India-Environmental benefits and impacts.
Geothermal Energy resources –Ocean Thermal Energy Conversion – Tidal.
Air pollution- Sources, effects, control, air quality standards, air pollution act, air pollution measurement. Water Pollution-Sources and impacts, Soil Pollution-Sources and impacts, disposal of solid waste.
Greenhouse gases – effect, acid rain. Noise pollution. Pollution aspects of various power plants. Fossil fuels and impacts, Industrial and transport emissions- impacts.

Reference Books

1	Boyle G, Renewable energy: Power for a sustainable future. Oxford University press, 2004.
2	B H Khan, Nonconventional Energy Resources, The McGraw –Hill Second edition.
3	G. D. Rai, *Nonconventional energy sources*, Khanna Publishers, New Delhi, 2006.
4	Gilbert M. Masters, *Introduction to Environmental Engineering and Science*, 2nd *Edition, Prentice Hall, 2003.*
5	G Sargsyam, M Bhatia, S G Banerjee, K Raghunathan and R Soni, Unleashing the Potential of Renewable Energy in India, World bank report, Washington D.C, 2011.
6	Godfrey Boyle, Bob Everett and Janet Ramage, *Energy Systems and Sustainability: Power for a sustainable future.* Oxford University press, 2010.

Course Outcomes

CO1	Students will be introduced to the Principal renewable energy systems and explore the environmental impact of various energy sources and also the effects of different types of pollutants.

Course Code	**:**	PRIR11
Course Title	**:**	Engineering Practice
Number of Credits		2
LTPC Breakup	**:**	L: 0 | T: 0 | P: 2 | Contact hours: 2 | C: 2
Prerequisites (Course code)	**:**	Nil
Course Type	**:**	GIR

Course Learning Objectives

- To use hand tools and machinery in Carpentry, welding shop, Foundry, Fitting shop and Sheet Metal work.
- To manufacture engineering products or prototypes.

Course Content

Foundry: Mould preparation for Flange and Hand Wheel, Plastic moulding / Wax moulding.

Welding: Fabrication of Butt Joint and Fabrication of Lap Joint.

Carpentry: Wood sizing exercise in planning, marking, sawing, chiseling and grooving to make; Tee Through Halving Joint and Dovetail Scarf Joint.

Fitting: Preparation of joints, markings, cutting and filling for making; Semi-circle part with the given work piece, Dovetail part with the given work piece.

Sheet metal: Fabrication of Dust Pan and Fabrication of Corner Tray.

Reference Books

1	R.K. Rajput, Workshop Practice, Laxmi Publications (P) Limited, 2009.
2	Shashi Kant Yadav, Workshop Practice, Discovery Publishing House, New Delhi, 2006.

Course Outcomes

At the end of the course, students will be able to

CO1	Know to utilize hand tools and machineries in Carpentry, Welding shop, Foundry, Fitting shop and Sheet Metal work.
CO2	Produce simple engineering products or prototypes

CourseCode	**:**	MTPC11
CourseTitle	**:**	Metallurgical Thermodynamics and Kinetics
NumberofCredits		4

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	1	0	4	4

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	PC

CourseLearningObjectives

To learn the basic principles and concepts of thermodynamics, in terms of various laws pertinent to gaseous, liquids (solutions) and solid systems and their significance in various of metallurgical processes

CourseContent

Types of system, state of a system, state properties- First law of thermodynamics; heat ofreaction, heat of formation, standard heats, heat of transition; Hess's law of heat summation.

Second law, entropy of irreversible processes, combined statements of 1st and 2nd laws - Maxwell's relations, Clausius- Clapeyron equation, Trouton's rule, Gibb's - Helmholtz relations.

Third law of thermodynamics, relation between C_P and C_V,Nernst heat theorem, equilibrium constant, Van't Hoff equation, concept of fugacity, activity, mole fraction.

Thermodynamics of solutions, Gibb's Duhem equation, partial molar properties of mixing, concept of chemical potential, ideal solution, Raoult's law, Henry's law; nonideal solution, excess functions, regular solutions.

Sievert's law- residual gases in steel–properties and functions of slags, slag compositions, structure of molten slags, molecular theory, concept of basicity index, ionic theory; thermodynamics of slag- metal reactions.

Kinetics: First, Second and third order reactions, Arrhenius equation - activation energy, Determination of order of the reaction, rate constants and rate limiting steps. Numerical problems on the concepts mentioned in all the above units.

ReferenceBooks

1	*Tupkary R.H., 'Introduction to Metallurgical Thermodynamics', 1st Edition, TUPublishers,1995*
2	*Upadhyaya G.S., DubeR.K., 'Problems in Metallurgical Thermodynamics and Kinetics', 1st Edition, PergamonPress,1977*
3	*Ahindra Ghosh, 'Text book of Materials and Metallurgical Thermodynamics', PHI Learning,2002.*

CourseOutcomes

At the end of the course, students will be able to

CO1	Matter, energy, heat- Types of system, state function, first law of thermodynamics, its significance, standard heats of formation, laws of thermochemistry- Numerical examples.			1, 2
CO2	Nature and second law of thermodynamics-various statements, concept of entropy, Maxwell, Clausius-Clapeyron equations, Trouton's rule, Gibbs Helmholtz relation and their importance - Numerical examples.			1, 2
CO3	The need for third law of thermodynamics-statement and its relevance to perfectly pure crystalline substances - Numerical examples.			1, 2
CO4	Thermodynamics of solutions; Gibbs-Duhem relation-partial molar properties-chemical potential Raoult's law, Henry law, on-ideal solutions, excess functions and regular solutions-Numerical examples.			1, 2

CO5	Thermodynamics of gases in metals: Sievert's law and its significance, thermodynamics of slag –metal interactions – numerical examples.		4, 7	12
CO6	Kinetics: order of a reaction, rate constants and rate limiting steps –Numerical examples		4, 5	3, 6, 12

Course Code	:	MTPC12					
CourseTitle	:	Physical Metallurgy					
NumberofCredits		4					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	:	NIL					
CourseType	:	PC					

CourseLearningObjectives

Todevelopan understandingof thebasicprinciplesofphysicalmetallurgyandapplythoseprinciples to engineeringapplications.

CourseContent

Crystallography - co-ordinationnumber,effectivenumberof atoms,packingfactor,crystal system relevanttometals, indexingof crystalplanesanddirections incubic andhexagonalsystem, linear andplanar density,interplanar spacing.

Crystal imperfections anditstypes;pointdefects,dislocations- unitdislocation,partial dislocation, motion of dislocations,slipandtwincrystalorientation,conceptoftexture, grainandgrain boundaries,methodsof grainsize determination.

Self-diffusion, diffusion in alloy, diffusion mechanisms, activationenergy, lawsof diffusion- Fick's I law, II law,inter-diffusionandKirkendalleffect, typesof diffusionandexamplesof diffusion; problems basedondiffusion.

Solidsolutions anditstypes andintermediatephases- HumeRothery'srule- solidificationofmetals andalloys, coolingcurves,concepts of phase diagrams,coringandsegregationasappliedto variousbinarysystems, ternarysystems.

Thermodynamicpropertiesof binarymetallurgicalsystems,freeenergy- compositioncurvesand their relationtophasediagramsof differenttypes;ternaryphasediagram-Gibbs phasetriangle.

ReferenceBooks

1	*Reza Abbaschian, Reed Hill R.E.,'PhysicalMetallurgy Principles',4th Ed, Cengage Learning, 2008*
2	*R. Balasubramaniam, Callister's Material Science and Engineering: Indian Adaptation, 2nd Ed, John Wiley & Sons, 2009*
3	*Raghavan V., 'PhysicalMetallurgy- PrinciplesandPractice', PHI Learning Private Limited, 2015*
4	*Donald R. Askeland, Pradeep P. Fulay, Essentials of Materials Science and Engineering, Cengage Lerning, 2013*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandthegeometryandcrystallographyofcrystallinematerials; Identifyplanesanddirections in crystalsystems.	5	2,4,12	1

CO2	Recognize the nature of the crystal defects; estimate the grain size	5	2,4	1
CO3	Apply the concept of diffusion in designing heat treatment	5	2,4	1
CO4	Understand the concept of phase diagram in recognizing the phase changes during heating/cooling	5	2,4	1
CO5	Applythermodynamicconcepts inthe constructionofphasediagrams	5	2,4	1

CourseCode	:	MTPC13					
CourseTitle	:	Engineering Mechanics and Strength of Materials					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	NIL					
CourseType	:	PC					

CourseLearningObjectives

To enhance the knowledge in the area of rigid body mechanics. Determine the stresses, strains on various structural object, displacements in various structures and their components under the specific external loads such as axial load, bending, shear load as well as torsion.

CourseContent

Engineering Mechanics

Point force and distributed forces- Equivalent systems of Forces – Equilibrium of Rigid Bodies – Free body Diagram – Centroids and Center of Gravity. Dry Friction, Wedge Friction, Disk Friction (thrust bearing), Belt friction, Square of threaded screw, Journal bearings (Axle friction), Wheel friction, Rolling resistance, Moment of Inertia

Concurrent Forces in a Plane and its Equilibrium, Centroids of Composite Plane Figures, General Case of Forces in a Plane.

Moment of Inertia of Plane Figures, Parallel Axis Theorem, Polar M.I., Concept of Mass M.I.,

Strength of Materials:

Simple Stress and Strain, Stresses on Inclined Plane, Two-dimensional Stress Systems, Principal Stress and Principal Planes, Mohr's Circle.

Shearing Force and Bending Moment, Types of Loads, Types of Supports, S.F. and D.M. Diagrams for Cantilever and Simply Supported Beams under Concentrated Loads and under U.D.L.

Flexure formula, Bending Stresses on the above types of Beams and Circular Sections.

Torsion of Circular Shafts, Determination of Shear Stress.

ReferenceBooks

1	S. Timoshenko, Engineering Mechanics, Mc Graw Hill India, 2017
2	R.K. Bansal,Strength of Materials, Laxmi Publication, 3rd Edition, 2010
3	S. Ramamrutham, Strength of Materials, Dhanapat Rai, 2008.
4	Irving H.Shames, Engineering Mechanics – Statics and Dynamics, 4th Ed, Prentice Hall of India PVT.Ltd Eastern Economy Edition, 2005.

CourseOutcomes

At the end of the course, students will be able to

CO1	solve problems dealing with forces in plane or in space and equivalent forces systems
CO2	identify, analyse and solve problems related to rigid body mechanics involving friction.

CO3	Understand the different types of material behaviour such have elastic, plastic, ductile and brittle
CO4	Study the fundamental mechanics of solid deformable bodies.
CO5	Use the concept of moment of inertia of lamina for different shapes

CourseCode	**:**	MTPC14					
CourseTitle	**:**	Transport Phenomena					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PC					

CourseLearningObjectives

Tounderstandbasic conceptsrelatedtoheatflow,fluidflow, mass transfer, inthe contextofmetallurgical processes;tobecomefamiliar with themathematical treatmentandequations relatedtoabove transportphenomena;tocomprehendthe sciencebehind process modelling.

CourseContent

FluidFlow- Viscosity –differentialmassandmomentumbalances–overall momentumbalance–mechanicalenergybalance–applications

HeatTransfer –heatconductionequation– applications – steady and transient heat conduction. Two dimensional heat conduction

Convective heattransfer –conceptofheattransfer coefficient–forced and free convection; Radiation – view factor - radiative heatexchange between surfaces

Mass Transfer- Diffusion: Diffusivityingases,liquids,solids–convectivemass transfer–concept ofmass transfer coefficient

Dimensionlessanalysis–Rayleigh's method,Buckingham method–use of differential equations – similaritycriteria– applications inphysical modeling

ReferenceBooks

1	*A.K.Mohanty,"RateProcesses inMetallurgy",PH India Ltd.,2000*
2	*B.R.Bird,Stewart,Lightfoot,'Transport Phenomena',JohnWiley,New York, 1994*
3	*Poirier D.R. and Geiger G.H.,'Transport Phenomena in Materials Processing', Springer International Publishers, Switzerland, 2016*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Solve mass and energy balance calculations involved in fluid flow	12	4	1,2,3
CO2	Use the heat conduction equations in solving 1D and 2D heat transfer in real time situations	12	5	1,2,3
CO3	Differentiate the forced and free convection and perform calculations on convective and radiative heat transfer	5, 12	4	1,2,3

CO4	Understand the concepts of diffusion, diffusivity in different materials and mass transfer coefficient	12	4	1,2
CO5	Model any processes by converting actual (descriptive) processes into appropriate equations and then attempt to solve the same	11	5	3,4,12

CourseCode	:	MTPC15					
CourseTitle	:	Mechanical Behaviour and Testing of Materials					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	0	
Prerequisites(Coursecode)	:	MTPC12					
CourseType	:	PC					

CourseLearningObjectives

To knowthefundamental conceptsofmechanical behaviorofmaterials, various mechanical testing practicesandtoapplythemtodesignthematerials forvariousload-bearingstructural engineeringapplications.

CourseContent

Elastic andplasticdeformation, stress-strainrelationship;plasticdeformationofmetallic materials,Mohr'scircle,Yieldingcriterion- VonMisses, andmaximum-shear-stress/Trescayieldingcriterion, failurecriteriaundercombined stresses

Elementsoftheoryof plasticity,dislocationtheory,propertiesof dislocation,stressfields arounddislocations, elementarydislocationinteractions;applicationofdislocationtheoryto workhardeningand strengtheningmechanisms.

Engineeringstress-straincurve,true stress-straincurve,instabilityintension, stressdistribution atthe neck,ductilitymeasurement,effectofstrainrateandtemperatureonflowproperties, testingmachines,Tensilepropertiesof importantmaterials.

Introduction, Brinell,Vickers andRockwell hardness tests,Meyerhardness,analysisof indendationbyanindenter, relationshipbetweenhardnessandtheflowcurve,microhardness tests,hardnessconversion;hardnessatelevated temperatures. Introduction totorsion, torsional stressesfor largeplasticstrains, types of torsionfailurestorsiontestvs. tensiontest, hottorsiontesting.

Introduction to fatigue testing, practice and evaluation; fatigue crack growth; low cycle, high cycle fatigue; Introduction to creep; stress rupture testing; creep data extrapolation; fatigue-creep interactions; superplasticity.

ReferenceBooks

1	DieterG.E., 'MechanicalMetallurgy',3rdEdition,McGrawHill Publications,2004
2	Dowling NE, Mechanical Behaviour of Materials, 4th Ed, Pearson, 2013
3	Hull, D., Bacon, D.J., Introduction to Dislocations, 5th Ed., Butterworth-Heinemann, 2011
4	Suryanarayana, AVK., 'Testing ofMetallicMaterials',BS Publications, 2018

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the basics of elastic and plastic deformation behaviour of materials		2	1
CO2	Analyse the plasticity, dislocation and strengthening mechanisms		2	1

CO3	Understand and analyse the tensile behaviour of materials and correlating with microstructures		2	1
CO4	Understand and analyse various other mechanical testing practices		2	1
CO5	Understand fatigue and creep behaviour and evaluate & design materials for better creep and fatigue resistance	4	2,3	1

CourseCode	:	MTPC16					
CourseTitle	:	Polymers, Composites and Ceramics					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	Nil					
CourseType	:	PC					

CourseLearningObjectives

Todevelopthebasicknowledge ofmaterialsparticularly ceramics, polymersandcompositesotherthan conventionalmetalsandalloys toapplythemtoadvanceengineeringapplications

CourseContent

Introduction - as amaterial, classification,types ofpolymerization,mechanisms,statisticalapproach,catalystsinpolymerization,molecularweightdetermination, methods ofmolecular weightcharacterization

Plasticcompoundingof plasticsmechanical, thermal,optical,electricalproperties with referencetoimportantengineeringplastics- LDPE,HDPE,PVC, polyester,phenol formaldehyde,alkyds, cellulose,elastomers

Fabricationtechnologyandpolymerprocessing,mouldingpractices,extrusion;applicationof polymersandplasticfibers,elastomers,adhesives,bio-medical applications, fiberreinforced plastics,conductingpolymers

Introductiontoceramicmaterials;general propertiesof ceramics;andclassificationofceramic materials;Bondingandstructureofoxideandnon-oxideceramicmaterials;

Introductiontoceramicsprocessing;Structure–propertycorrelationin ceramicmaterials; Selectionof ceramicmaterials for differentapplications

ReferenceBooks

1	*BillmeyerF., 'Textbookof PolymerScience',3rd Ed., WileyInterscience, 2007*
2	*RichersonD.W., 'Modern Ceramic Engineering- Properties Processingand UseinDesign', 3rdedition, CRC press,2006*
3	*Carter, C. Barry, Norton, M.Grant,Ceramic Materials: Science andEngineering, 2ndEdition, Springer,2013*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Classify the various types of polymers and understand molecular weight determination methods.		2	1
CO2	Understand the mechanical, thermal, optical and electrical properties of various engineering plastics		3	1,2

CO3	Identify a suitable polymeric materials and its processing route for a given application	7	2,4	1,3
CO4	Understand the bonding and structural characteristics of ceramic materials		2	1
CO5	Select the appropriate ceramic materials and processing method for different applications.	5	3	1,2

CourseCode	**:**	MTLR11					
CourseTitle	**:**	Process Metallurgy Laboratory					
NumberofCredits		2					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		0	0	2	2	2	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	ELR					

CourseLearningObjectives

Tolearn abouttheproperties ofminerals;tobecomefamiliarwith equipment usedin mineral processing, bymeansofexperiments/demonstrationoflaboratoryscaleequipment

CourseContent

Listof experiments:

1. Determination of Flash and fire point
2. ViscosityMeasurement
3. Proximate analysis of coal
4. Determination of calorific value using BombColorimeter
5. Sieveanalysis and determinationof sizedistributionin sample
6. Estimation of screening efficiency
7. Sedimentationanddecantation
8. Jawcrusher
9. Demonstration of Froth floatation
10. Observationsofmineralsamples
11. Observations offurnaces and temperature calibration

Reference Books

1	Gupta O. P.,' Elementsof Fuels,Furnacesand Refractories',2nd Edition, KhannaPublishers,1990
2	Barry A. Wills, Tim Napier-Munn, Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, Elsevier Science & Technology, 2006
3	Process Metallurgy Laboratory Manual, NIT Tiruchirappalli, 2019.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Analyse the various properties of solid and liquid fuels		3	1,2,4
CO2	Perform sieve analysis to determine the particle size distribution of any given sample.		4	1,2
CO3	Understand the principle of settling velocity and sedimentation of solid particles in a vertical column of fluid		3	1,2

CO4	Reduce the particles size using jaw crusher and determine the screening efficiency		4	1,2
CO5	Understand the working of different type of furnaces and the temperature calibration		4	1,2

CourseCode	:	MTLR12					
CourseTitle	:	Polymers, Composites and Ceramics Laboratory					
NumberofCredits		2					
LTPCBreakup	:	L	T	P	Contact hours	C	
		0	0	2	3	2	
Corequisites(Coursecode)	:	MTPC14					
CourseType	:	ELR					

CourseLearningObjectives

To become familiar with the synthesis and various testing and characterization techniques used for polymer, composite and ceramic materials

CourseContent

1. Determination of molecular weight and density of polymers
2. Synthesis of polymer
3. Melt flow index of polymer
4. Environmental stress cracking resistance of polymer
5. Fabrication of polymer composites
6. Hardness of polymer/composite materials/ceramics
7. Tensile strength of the polymer composites
8. Flexural testing of polymer composites/ceramics
9. Impact strength of polymer composites
10. Synthesis of nanostructured ceramic particles
11. Fabrication of ceramic coatings on metals by plasma electrolytic oxidation
12. Structural parameters/ Functional groups analysis of ceramic materials
13. Band gap measurement of ceramic materials/coatings

ReferenceBooks

1	G.M. Swallowe, Mechanical Properties and Testing of Polymers: An A–Z Reference, Springer Netherlands, 1999
2	W. Grellmann, S. Seidler, Polymer Testing, Carl Hanser Verlag, Munich 2007
3	Polymers, composites and ceramics laboratory manual, NIT Tiruchirappalli, 2019.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Determine the molecular weight of the polymer materials		2	1,4
CO2	Synthesize and characterize different polymeric materials	9	3	1,2
CO3	Fabricate particulate/fiber reinforced polymer matrix composite materials	9	3	1,4
CO4	Test and characterize the mechanical properties of polymer and composite materials		2,4	1,3

CO5	Synthesize and characterize ceramic powders and coatings		2,3	1,4

CourseCode	:	MAIR44					
CourseTitle	:	Mathematics III					
Number ofCredits		4					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	:	MAIR21					
CourseType	:	GIR					

CourseLearningObjectives

This course
1. discuss various approach to find the solution of partial differential equations.
2. construct mathematical model and solution of some physical problem
3. introduce various numerical algorithm to find numerical solution of mathematical equation.
4. validate numerical solution through mathematical analysis.

CourseContent

Fourier series - Dirichlet's conditions - Half range Fourier cosine and sine series - Parseval's relation - Fourier series in complex form – Harmonic analysis.

Classification of second order linear partial differential equations; Method of separation of variables; Laplace equation; Solutions of one dimensional heat and wave equations -Fourier series solution.

Solution of systems of linear equations using LU decomposition, Gauss elimination and Gauss-Seidel methods; Lagrange and Newton's interpolations, Solution of polynomial and transcendental equations by Newton-Raphson method.

Numerical integration by trapezoidal rule, Simpson's rule and Gaussian quadrature rule; Numerical solutions of first order differential equations by Euler's method, Modified Euler's method and 4th order Runge-Kutta method.

ReferenceBooks

1	Grewal.B.S., Advanced Engineering Mathematics, Mercury Learning & Information, 2019
2	Erwin Kreyszig, Advanced Engineering Mathematics, John Wiley & Sons, 2019
3	Elliott Ward Cheney, David Ronald Kincaid, Numerical Mathematics and Computing, Brooks/Cole, Cengage Learning, 2013
4	K. Sankara Rao, Introduction to Partial Differential Equations, PHI Learning Pvt. Ltd., 2010

CourseOutcomes

At the end of the course, students will be able to

CO1	Write Fourier series for a given function
CO2	Form the partial differential equation for family of surfaces.
CO3	find solution of Laplace equation for various boundary conditions.
CO4	model vibration of an elastic string/membrane and find discuss solution of it.
CO5	model one dimensional heat equation and find analytic solution for some boundary condition
CO6	find the numerical solution of linear system of equations $AX = b$
CO7	find the roots of transcendental and polynomial equations
CO8	approximate the function and interpolate function and its derivatives

CO9	find single and double integral numerically
C010	find numerical solution of ordinary differential equation.

Course Code	:	MTPC17					
CourseTitle	:	Iron Making and Steel Making					
NumberofCredits		4					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	:	MTPC11,MTPC14					
CourseType	:	PC					

CourseLearningObjectives

Toknowtheimportance oftheIronandSteelmakingandtoapplythemfortheadvancement ofthe productionfeasibilities in steel Industriestocompetewith themodern-daymanufacturingroutes.

CourseContent

Classificationoffurnaces;differentkinds offurnaces; heatbalance,energyconservationandenergy audit;parts,constructionanddesignaspectsofblastfurnace,ancillaryequipment; blastfurnace instrumentation.

Blastfurnacereactions;Gruner's theorem,carbondeposition, thepartitioning of soluteelements between theIronandthe slag;reactionsin blast furnace;blastfurnaceslags;mass balanceandheat balance

Blast furnace(B/F)operations;B/F irregularities and remedial measures,B/Frefractoriesand causesof failure,moderntrends in (B/F) technology overviewofdirectreductionprocesses,electric smelting;productionofDRI(HBI/ Spongeiron)

Reviewoftraditional steel making;physical chemistryandthermodynamics;air/O_2 impurity interaction, slagmetal interaction, roleof slags in refining, continuouscasting;foamingslag; removal of S andP; de-oxidizers,alloying;

Open hearthF/C;Bessemerconverters;bottomblown and top blownprocesses;slag practicesand sequencing;LD, VD,AOD,andVOD;Ladlemetallurgy; electric arcfurnaceandDRIusage;energy, environmental andqualityconsiderations

ReferenceBooks

1	*Thupkary R.H, 'Introductionto Modern IronMaking', Khanna Publications, Delhi,2004*
2	*Tupkary R.H., 'Introductionto Modern SteelMaking', Khanna Publishers,2004*
3	*Gupta O. P.,' Elementsof Fuels,Furnace and Refractories',2nd Edition,KhannaPublishers,1990*
4	*BashforthG.R, 'Manufacture of Ironand Steel',Volume I- IV, AsiaPublications,1996*
5	*Ghosh A, Chatterjee A, IronMakingand SteelMaking:Theory andPractice,PHIEEE,2008.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Classifydifferentkinds offurnacesandtheirancillaryequipment'sused for Iron&Steelmaking		2	1
CO2	Analysevarious factors influencingqualityof theproductinblastfurnaceduringIron&Steel making		2,3	1,4
CO3	Analyze theirregularities andcauseof failuresin blastfurnaceandapplytheremedial measures for immediaterectification		4	1,3

CO4	Understand the physical chemistry and thermodynamics of iron and steel making		3	1,2
CO5	Compare thetraditional steel makingto modern daymanufacturingroutesfor the improvement ofquality	12	5	1

CourseCode	**:**	MTPC18					
CourseTitle	**:**	Phase Transformation and Heat Treatment					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC12					
CourseType	**:**	PC					

CourseLearningObjectives

To study the phase changes that occursduring both thermal and thermomechanical treatments.

CourseContent

Introductionandclassificationofphasetransformations.Diffusioninsolids:phenomenological approachandatomisticapproach.Nucleationandgrowth theories of vapourtoliquid,liquidto solid,andsolidtosolid transformations;homogeneousandheterogeneousstrainenergyeffect duringnucleation;interface-controlledgrowthanddiffusioncontrolledgrowth;overall transformationkinetics.

Principles ofsolidification,evolution ofmicrostructuresinpuremetalsandalloys.Precipitation fromsolidsolution:typesofprecipitationreactions, crystallographicdescriptionofprecipitates, precipitationsequenceandage hardening, spinoidaldecomposition.

Iron-carbonalloysystem:iron-carbondiagram,nucleationandgrowth ofpearlite,cooling of hypo-eutectoid,eutectoid, andhyper-eutectoidsteels,development of microstructuresincast irons.Heattreatment ofsteels:TTTandCCTdiagrams,bainitictransformation,martensitic transformation, hardenability, roleofalloyingelements in steels

Conventionalheattreatmentofsteels. Massivetransformation.Order-disordertransformation. Phasetransformationsin andheattreatmentofsomecommonnon-ferrousmetals andalloys

Types offurnaces and furnace atmospheres; quenching media; types of quenching, mechanism of quenching,quenching characteristics,choice of quenchants;surfacehardening ofsteels-carburizing,nitriding,carbonitridingandothers..Various thermo-mechanical treatments;Designingforheattreatment,defectsinheattreatedparts,causesforthedefects inheat-treatedparts andremedies

ReferenceBooks

1	Porter, D.A, Easterling, K.E., and Sherif, M.A., Phase transformations in metals and alloys, 3rd Ed, CRC press, 2017.
2	Reza Abbaschian, Robert E. Reed-Hill, Physical Metallurgy Principles, Cengage Learning, 2008
3	LakhtinY.,'EngineeringPhysical Metallurgy',2ndEdition, University Press of the Pacific,2000
4	PrabhuDevK. H., 'Handbookof HeatTreatmentofSteel', McGraw Hill Education,2003

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the liquid –Solid transformational with respect to their nucleation and growth phenomena	8,11	43,	1,2
CO2	Study the kinetics and mechanism of solid-solid phase transformation and understand the structure –property relation	8	3	1,3

CO3	Comprehensive understanding on Fe-Fe_3C Phase diagram and Time –Temperature –Transformation diagram and study their structural transformation with varying temperature	6	2,4	1,2,3
CO4	Know the different heat treatment processes and understand their industrial practice and applications	9	7	1,5
CO5	Demonstrate the various surface thermal and chemical processing; thermo-mechanical treatment and understand the heat treatment issues and remedial measures	9	5	7

CourseCode	**:**	MTPC19					
CourseTitle	**:**	Material Characterization					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	Nil					
CourseType	**:**	PC					

CourseLearningObjectives

To familiarize the various microscopic, spectroscopic, x-ray diffraction and thermal analysis techniques used for material characterization.

CourseContent

Specimen preparationtechniquesforopticalmicroscopy, Principlesofopticalmicroscopy,brightanddark field illumination,polarized andinterference contrastmicroscopy;quantitativemetallography.
Interactionof electronbeamwithmaterials;transmissionelectronmicroscopy-brightanddark fieldimaginganddiffractiontechniques;specimen preparationforTEM;applicationsof TEM;
Scanningelectronmicroscopy–constructionand workingof SEM,variousimagingtechniques, applications;EDSand WDS, EPMA.
X-raydiffraction - constructionandoperationofdiffractometer,anddiffractionpattern;usesof diffractionpatternin powdermethod- identificationofcrystalstructure,estimationof relative amount ofphases,order- disordertransformation, determinationof solvusline,estimationof crystallitesizeandstrain;residual stressmeasurement.
Introduction to spectroscopic techniques: Optical emission spectroscopy (OES), ICP-OES, atomic absorption spectroscopy (AAS), UV-Vis, FTIR, Raman spectroscopy, Introduction to XPS, XRF.
Introduction to thermal analytical techniques and other characterization techniques: Differentialthermal analysis (DTA), differentialscanningcalorimetry(DSC)andthermogravimetricanalysis(TGA); Scanning probe microscopy - Atomic force microscopy (AFM), scanning tunnelling microscope (STM), Field ion microscopy

ReferenceBooks

1	B.D. Cullity, S.R. Stock, Elements of X-ray Diffraction, 3rd Ed, Pearson, 2001
2	P.J. Goodhew, J. Humphreys, R. Beanland, Electron Microscopy and Analysis, 3rd Ed, Taylor & Francis, New York, 2001.
3	Vander Voort, G.F., Metallography: Principle and practice, ASM International, 1999.
4	P.C. Angelo, Material Characterization, 1st Ed, Cengage learning, 2016.
5	Leng, Y., Materials Characterization: Introduction to Microscopic and Spectroscopic Methods, John Wiley & Sons (Asia) Pte Ltd, Singapore, 2008

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Explain the principles of optical microscopy and perform quantitative analysis of microstructures		3	1,2

CO2	Prepare samples and analyse microstructure using scanning and transmission electron microscopes.	12	1	2,3,4
CO3	Demonstrate the various application the x-ray diffraction techniques for material characterization		3,4	1,2
CO4	Understand working principles of various spectroscopic techniques		5	1,2
CO5	Analyse and characterize the materials using different thermal analysis and scanning probe techniques		1,3	2, 4,5

CourseCode	**:**	MTLR13					
CourseTitle	**:**	Metallography and Heat Treatment Laboratory					
NumberofCredits		2					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co-requisites(Coursecode)	**:**	MTPC17					
CourseType	**:**	ELR					

CourseLearningObjectives

- To learn and to gain experience in the preparation of metallographic specimens.
- To examine and analyse the microstructures of carbons steels, alloy steels, cast irons and other ferrous materials.
- To understand the basic principles of optical microscopy to measure the grain size of materials

CourseContent

1. Specimen preparation for metallographic observation -working of metallurgical microscope, Grain size measurements
2. Microstructure cast iron -gray, nodular and malleable iron –unetched & etched
3. Microstructure of gray, nodular and white iron –etched
4. Microstructure of steels (Carbon steels & Alloy steels)
5. Microstructure of stainless steels and high speed steels
6. Conduct of different heat treatment processes such as annealing and normalising and study their microstructure
7. Perform the hardening and tempering and assess the hardening characteristics using hardness test
8. Heat treatment of non-ferrous alloys (Precipitation hardening) and understand the effect of parameters
9. Experiment on Jominey End Quench test
10. Heat treatment of various alloy steels and understand their microstructure

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the basic metallographic practices and know the microscopic facilities		2	1
CO2	Analyse the structural features of ferrous alloys: carbon steels, cast iron, alloy steels		2,3	1,4
CO3	Perform the various basic heat treatment processes and know their effect on structural transformation		2,3	1,4

CO4	Conduct the precipitation hardening heat treatment and correlate structure-property		2	1,4
CO5	Learn the heat treatment practices for various speciality steel and understand their importance		2,3	1

CourseCode	:	MTLR14					
CourseTitle	:	Materials Testing and Inspection Laboratory					
NumberofCredits		2					
LTPCBreakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co-requisites(Coursecode)	:	MTPC18					
CourseType	:	ELR					

CourseLearningObjectives

To knowthe conceptsofmechanical testingandtoapplythemfor thedestructiveandnon-destructivetestingofvarious structuralengineeringapplications.

CourseContent

List of Experiments

1. TensiletestingusingUTM
2. TensiletestingusingHounsfieldtensometer
3. HardnesstestingusingBrinellandRockwellmethods
4. HardnesstestingusingVickersmethodandmicrohardnesstesting
5. Impacttestingofmetals–Izod/Charpy
6. Compressiontesting
7. Creep andtorsiontesting
8. Liquidpenetranttesting
9. Magneticparticletesting
10. Ultrasonictesting–Defectlocationand wearestimation

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Classify the different destructive and nondestructive testing methods with their inherent merits and limitations			1
CO2	Analyse the test sample by different destructive testing methods of testing	5	9	2
CO3	Differentiate between testing and inspection			1
CO4	Analyse the test sample by different nondestructive testing methods of testing	5	9	2

CO5	Conduct Investigations of engineering components	4		

Course Code	:	HSIR13					
Course Title	:	Industrial Economics and Foreign Trades					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course code)	:	Nil					
Course Type	:	GIR					

Course Learning Objectives

To provide a thorough understanding of the principles of economics that apply to the decisions of individuals and the application of those principles to the world around them and a framework for consistent reasoning about international flows of goods, factors of production, and financial assets, and trade policy.

Course Content

Demand Analysis and Forecasting: Cardinal Ordinal Approaches. Demand and Supply, Elasticties, Forecasting techniques, Consumer behaviour. Production, Cost, and Market structure: Variable proportions, Returns to Scale, Isoquants Analysis, Production Functiqn, Cost Curves, Cost Function, Market Analysis and game theory.

Types, Location, Efficiency and Finance: Mergers & Amalgamations, Location of Industries and Theories, Productivity and Capacity Utilization, Shares, Debentures, Bonds, Deposits, Loan etc. FDI, Foreign Institutional Investment, Euro Issues, GDR, ADR, External Commercial Borrowings.

Introduction: Features of International Trade. Inter-regional and international Trade. Problems of International Trade. Theories - Terms of Trade- Concept, Measurement, Types, Factors affecting Terms of Trade, Exchange rate.

Free Trade, Protection and Tariffs, Balance of Payments: Free Trade, Protection- Quotas, Dumping, etc. Balance of Trade and Balance of Payments.

Regional Economic Groupings and International Institutions: BRICS, EU, SAARC, OPEC, ASEAN. International Institutions: GAIT, WTO, UNCTAD, IBRD, IMF.

Reference Books

1	Dewett KK, "Modern Economic Theory", Chand & Coy, 1998.
2	Gupta C.B., "Business Organisation and Management", Chand.S & Coy, 1998.
3	Maheswari S. N., "An Introduction to Accountancy", Vikas publishing House Pvt. Ltd,1999.
4	Ramasamy VS, NamaKumari S., "Marketing Management", MacMillan India Pvt. Ltd, 1996.
5	Aswathappa K., "Organizational behavior", PHI India Pvt. Ltd, 1998.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Demand and supply analysis, the techniques of demand forecasting Cost analysis, the market structure and the production functions and its theories		2	1,11
CO2	Mergers & Amalgamations Location of theories and types and the efficient use of finance in Management		1	11
CO3	Features of International trade and difference between internal and international trade and the theories of international trade.		1	11

CO4	Free Trade, Protection- Quotas, Dumping. etc. Balance of Trade and Balance of Payments		1	11
CO5	Regional Economic Groupings and International Financial Institutions		1	11

CourseCode	:	MTPC20					
CourseTitle	:	Metal Casting Technology					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	NIL					
CourseType	:	PC					

CourseLearningObjectives

Toknowthebasicconceptsofmetalcastingtechnologyandtoapplythemtoproduceofnew materials

CourseContent

Introductiontocastingandfoundryindustry;basic principles ofcastingprocesses;sequencein foundryoperations;patterns;mouldingpractice;ingredientsofmouldingsandandcoresand,sand testing;differentmouldingprocesses

Typesof furnacesused infoundry;furnaces formelting;meltingpracticefor steel, castiron, aluminiumalloys, copperalloysandmagnesiumalloys;safetyconsiderations;fluxing, degassingand inoculation

Sandcasting, permanentmouldcasting,diecasting,centrifugal casting, plastermouldcasting, investment casting,continuous casting, squeezecasting, full mouldprocess,stripcasting

Overviewof pouringandsolidification, conceptofshrinkage, Chvorinov'srule,chilling;gating systems, functionsof riser,typesof riser,bottompouringandtoppouring, yieldcalculations, visualizationofmouldfilling(modeling),methoding

Concepts ofsolidification; directionalsolidification,role ofchilling;filtrationof liquidmetals; consumables;detailsofinoculationandmodification–with respecttocastironsandAl-Sisystem; castingdefects;soundnessof castinganditsassessment

ReferenceBooks

1	*HeineR.W.,LoperC.R.,RosenthalP.C.,'PrinciplesofMetalCasting', 2nd Edition,McGraw Hill Education, 2017*
2	*Jain P. L., 'Principlesof Foundry Technology',3rdEdition, Tata McGrawHill,1995*
3	*SrinivasanN.K., 'Foundry Technology', Khanna Publications,1986*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the sequence of foundry operations and testing of moulding and core sands		2,3	1
CO2	Classify different types of furnaces used for melting and choose theappropriatefurnacefor theproductionofnewmaterials		4	1,3

CO3	Distinguish different types of moulding processes and their advantages, disadvantages and applications.		3	1,2
CO4	Design a suitable riser system to avoid shrinkage problem during the casting process.		1,2	3,4
CO5	Alter themicrostructureof the cast materials for differentapplicationsby changing the solidification pattern.		5	3,4

CourseCode	**:**	MTPC21					
CourseTitle	**:**	Materials Joining Technology					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PC					

CourseLearningObjectives

To knowthe conceptsofdifferentmaterials joiningtechnologyand emphasisonunderlyingscience andengineeringprinciple of everyprocesses.

CourseContent

Classificationofweldingprocesses,arc physics, power sources,workingprinciple, advantages, limitationsof arcweldingprocesses –MMAW, GTAW,GMAW,SAW,ESW&EGW

Workingprinciple, advantagesandlimitationsof solidstateweldingprocesses.- Friction, frictionstir, explosive,diffusionandultrasonicwelding.

Workingprinciple, advantagesandlimitationsofpowerbeamprocesses: Plasmaarcwelding, electronbeam&laserbeamwelding.

Principlesofoperation, process characteristics,typesandapplications–Resistancewelding, Gas welding, brazing, solderingandjoiningofnon-metallicmaterials.

Weldingmetallurgy:Introduction,thermal cycles,prediction ofpeaktemperature,preheatand coolingrate,PWHT. Weldability ofcarbonsteel, stainlesssteel &aluminum. Hot&coldcracking phenomenon,welddefects, causesandtheir remedies

ReferenceBooks

1	*Parmer R.S., 'Welding processes",Khanna Publishers,1997*
2	*RobertWMessler,Jr."Principlesof welding,Processes, physics,chemistry and metallurgy", Wiley,2004.*
3	*LarryJeffus,"WeldingPrinciplesand Applications"Fifth edition, Thomson,2002*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Learntheworkingprinciple, meritsanddemerits of fusion welding processes	6, 7	3	1, 2, 9

CO2	Learntheworkingprinciple, meritsanddemerits of solid welding processes	6, 7	3	1, 2, 9
CO3	Understandtheworkingprinciple andimportanceofweldingallied processes	6, 7	3	1, 2, 9
CO4	Solve weldingheatflowrelatedproblems	5	2	1, 3, 4,
CO5	Learnweldabilityand weldingrelated problemsof differentmaterials	5, 6	3, 7, 12	1, 2, 4,

CourseCode	**:**	MTPC22
CourseTitle	**:**	Metal Forming Technology
NumberofCredits		4

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	1	0	4	4

Prerequisites(Coursecode)	**:**	MTPC18
CourseType	**:**	PC

CourseLearningObjectives

To knowthe conceptsofmetal formingandassociatetechnologiesandapplythemtothe conventionalandadvancedmaterialsmanufacturingforvariousstructuralapplications

CourseContent

Classificationofmetalformingprocesses,hot,coldandwarm working, flowcurve for materials,effectoftemperature,strainrateandmicrostructuralvariables;residual stresses,experimentaltechniques; yieldingtheories;processingmaps

Classificationofforgingprocesses, forgingequipment,forgingdefects,planestrainforging analysis,open dieforgingandclosedie forgingoperations, forcecalculations

Classificationofrollingprocesses, rollingmills,coldrolling, hot rolling, rollingofbars, billets andshapes,defects inrolledproducts, gauge controlsystems,processvariables inrolling

Typesofextrusion, processvariables, extrusiondefects, forcecalculation,wire,rod, andtube drawing, lubricationprocesses

Shearing, blanking, bending, stretchforming, deepdrawing, defectsinformedproducts, explosiveforming,electro-hydraulic andmagnetic formingprocesses, formabilitydiagrams

Severe Plastic Deformation techniques – Brief introduction

Powder Consolidation : Cold compaction – die compaction, powder rolling & extrusion, Powder injection moulding, high velocity compaction, Sintering methods

Hot Compaction – Vacuum hot pressing, spark plasma sintering, high velocity compaction

ReferenceBooks

1	DieterG.E,'Mechanical Metallurgy',3rdEdition,McGrawHill Education, Indian Edition,2017
2	HigginsR.A, 'EngineeringMetallurgy',VolumeII, ELBS, 1975
3	HarrisJ.N,'Mechanical Working ofMetals-Theoryand Practice',Pergamon Press,1983
4	Mahmood Aliofkhazraei (Editor) "Handbook of Mechanical Nanostructuring" Wiley-VCH Verlag GmbH & Co, Germany, 2015

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering applications			1
CO2	Differentiate the various bulk metal forming technology and choose the appropriate one for required engineering applications	5	2	1
CO3	Analyze various operational and materials parameters influencing the metal forming quality	3		1

CO4	Differentiate the various sheet metal forming technology and choose the appropriate one for required engineering applications	5	2	1
CO5	Acquire knowledge about powder consolidation techniques		3	1, 2, 4

Course Code	:	HSIR14					
CourseTitle	:	Professional Ethics (Non-Circuit)					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	Nil					
CourseType	:	GIR					

CourseLearningObjectives

Identifythecorevaluesthatshapetheethicalbehaviorofanengineer.Tocreateanawarenesson professional ethicsandHumanValuesandtoappreciate therightsofothers

CourseContent

Morals, Values and Ethics - Integrity - work Ethic - Service Learning - Civic Virtue - Respect for others - Living peacefully - Caring - Sharing - Honesty - Courage - Valuing time - Co-operation - Commitment - Empathy - Self-Confidence - Character - Spirituality - The role of engineers in modern society - social expectations.

Sense of 'Engineering Ethics' - Variety of moral issued - types of inquiry - moral dilemmas - moral autonomy - Kohlberg's theory - Gilligan's theory - Consensus and controversy - Models of Professional Roles & Professionalism - theories about right action - Self-interest - customs and religion - uses of ethical theories.

Engineering as experimentation - engineers as responsible experimenters - Research ethics -Codes of ethics - Industrial Standard - Balanced outlook on law - the challenger case study.

Safety and risk - assessment of safety and risk - Riysis - Risk benefit analysis and reducing risk - Govt. Regulator's approach to risks - the three mile island and Chernobyl case studies & Bhopal - Threat of Nuclear power, depletion of ozone, greenery effects - Collegiality and loyalty - respect for authority - collective bargaining - Confidentiality - conflicts of interest - occupation crime - professional rights - employees' rights - Intellectual Property rights (IPR) - discrimination.

Multinational corporations - Business ethics - Environmental ethics - computer ethics - Role in Technological Development - Weapons development engineers as managers - consulting engineers - engineers as expert witnesses and advisors - Honesty - leadership - sample code of conduct ethics like ASME, ASCE, IEEE, Institution of Engineers (India), Indian Institute of Materials Management Institution of electronics and telecommunication engineers (IETE), India, etc.,.

ReferenceBooks

1	Mika martin and Roland Scinger, 'Ethics in Engineering', Pearson Education/Prentice Hall, New York 1996.
2	Govindarajan M, Natarajan S, Senthil Kumar V.S, 'Engineering Ethics', Prentice Hall of India, New Delhi, 2004
3	Charles D. Fleddermann, 'Ethics in Engineering', Pearson Education/Prentice Hall, New Jerssy, 2004 (Indian Reprint)
4	Charles E Harris, Michael S. Protchard and Michael J Rabins, 'Engineering Ethics - Concept and Case', Wadsworth Thompson Learning, United States, 2000
5	'Concepts and Cases', Thompson Learning (2000)
6	John R Boatright, 'Ethics and Conduct of Business', Pearson Education, New Delhi, 2003.

7	Edmund G Seebauer and Robert L Barry, 'Fundamentals of Ethics for Scientists and Engineers', Oxford University of Press, Oxford, 2001.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understood the core values that shape the ethical behaviour of an engineer			8
CO2	Exposed awareness on professional ethics and human values.			8
CO3	Known their role in technological development			6,8

CourseCode	:	MTLR15
CourseTitle	:	Foundry and Welding Laboratory
NumberofCredits		2

LTPCBreakup :

L	T	P	Contact hours	C
0	0	2	2	2

Co-requisites(Coursecode)	:	MTPC20,MTPC21
CourseType	:	ELR

CourseLearningObjectives

To knowthe conceptsofsand casting and materials joiningtechnologyandtoapplythemforthe advancedmanufacturingprocessingforvariousengineeringapplications.

CourseContent

Listof Experiments

Foundry

1. Determination of permeability, shear strengthandcompressionstrengthofthe given foundrysand
2. Determination o f claycontentfor thegivenmouldingsandsampleandalsotostudy the variationofcompressionstrength forvariousmoisturecontents
3. Determinationofthe grainfinenessof thegiven foundrysand
4. Preparethemouldfor thegivenpattern with coreusingtwo boxes andthree-boxmoulding process
5. Determinationof flowabilityforthegiven foundrysand
6. Foundrymeltingpractice – demonstration

Welding

1. Arcstrikingpractice
2. Bead-on-platewelding
3. Effectofweldingparameters onweldbead
4. GTA welding(Demonstration)
5. Microstructuralobservationofweldments
   - Carbonsteel
   - Stainlesssteel
   - Aluminiumalloy
   - Titaniumalloy
   - Dissimilar joints

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Determine the properties of foundrysand		2,3	1,4
CO2	Understandthefoundrymeltingpractice		4	1,2,3

CO3	Developbasicweldingskills in manual arcweldingprocesses	9, 11	4	1,2,3
CO4	Analysis theweldmentmicrostructure	9, 11	4, 5	1,2,3
CO5	Analyze thevariousmetallurgical factors affectingmechanical propertiesof differentmetals andalloys	9, 11	4, 5	1,2,3

CourseCode	**:**	MTLR16
CourseTitle	**:**	Metal Forming and Particulate Processing Laboratory
NumberofCredits		2

LTPCBreakup :

L	T	P	Contact hours	C
0	0	2	2	2

Co-requisites(Coursecode)	**:**	MTPC22
CourseType	**:**	ELR

CourseLearningObjectives

To familiarize the calibration of load cells and LVDT
To perform simple metal forming and powder metallurgy experiments

CourseContent

1. Calibration of load cells
2. Calibration of LVDT
3. Upsetting / Forging of a cylinder
4. Rolling, extrusion
5. Cupping test
6. V- and U-Bending
7. Surface Strain prediction and Estimation of Forming Limit Curve
8. Powder characteristics such as metal powder size and shape, Apparent density and tap density, Flow rate
9. Compressibility of different powders and Green density of powder preform
10. Sintering (Conventional and Micro-wave) of powder preforms
11. Demonstration on Atomization
12. Demonstration of hot pressing (Vacuum hot pressing & Spark Plasma Sintering)

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Calibrate the load cells and LVDT		1,5	2,4
CO2	Perform forging, rolling, extrusion, bending and cupping test		1	2,4
CO3	Predict surface train and determine forming limit curve		1,3	2,4
CO4	Understand the powder characteristics by using standard procedure		4	1,2
CO5	Learn the density measurements and sintering procedures of various powder preforms		2	1

CourseCode	**:**	MTPC23					
CourseTitle	**:**	Non-Ferrous Physical Metallurgy					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC12					
CourseType	**:**	PC					

CourseLearningObjectives

Tocomprehendthe basicprinciples of non-ferrousmaterials andapplythoseprinciples todemandingengineeringapplications.

CourseContent

Aluminiumandits alloys;physical. chemicaland mechanical properties,classifications, heattreatable andnon-heat-treatabletypes– structuralfeaturescorrosionbehaviour;claddingandothermethods of corrosionprotection.

Titaniumanditsalloys;physical,chemical andmechanical propertiesoftitanium,effectofother elementson itsproperties, typesof titaniumalloys,microstructuralfeatures,propertiesand applications.

Magnesium and itsalloys;structure, propertiesandapplications ofmagnesiumandsomeits alloys;metallurgyofmagnesiumcastings; Copperanditsalloys,electricalconductivityasinfluenced byother elements,alloys for highconductivity.

Lead, tin,zinc,zirconium,other non-ferrousalloys, relevantphasediagrams andmicrostructural features,propertiesandapplications

Nickel and its alloys: physical, chemical and mechanical properties, microstructural features.Creep resistantmaterials, structure-propertyrelationship, hightemperature applications, superalloys, applications based onstructureandproperties,Intermetallics.

ReferenceBooks

1	*PolmearI.J.,LightAlloys:FromTraditional AlloystoNanocrystals,4th Edition, Butterworth-Heinemann, 2006*
2	*AlanRussell and, Kok LoongLee .,Structure-PropertyRelationsinNonferrousMetals, Wiley-Interscience,2005.*
3	*ASMHandbook: PropertiesandSelection:NonferrousAlloysandSpecial-PurposeMaterial,10th edition, ASMInternational,1990*
4	*JosephR. Davis,Alloying:Understandingthe Basics, ASMInternational, 2001*
5	*Angelo P C and Ravisankar B"Non Ferrous Alloys: Structures, Properties and Engineering Applications", Cengage publishers, 2018*

CourseOutcomes

At the end of the course, students will be able to	PO Correlation		
	Low	Medium	High

CO1	Understand the structure and properties of nonferrous metals and alloys			1
CO2	Identify the phases present in different alloy systems by analyzing the phase diagrams		2	1
CO3	Apply the basic principles of non-ferrous physical metallurgy for recommending materials for specific applications		3	1

Course Code	:	MTPC24					
CourseTitle	:	Electrical, Electronic and Magnetic Materials					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	Nil					
CourseType	:	PC					

CourseLearningObjectives

Tounderstandthebasic principles andphysicaloriginsofelectronic,magnetic&optical propertiesof materials andtostudy thevariousmaterialswhichexhibit thesefunctional properties

CourseContent

Free electrontheory- Bandtheory- discussiononspecificmaterialsused as conductors-Dielectric phenomena - conceptof polarization-frequencyandtemperaturedependence-dielectricloss-dielectricbreakdown-ferro electricity-piezoelectricityandpyroelectricity–$BaTiO_3$–structure and properties.
OriginofMagnetism-Introductiontodia, para, ferriandferromagnetism–Curietemperature–Magneticanisotropy- hardandsoftmagneticmaterials- iron based alloys-ferrites andgarnets– rareearth alloys-fineparticlemagnets.
Conceptofsuperconductivity–BCStheoryof superconductivity –Typesofsuperconductors–YBCO-structureandproperties –specificsuperconductingmaterials–Fabricationandengineering applications.
Semiconductingmaterialsandtypes;simple,compoundandoxidesemiconductors–semiconducting materials in devices–Productionof siliconstartingmaterials –methods for crystal growth forbulk single crystals-zonemelting–Czochralskimethod–Epitaxialfilms byVPE, MBEandMOCVD techniques–Lithography Principlesof photoconductivity,luminescence- - photodetectors–Opticaldiscandoptoelectronic materials–LCD, LEDanddiodelasermaterials-electrooptic modulators- Kerr and Pockel'seffect– $LiNbO_3$.

ReferenceBooks

1	*Electronic, Magnetic, and Optical Materials, Pradeep Fulay , Jung-Kun Lee, CRC press, 2016*
2	*Kittel C.,'Introduction to Solid StatePhysics',7thEdition, Wiley Eastern, NewInternational Publishers,2004*
3	*Ed.KasapandCapper,handbookof electronicandphotonicmaterials,2006,NY.*
4	*Dekker. A.J,Solid statePhysics, MacMillanIndia, 1995*
5	*VanVlackL.H, ElementsofMaterialsScience andEngineering,6thedition,AddisonWiley,1989*
6	*RaghavanV, MaterialsScience andEngineering–AFirstCourse, Prentice Hall India, 2004.*

CourseOutcomes

At the end of the course, students will be able to	PO Correlation		
	Low	Medium	High

CO1	Understand various electrical phenomenon such as band gap theory, ferro electricity, piezo electricity and pyro electricity along with dielectric behaviour of materials	5	3	1
CO2	To study various kinds of magnetism principles, various types of materials exhibiting magnetism and their day to day applications in industry with recent advancements	5	3	1
CO3	To study the theory of superconductivity phenomenon and superconducting materials and their applications along with recent advancements	2	3	1
CO4	Understand the fundamentals of semiconducting materials and operational principles of solid-state devices made of these semiconducting materials. To learn various methods of producing semiconductors and their processing methods used in the semiconducting materials industry.	3	2	1
CO5	To learn about photoconduction phenomenon, optical materials and various optical devices and their performances.	5	3	1

CourseCode	**:**	MTPC25					
CourseTitle	**:**	Corrosion and Surface Engineering					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PC					

CourseLearningObjectives

To acquire knowledge on principles, various forms, testing, monitoring and prevention of corrosion phenomenon.

CourseContent

Electrochemical and thermodynamic principles, Nernst equation and electrode potentials of metals, EMF and galvanic series, merits and demerits; origin of Pourbaix diagram and its importance to iron, aluminium and magnesium metals

Exchange current density, polarization- concentration, activation and resistance, Tafel equation; passivity, electrochemical behaviourof active/passive metals, Flade potential, theories of passivity

Atmospheric, pitting, dealloying, stress corrosion cracking, intergranular corrosion, corrosion fatigue, fretting corrosion and high temperature oxidation; causes and remedial measures

Purpose oftesting, laboratory, semi-plant and field tests, susceptibility tests for IGC, stress corrosion cracking and pitting, sequential procedure for laboratory and on-site corrosion investigations, corrosion auditing and corrosion map of IndiaCorrosion prevention by design improvements, anodic and cathodic protection, mechanical and chemical methods and various corrosion inhibitors
Corrosion prevention by coatings. metallic, non- metallic and inorganic coatings Conversion coatings – anodizing, chromizing, siliconizing, aluminizing, phosphating, boronizing. Electroplating, electroless plating, galvanizing, physical vapour deposition, chemical vapour deposition. Thermal spraying

ReferenceBooks

1	*Raj Narayan, 'An Introduction to Metallic Corrosion and itsPrevention',1stEdition, Oxford and IBH, 1983*
2	*Fontana M. G., Greene N.D., 'CorrosionEngineering',2nd Edition, McGrawHill,1983*
3	*Denny Jones, "Principles and Prevention of Corrosion", Prentice Hall of India,1996.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	basic principles related to thermodynamic feasibility of corrosion phenomenon in metals and alloys.			1, 2
CO2	basics of kinetics of electrochemical corrosion, relevant theories and equations.			1, 2
CO3	manifestations of corrosion phenomenon through their origin, mechanisms and remedies.			1, 2
CO4	origin and causes of high temperature oxidation through their kinetics, governing equations and remedies.			1, 2
CO5	Different methods of corrosion testing, susceptibility tests, corrosion auditing and map of India.		4, 7	1, 2
CO6	Various corrosion preventive methods through design, coatings, inhibitors, cathodic and anodic protection Industrial examples to highlight the above phenomena.		4, 5	3, 6, 12

CourseCode	**:**	MTLR17
CourseTitle	**:**	Non-Ferrous Metallography and Characterization Laboratory
NumberofCredits		2
LTPCBreakup	**:**	L: 0 | T: 0 | P: 2 | Contact hours: 2 | C: 2
Pre-/Co-requisites(Coursecode)	**:**	MTPC19, MTPC24
CourseType	**:**	ELR

CourseLearningObjectives

- Toevaluatethevariousmicrostructureofthenon-ferrousmetalsandalloysusingmicroscope andapplytheconceptstomaketailor made materialsforgivenengineeringdesignand applications.
- Todeveloptheknowledgeofheattreatmentandassociatedprocedureofvariousnon-ferrous engineeringmaterialsandapplythemtostudyhowitinfluencesthemicrostructureandresults indifferentmechanical behavior.

CourseContent

Listof Experiments

1. Electrochemicalpolishing/etchingformetallography
2. Microstructureof copperalloys
3. Microstructureof aluminiumalloys(as receivedandHeat-treatedconditions:Solutionizingand Ageing)
4. Microstructureof lead alloys
5. Microstructureofmagnesiumalloys(asreceived andHeat-treatedconditions:Solutionizingand Ageing)
6. Heat treatmentoftitaniumalloys
7. Microstructureof superalloys
8. Heattreatmentof superalloys
9. Stereographic projection
10. Indexing of x-ray diffraction pattern

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Differentiatevarietyofmicrostructureofnon- ferrousmaterials(Al, Mg, Tietc)usingmicroscope		1	2,3
CO2	Providethecomprehensivemetallographyprocedureforagivennon-ferrousmetaloralloy		1	2,3
CO3	Analyzethemicrostructureofthegivennon-ferrousmetaloralloyusingmicroscope		1	2,4
CO4	Classifydifferent heattreatedmicrostructureof non-ferrousmetals andalloys		1	2,3
CO5	Index the x-ray diffraction pattern of BCC and FCC materials and estimate lattice parameter.		1,5	2,4

CourseCode	**:**	**MTLR18**
CourseTitle	**:**	Corrosion and Surface Engineering Laboratory
NumberofCredits		2

LTPCBreakup :

L	T	P	Contact hours	C
0	0	2	2	2

Co-requisites(Coursecode)	**:**	MTPC25
CourseType	**:**	ELR

CourseLearningObjectives

To provide practical knowledge and hands on experience in experiments related to plating, various forms of corrosion and remedies through different coating methods thus covering broad spectrum of corrosion and surface engineering.

CourseContent

1. Copper electroplating, electroless plating, anodizing of aluminum, and corrosion rate determination by weight loss method (with and without inhibitor)
2. Corrosion rate by electrical resistance method, corrosion rate by potentiostaticpolarization experiment(a) Tafel method and (b) LPR method
3. Atmospheric/environmental corrosion (using colour indicator method)
4. Galvanic corrosion, pitting corrosion, stress corrosion cracking
5. IGC susceptibility tests for stainless steels, salt spray test, coating thickness measurement
6. Metallic coating on a substrate using wire-arc spray process
7. CERMET coating on a substrate using HVOF process
8. Testing of coated samples using salt-spray chamber

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Acquire hands on experience in conducting electroless plating of copper and anodizing of aluminium		7	1, 2
CO2	Familiarize with electrochemical and non-electro chemical methods for corrosion rate measurements		7	1, 2
CO3	To gain practical knowledge in conducting susceptibility tests for IGC and salt spray and their assessment		7	1, 2, 4
CO4	To perform coatings through thermal spray coating process and their assessment		7	1, 2, 4
CO5	From the above experiments to acquire comprehensive knowledge on industrial corrosion problem and contemplate possible remedial measures.		7	1, 2, 4, 12

CourseCode	**:**	**MTPE11**
CourseTitle	**:**	Mineral Processingand Metallurgical analysis
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	PE

CourseLearningObjectives

Theoreticalaspectsof commonmineralprocessingtechniquesandtheassociatedequipmentused in miningandpre-extractionpractices.

CourseContent

Principlesof combustion, testingoffuels,-Coal -Manufactureofmetallurgical cokeandits properties-typical energyconsumptioninmetallurgical processes, overviewof differentraw materials (includingfluxes)in metals processing

Physicalproperties ofminerals,physical andchemicalcharacteristics ofindustrialminerals such as magnetite,haematite,galena, chalcopyrite,azurite, sphalerite,monazite,cassiterite, chromite, bauxiteandilmenite

Mineral Processing: economicsoforeprocessing; Comminution – Principle, comminution theories, Crushing and grinding – equipment and working principle. Laboratory and industrial screening.

Classification: Principles of classification - settling velocity, Classifiers, hydrocyclones. Gravity concentration - Jigs and Tables, Heavy medium separation

Froth flotation-principles, types of reagents. Magnetic and electrical separation. Dewatering – thickening and filtering. Useof flowsheets (specificexamplesfrommetals processing),wet anddrysampling. Introduction to hydrometallurgy.

Principlesof chemical analysis-ores,metals, alloys, detailsofspecificchemical analysis techniques,introductiontocommonanalysistechniquesusedin metallurgicalindustries.

ReferenceBooks

1	Gupta O. P.,' Elementsof Fuels,Furnacesand Refractories',2nd Edition, KhannaPublishers,1990
2	GaudinA.M., 'PrinciplesofMineralDressing',1st Edition, TMH, 1986
3	Barry A. Wills, Tim Napier-Munn, Mineral Processing Technology: An Introduction to the Practical Aspects of Ore Treatment and Mineral Recovery, Elsevier Science & Technology, 2006
4	Vogel A.I., 'A TextBookofQuantitative InorganicAnalysis',3rd Edition,ELBS,Longman, 1978

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandtheprinciples of combustion and manufacturing of coke	7	12	1, 2
CO2	Describethephysicalandchemicalpropertiesofvarious minerals and ores	12	3	2
CO3	Explain the principles and applications of various size reduction techniques and screening methods	4	2	1, 3
CO4	Knowandunderstandthe various concentration techniques used in the mineral processing industries	6, 7	4	1, 3

CO5	Understand the commonanalysis techniquesusedin metallurgical industries	10	4	5, 12

CourseCode	**:**	**MTPE12**					
CourseTitle	**:**	Non-Ferrous Extractive Metallurgy					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPE11					
CourseType	**:**	PE					

CourseLearningObjectives

To understand the nature's resources in terms of minerals for non-ferrous metals available on the earth crust, familiarize with principles and extraction of the same and their significance to the mankind.

CourseContent

Principlesof pyrometallurgy, chemistry of roasting, drying and calcination; classificationof pyrometallurgical processes, useof Ellingham diagram in pyrometallurgy

Metallic oxide reduction by C, CO, hydrogen and metals; principles of metallothermic reduction and halide metallurgy; physicochemical principles of fused salt electrolysis

Principles of hydro metallurgy; properties of good solvent, leaching and precipitation, solvent extraction, ion exchange and pressure leaching gaseous reduction of aqueous solutions, bacterial leaching

Extraction schemes for copper, nickel, titanium, aluminium, magnesium, indium, gold and silver

Extraction of metals from secondary sources, energetics of non-ferrous extraction, extraction schemes of zinc, lead, zirconium and tantalum; prospects of non-ferrous industries in India

ReferenceBooks

1	*RayH. S.,SridharR.,AbrahamK.P, 'Extraction of Non-ferrous Metals', 1st Edition, Affiliated East WestPress,1987*
2	*Rosenquist T., 'PrinciplesofExtractiveMetallurgy',2nd EditionMcGrawHill,1983*
3	*Raghavan R., 'Extractive Metallurgy of Non-Ferrous Metals', Vijay Nicole Imprints, 2015.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Basic principles of pyrometallurgy, different types, Ellingham diagram and its significance			1, 2
CO2	Principles of metallothermic reduction, halide metallurgy and fused salt electrolysis			1, 2
CO3	Principles of hydrometallurgy, properties of good solvent leaching and precipitation			1, 2
CO4	Extraction schemes for Cu. Ni, Ti, Al, Mg, In, Au and Ag metals			1, 2

CO5	Principles and practice of extraction of secondary metals		4, 7	12
CO6	Energetics involved in extraction of non-ferrous metals and prospects of non-ferrous industries in India		4, 5	3, 6, 12

Course Code	:	MTPE13					
CourseTitle	:	Manufacturing Processes					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	NIL					
CourseType	:	PE					

CourseLearningObjectives

To know the fundamental concepts of various manufacturing processes and its applications and limitations with respect to industries.

CourseContent

Introduction to manufacturing processes – different approaches – technical and economic considerations – significance of material properties with respect to selection of manufacturing process

Conventional casting processes – advantages and limitations – melting practices – design of castings – special casting processes

Conventional material joining processes – concept of weldability – need for dissimilar joints - machining processes – concept of machinability – material examples – developments in machining processes

Rolling – forging – extrusion – drawing - sheet metal forming – classification, advantages and limitations

Introduction to powder metallurgy – recent developments esp. in forging and mechanical alloying - concept of near net shape processing - concept and applications of rapid prototyping – emerging technologies for nano – processing

ReferenceBooks

1	Rao, P.N, 'Manufacturing Technology—Foundry, Forming and Welding', 5th Edition, Tata McGraw Hill, 2018.
2	Kalpakjian, S. and Schmid, S.R., 'Manufacturing Engineering and Technology', 7th Edition, Pearson, 2014.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Know the selection of material and manufacturing process for particular application.			
CO2	Know the fundamental concepts of metal casting, melting techniques and its limitations			
CO3	Know the weldability and machinability concepts with respect to different materials and various welding and machining processes			

CO4	Know the concepts of various metal forming techniques and its applications and limitations regarding the manufacture of various			
CO5	Know the powder metallurgy concepts of powder production, sintering and nanomaterials processing techniques			

CourseCode	**:**	**MTPE14**					
CourseTitle	**:**	Non-destructiveTesting					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	0	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

To introduce the various non-destructive techniques for testing and inspection of materials to detect surface, sub-surface and internal defects produced during the fabrication process without destroying them.

CourseContent

Visual examination; Liquid penetrant inspection: Principle, applications, advantages and limitations, Dyes, developers and cleaners, Fluorescent penetrant test.
Magnetic particle inspection: Principles, applications, magnetisation methods, magnetic particles, Dry technique and Wet technique, demagnetization, Advantages and limitations.
Radiography-basicprinciple,electromagneticradiationsources, types and use of filters and screens, geometric factors, Inverse square law, films characteristics,Penetrameters, Exposure charts, Radiographic equivalence, radiographicimaging, inspection techniques,applications, limitationsandsafety. Fluoroscopy- Xero-Radiography. Industrial computed tomography (ICT).
Ultrasonic testing - Types of Ultrasonic waves, principles of wave propagation, characteristics of ultrasonic waves, Attenuation, couplants. Inspection methods - pulse echo, Transmission and resonance techniques, flawcharacterizationtechnique,immersiontesting, Thickness measurement. Types of scanning, Test block, IIW - reference blocks. Time of flight diffraction (TOFD), Phased array ultrasonic testing
Eddycurrent testing-principle,application,limitation; acoustic emission testing-principles, applications, merits and demerits; Leaktesting,HolographyandThermography-principles,proceduresandapplications,Comparison andselectionof NDTmethods;defectsincasting, forging, rollingand others. Introduction to ASNT codes and certification of NDT personnel.

ReferenceBooks

1	Barry Hull and Vernon John,Non Destructive Testing, ELBS / Macmillan, 2001.
2	Baldev Raj, Jayakumar T. Thavasimuthu M, Practical Non-Destructive testing, Narosa Publishing House, New Delhi, 1997.
3	Louis Cartz, Non-Destructive Testing, ASM International, Metals Park Ohio, US, 1995.
4	ASM Handbook, Vol.17: Nondestructive Evaluation and Quality Control, ASM International, Metals Park, Ohio, USA, 1992.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Perform liquid penetrant testing to identify the surface defects		1	2

CO2	Demonstrate suitability, merits and demerits of magnetic particle testing method for material characterization		3	1,2
CO3	Understand principles, inspections techniques and process variables in radiographic testing.		4	1,2,3
CO4	Choose an appropriate ultrasonic inspection and scanning method to detect the internal defects in the materials	5	4	2,3
CO5	Select a suitable non-destructive testing technique to identify the defect in the products.		4	3

CourseCode	**:**	**MTPE15**					
CourseTitle	**:**	WeldingMetallurgy					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC21					
CourseType	**:**	PE					

CourseLearningObjectives

- Togainunderstandingofheatflowandtemperaturedistributiononweldcomponentsbasedon weldgeometry
- Tounderstandthesolidificationstructureandgrowthmorphologyonweldjoinsinrelationtothe weldingparameters
- Studyphasetransformations in weldjointswith aidofCCT, SchafflerandDelongdiagrams
- Gain knowledge ofprocess, difficulties, and microstructures formed during welding of some specificalloys suchasCu, Al,TiandNialloysandtheremedial measuresto minimize oreliminate the occurrenceof weld defects.

CourseContent

Heat flow- temperaturedistribution-coolingrates-influence ofheatinput, jointgeometry, platethickness,preheat, significanceof thermalseveritynumber

Weldmetal solidification - Epitaxial growth -columnarstructuresandgrowthmorphology-effectof weldingparameters -Gas/metalandslag/metal reactions

Weldabilityof Carbon steels, lowalloysteels, weldingofstainlesssteels and castirons

WeldingofNon-ferrous alloys: Al,Ti, Mg andNialloys–processes, difficulties,microstructures, defects andremedial measures

Originof defects,-significance- remedialmeasures,Hotcracking -cold cracking -lamellartearing- reheatcracking - weldabilitytests-effect of metallurgical parameters.

ReferenceBooks

1	*SindoKou.,'WeldingMetallurgy', 2nd Edition, Wiley Interscience, 2002*
2	*GranjonH., 'Fundamentalsof Welding Metallurgy', JaicoPublishing House,1994*
3	*Kenneth Easterling,'Introduction to PhysicalMetallurgy ofWelding',2nd Edition, Butterworth Heinmann, 1992*
4	*SaferianD., 'The Metallurgy of Welding',Chapmanand Hall, 1985*
5	*JacksonM.D., 'Welding Methodsand Metallurgy',Grffin, London, 1967*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandtheinfluenceof heatinputandtemperaturedistributionacrossaweldedstructure based onweldgeometry and importance of preheating and PWHT.	10	4, 5,	1,2,3,
CO2	Learnthe solidificationconcepts of weld	12	4,5	1,2,3
CO3	Learnweldability ofvarious ferrous alloys	7, 12	4, 5	1,2,
CO4	Understand the weldability issues of non-ferrous materials.	7, 12	4, 5	1,2,
CO5	Identifytheoriginandtypes of various defects of welds and its susceptibility tests,	7,9,12	4, 5, 8	1,2,

CourseCode	**:**	**MTPE16**					
CourseTitle	**:**	Materials for extreme environments					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

Student shouldbecapableof understandvarious extremeenvironment conditions andchoose suitablematerials for variousconditions.

CourseContent

Fundamentalsof hightemperature deformation, creep- Mechanism-Deformation MechanismMaps - Superplasticity- Engineeringmaterials applied inextremeenvironments:structuralmaterials at hightemperaturessuchas gas turbineapplications

Introductionradiationresistancematerials;radiationdamage- halflifeperiod- irradiationdamage resistance- BCCstructuresandferriticgradesteels forradiationdamageresistanceapplications- Liquidsodiumstoragematerials in nuclearindustry-nuclear wastedisposal.

Spaceenvironment- anomalous behaviorofmaterialsin space-Engineeringmaterials applied in extremeenvironments:spacecraftmaterials - reusablespace vehicles-carbon-carboncomposites (CCC).

Understandinghighstrainratedeformation- Elasticwavepropagation-Materials underthermo-mechanicalextremes(static vsdynamic;high-pressurephases;shock;detonation;cavitation;super- cooled liquids andglasses)- Shockresistantmaterials- armor grademateriais.

Materials for cryogenicapplications-DBTT- FCC structures- Deformationbehavior incryogenic temperatures- cryorolling.

ReferenceBooks

1	G.E. Dieter,"MechanicalMetallurgy",McGrawHillPublishers, NY,2002
2	VincenzoSchettinoandRobertoBini, Materials UnderExtremeConditions, Imperial College Press,winter2012.

CourseOutcomes

At the end of the course, students will be able to	PO Correlation

		Low	Medium	High
CO1	Canunderstandthebehaviourof hightemperaturematerials		2	1
CO2	Capable ofassessingbehaviourof various irradiationdamageresistancematerials		3	1,2
CO3	Canunderstandthespaceenvironmentandchoosingmaterials for spaceapplications		2	1
CO4	Analysethehighstrainratedeformationbehaviourandcapable ofchoosingor fabricating materials		1	2,3
CO5	Capable ofunderstandingdeformationatcryogenic temperatures		2	1

CourseCode	:	**MTPE17**
CourseTitle	:	Thermodynamics of Solidification
NumberofCredits		3

LTPCBreakup	:	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	:	MTPC11, MTPC20
CourseType	:	PE

CourseLearningObjectives

- Astudyofimportantthermodynamicfunctionsrelatedtosolidificationofmetalinmolds involvingthecharacteristicsofliquid-solidphasetransformations,lawsofthermodynamics andotherfunctions.
- To analyze solidification processing ofengineering materialsintermsofthephase equilibrium,transport,and interfacephenomenagoverningmicrostructuredevelopmentin liquid-solidtransformations.

CourseContent

Introductionandimportantthermodynamicfunctions:Lawsof thermodynamics-enthalpy,heat capacity, applications of firstlaw to open and closed systems including chemical reactions; entropy, freeenergyandtheir interrelationships

Thermodynamics ofsolidification;Nucleationandgrowth; Puremetal solidification,Alloy Solidification,Constitutional undercooling, Mullins-Sekerka instability;Single phasesolidification: Cellularand Dendriticgrowth;Multiphase solidification:eutectic,peritecticandmonotectic; Modellingof solidification

Heterogeneoussystems–equilibriumconstants,Ellingham-Richardson diagrams, predominant areadiagrams,principlesoffreeenergy minimization;energybalanceof industrialsystems; solutions-chemical potential, Raoult/Henry's law, Gibbs-Duhemequations, regular solutions, quasi chemical theory

Evolution ofPhase diagrams -phase rule, free-energy-composition diagrams,solidus-liquidus lines,retrogradesolidus;determinationofactivityandother thermodynamicparametersfrom phasediagrams,;thermodynamic analysis of ternaryandmulti component systems, interaction parameters

Principles ofapplications-principlesofapplicationstomoltenslagsandsilicatemelts; electrochemical methodsandapplications,aqueoussystems;Interfaces-energy, shape, segregationatexternalandinternalinterfaces;solidelectrolytes;Effectofhigh-pressureon phasetransformations;Pointimperfections incrystallinesolids.

ReferenceBooks

1	Fleming, M.C.,Solidification Processing;McGraw-Hill,N.Y., 1974
2	Kurz, W. and Fisher, D.J., Fundamentals of Solidification by Trans-Tech Publications, Switzerland, 1989

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Recollect the thermodynamic principles relevant to solidification		2	1
CO2	Model solidification process of metals and alloys based on the knowledge gained on nucleation, growth, single phase and multi-phase solidification		4,5	2,3
CO3	Understand the thermodynamics of solutions, principles of free energy minimization and quasi chemical theory.			1,2
CO4	Analyse the binary, ternary and multicomponent phase diagrams to determine various thermodynamic parameters.		4	2,3

CO5	Demonstrate the importance of interface energy and shape on segregation.		3	1,2

CourseCode	**:**	**MTPE18**					
CourseTitle	**:**	Design aspects of Welding and Casting					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0		3	
Prerequisites(Coursecode)	**:**	MTPC20, MTPC21					
CourseType	**:**	PE					

CourseLearningObjectives

Toselecttheproperdesignforvariouscastingtechniquesandtominimizethedefects.Knowledgeof the variousweldingcodes used inindustryparlance.

CourseContent

Designingforeconomicalmoulding–designingforsandmoulding–investmentcastings.Designfor economicalcoring–generalrulesfordesigning cored holes.Designproblemsinvolving thin sections, uniformsectionsunequal sections.Consideringmetalflow,riserlocation,feedpath,mould-metal temperatureeffect.

Designproblems involvingjunctions,distortion–possibledesignremedies. Dimensional variations and tolerances–influence of cores–influenceoflocationofcores.Dimensionsforinspectionand machining. Surface finishISI specification, effect of mouldmaterial, parting line, fillet influences. Designof gatingandriseringfor ferrousandnon-ferrous metals

Types of joints,jointefficiency,edgepreparation,typesof loads,designfor staticlading,designfor cyclicloading,rigid structures,primaryandsecondarywelds,treatingaweldasaline,structural tubularconnections,influenceofspecifications ondesign,symbolsforweldingandinspection, estimatingandcontrol ofweldingcosts.Residualstresses, causesandeffects, methodsto measure residual stresses,welddistortion.

Boilerandpressurevesselcodes,structural weldingcodes,pipelinescodes.

Weldingproceduresspecifications,weldingprocedure qualifications,welderperformance qualifications,welding variables, filler metal qualifications, qualificationof weldinginspectors, weldingsupervisorsand weldingengineers,qualificationofNDTpersonnel.

ReferenceBooks

1	"*Casting.DesignHand Book",AmericanSocietyforMetals,1962*
2	*MatousekR.,"EngineringDesign".,BlackwellScientificPublications.,1962*
3	*Heine, Loperand Rosenthal, "Principlesof Metal Casting", TataMcGrawHillPublishing Co,1995.*
4	*HarryPeck,"Designing forManufacture",PitmanPublications,1983.*
5	*O.W. Blodgett, Design of weldments,* James F. Lincoln Arc Welding Foundation, 1963

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Selectthe appropriatedesignfor theparticularcasting process.		1	2,3
CO2	Minimizethedefectsbyproperselectionofcastingsystems		1	2,3

CO3	Select an appropriate joint design to reduce weld distortion and residual stresses.		1	2,3
CO4	Choose theappropriatecodesfortheproductionof pipelineandstructural materials		1	2,3
CO5	Categorizeweldingproceduresfordifferentapplications		1,10	2,3

CourseCode	**:**	**MTPE19**					
CourseTitle	**:**	Alloy Development					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0		3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

Tostudythefundamentals,classification,propertiesofapplicationsofvariousferrousandnon-ferroussystems.

CourseContent

MetalsvsAlloys;superiorityofalloysoverpureelementalmetals;strategiesforalloying;concepts suchasstrengtheningmechanisms.Thermodynamicsaspects of alloying;relationbetweenalloy composition,structureandproperties. ICMEapproachtoalloydesignanddevelopment.

Ferrous systems–Effect ofspecific alloyingelements;alloygradesof castirons, carbonsteels;role of heat treatment

Ferroussystems–Highlyalloyedsteels;specificexamples;Effectofalloying elements onphase transformations;development ofnovelgrades of steelssuchas maragingsteels,IFsteels,AHSsteels, PH steels,DPsteelsandDuplexstainless steels,roleofheattreatment

Non-FerroussystemsbasedonAluminium,Titanium andCopper;Typicalalloyingelementsandtheir effects;relevantphasediagrams;Input onheattreatment

Use ofalloying elementsforgrainrefinement;Inclusionengineering;conceptofODS alloys;special casessuchasHighEntropyAlloysandBulkmetallic glasses

ReferenceBooks

1	*Alloying: Understandingthe BasicsEdited byJosephR. Davis,ASMInternational*
2	PhaseTransformationsinMetalsandAlloys,ThirdEditionbyDavidA.Porter,KennethE. Easterling, *CRCPress*
3	*Bain, E.C.andPaxton, H.W.AlloyingElementsinSteels, ASM,MetalPark,Ohio*
4	*Lakhtin, Yu,M.,EngineeringPhysicalMetallurgyandHeat Treatment,MirPublishers,Moscow.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the strategies of alloying, effects of alloying and thermodynamics of alloying			1
CO2	Describe the carbon steels, cast iron and their grading, role of alloying elements and heat treatment			1,2

CO3	Choose a suitable alloying elements to develop a highly alloyed steels with specific properties		1	2
CO4	Develop a non-ferrous alloy systems with specific properties by adjusting the alloying elements		1	2
CO5	Understand the principle of formation of high entropy alloys and bulk metallic glasses.			1

CourseCode	**:**	**MTPE20**					
CourseTitle	**:**	Ceramic Materials					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

Tostudy thefundamentals(structure,propertiesandprocessing)ofceramicmaterials tounderstand its advantagesandlimitations andtoapply thosefundamentalsforselectinganddevelopingceramic materials for different engineeringapplications.

CourseContent

Ceramicsasaclassofengineeringmaterials;generalcharacteristicsof ceramics;classificationof ceramics;productionof ceramicpowders;bondingin ceramicMaterials,variations in propertiesas a functionof bonding;concept ofco-ordinationnumber, ratioofionicradii andcorrespondingcrystal structuresofoxides,silicates,other non-oxideceramics,theoretical densityofceramics, polymorphisminceramics.

Defectsincrystallineceramics,non-stoichiometry, Kgroger-Vinknotations, significanceof defectswith respecttoapplications;Glasses:types,structure,bridgingandnon-bridgingoxygen, significanceof oxygen tosiliconratio,commercialoxideglasses,devitrification;Introductiontoglass–ceramicsand temperingofglasses.

Introductiontoceramicsprocessing, densificationmethods, theoryof sintering, crystallineandnon-crystallinephasesinceramic microstructures;mechanical propertiesofceramicmaterials andtesting of ceramicmaterials;ToughеningMechanisms.

Electrical,magneticandoptical propertiesofimportantceramicsystems, correlationof properties with structure

Classificationofrefractories, characteristics ofrefractories.Productionofrefractories,propertiesand applicationsofvariousrefractories. Ceramicsforsensor applications, Introductiontobio-ceramicsand bio-glass.Applicationsofbioceramics.

ReferenceBooks

1	*RichersonD. W.,'Modern Ceramic Engineering– Properties, Processingand Usein Design',3rd edition, CRCpress,2006*
2	*Yet-MingChiang,Dunbar P. BirnieandW.DavidKingery,Physical Ceramics:Principlesfor CeramicScience andEngineeringJohnWiley&Sons,1996*
3	*Carter, C. Barry, Norton, M.Grant,Ceramic Materials:Science andEngineering, 2nd Ed, Springer,2013*

4	*KingeryW. D.,Bowen,H. K.and UlhmenD. R., 'Introduction to Ceramics',2nd E, JohnWiley, 1991*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Knowthestructureandpropertiesof different ceramic materials	5	3	1
CO2	Understandthephasediagrams andcomprehendthephasetransformationsin ceramic materials	5	3	1
CO3	Understandthetesting methods for evaluatingthe mechanical propertiesofceramicmaterials	5	3	1
CO4	Understandanddesigntheelectrical,magneticandoptical propertiesofceramicsystems	5	2,3	1
CO5	Selectceramicmaterialsandtodevelopnewceramicsfor different engineeringapplications	5	2,3	1

CourseCode	**:**	**MTPE21**
CourseTitle	**:**	Ceramic Processing
NumberofCredits		3

LTPCBreakup :

L	T	P	Contact hours	C
3	0	0	3	3

Prerequisites(Coursecode)	**:**	MTPC15
CourseType	**:**	PE

CourseLearningObjectives

ToknowmanufactureofdifferenttypeofCeramicmaterialsanddevelopforspecificengineering

CourseContent

Surfaceandinterfaces,grainboundaries,interfacialenergyandwetting;phase equilibriainceramic system - single componentSiO2transformations insilica;two componentsystems

Overview ofceramic processing- emphasisonpowder processingroute-crushing, grinding, sizing, pre-consolidation bypressing,casting,plasticforming,tapeformingandspraying--sintering stages, mechanisms,solidstatesintering, liquidphase sintering.

Hotpressing- reaction sintering-self-sustaininghigh temperaturesynthesis-highpressuresynthesis-fusioncastceramics- slurrycasting- overviewofrefractoryprocessing-sol-gelprocessing- ceramic coatings-manufactureof glasses

Principles,properties,applicationsandprocessingforimportantsystemssuchas:siliconcarbide, siliconnitride,boroncarbide,boronnitride, cermets,molybdenumdi-silicideandceramic fibres

Principles,properties,applicationsandprocessingofimportantsystemssuch as:zirconia,stabilized zirconia,sialons, magneticceramics,superconductingceramics,semiconductors,glass ceramics,bio ceramics

ReferenceBooks

1	*McColmJ., 'Ceramic Science forMaterialsTechnology', Leonard Hill,1983*
2	*RichersonD.W.,'ModernCeramicEngineering- Properties Processingand UseinDesign', MarcelDeckker, 1982*
3	*KingeryW. D.,Bowen H.K.,UhlmanD.R.,'Introduction to Ceramics', 2ndEd, JohnWiley,1976*

4				
CourseOutcomes				
At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	DefinetheTypeofComponent systempresentintherefractorymaterials. Selectthe powderProcessingroutetopreparetheceramics	5	2	1
CO2	DifferentiatePressingandCastingtechniquesfortheceramicmaterials developrefractorymaterials forspecificapplication	5	2	1
CO3	ApplythePrinciple andEvaluate thepropertiesofmaterials	1	2	5
CO4	DefinetheTypeofComponent systempresentintherefractorymaterials. Selectthe powderProcessingroutetopreparetheceramics.	5	2	1
CO5	DifferentiatePressingandCastingtechniquesfortheceramicmaterials Developceramicmaterials forspecificapplications.	1	2	3

CourseCode	**:**	**MTPE22**
CourseTitle	**:**	High Temperature Materials
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	MTPC12
CourseType	**:**	PE

CourseLearningObjectives

To studythe high temperature sustainability of various materials in critical high temperature applications.

CourseContent

Factorsinfluencingfunctionallifeofcomponentsatelevatedtemperature,definitionofcreepcurve,

variousstages of creep,metallurgicalfactorsinfluencingvariousstages,effect ofstress,temperature andstrainrate

Introduction totransientcreep,timehardening,strainhardening,expressionsfor rupturelifeforcreep, ductileandbrittlematerials, Monkman- Grantrelationship

Varioustypes offracture,brittletoductilefromlowtemperaturetohightemperature, cleavage fracture,ductilefractureduetomicrovoidcoalescence-diffusioncontrolledvoidgrowth;fracture maps for different alloysandoxides

Oxidation,Pilling-Bedworthratio,kineticlawsofoxidation-defectstructureand controlofoxidation byalloys additions, hotgascorrosiondeposit,modifiedhotgas corrosion, fluxingmechanisms,effect of alloyingelementsonhotcorrosion

Ironbase,nickelbaseand cobaltbasesuperalloys,compositioncontrol,solidsolution strengthening, precipitationhardeningbygammaprime,grainboundarystrengthening,TCPphase-embrittlement, solidificationof single crystals

ReferenceBooks

1	*Raj R., 'Flowand Fracture and Elevated Temperatures',American SocietyforMetals, 1985*
2	*HertzbergR.W.,'DeformationandFractureMechanicsofEngineeringMaterials',4thEdition, JohnWiley, 1996*
3	*Courtney T.H,'Mechanical BehaviourofMaterials', McGrawHill,1990*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand and analysethebasicmechanismsof hightemperaturedeformation			1
CO2	Evaluate the long term high temperature life of components.	4	2	1
CO3	Analyze thefracturephenomenonin variousmaterialsin hightemperaturefailures		2	1
CO4	Applybasic understandingof hightemperaturephenomenonlike oxidationandhotcorrosionin identifyingsuitablematerials forspecifichightemperature applications		2	1
CO5	Study thehightemperaturebehaviourof various high temperature materials and design new materials for high temperature applications	3		1

CourseCode	**:**	**MTPE23**
CourseTitle	**:**	Emerging Materials
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	PE

CourseLearningObjectives

Todefinenewengineeringmaterials andapplyformulti-functional areas.

CourseContent

Techniquesofrapidsolidification.productionofmetallicglasses,atomicarrangement, comparison withcrystallinealloys- mechanical,electrical, magnetic,superconductingandchemicalpropertiesand applications

Phasediagrams offerritic,martensiticandausteniticstainlesssteels,duplexstainlesssteels, precipitationhardenablestainlesssteels, mechanical andmetallurgicalpropertiesofstainlesssteels, HSLA steels,micro-alloyedsteels

Aluminiumalloys, magnesiumalloysandtitaniumalloys;metallurgicalaspects, mechanicalproperties andapplications

Developmentofsuperalloys-ironbase,nickelbaseandcobaltbase-propertiesandtheirapplications; materials for cryogenicservice,materialsin nuclearfield, materialsused inspace

Carbonaceous materials- including nanotubesand fullerenes;shape memoryalloys, functionally gradient materials,hightemperaturesuperconductors- biomaterials

ReferenceBooks

1	*SukhDevSehgal, LindbergR.A.,'Materials,theirNature,PropertiesandFabrication', SChand, 1973*
2	*PolmearI. J. 'Lightalloys:Metallurgyof LightMetals', 3rd Edition, Arnold, 1995*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describethe processing route, mechanical, electrical, magnetic and chemical properties of metallic glasses.			1
CO2	Analyse the PhasediagramandMicrostructureof different type of stainless steelmaterials.		1	2
CO3	Demonstrate the metallurgical aspects and applications of aluminium, magnesium and titanium alloys.			1
CO4	Describe the materials used for cryogenic, nuclear and space applications		3	1,2
CO5	Understand the effect of structures on the properties of functional materials like carbon nanotubes, fullerenes, shape memory alloy, biomaterials, etc.		3	1

CourseCode	**:**	**MTPE24**

CourseTitle	**:**	AutomotiveMaterials					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC12					
CourseType	**:**	PE					

CourseLearningObjectives

Tounderstandtheworkingprinciples ofautomobiles,differentsystemsin automobilesandmaterials used inautomobilecomponentsfabrication

CourseContent

Reciprocating engines, Otto cycle, Diesel cycle, four stroke and two stroke engines, working principle and constructional details of two stroke and four stroke engine, engine components, automobile construction, recent trends in automobile technology.

Engine cylinder: Structure and functions, types, cylinder blocks materials and manufacturing processes, improving engine components with surface modifications, Piston: Structures and functions, types, piston materials, piston manufacturing processes

Structure, function and materials for piston rings, camshaft, valves and valve seats, valve springs, connecting rod, crankshafts, turbocharger and exhaust manifold; tailor welds.

Types of chassis layout and chassis materials, vehicle frames, materials used for car body, front axle and steering system, drive line, propeller shaft, universal joints, wheels and suspension system. Types of tires, applications of polymers in automobiles, environmental impact of emissions from IC engines and its control.

Working principle of electric vehicles, fundamental of drives and DC machine, drives and Control of EV Using DC Machines, materials used in electric cars.

ReferenceBooks

1	*Ganesan.V, Internal CombustionEngines,Tata-McGrawHill PublishingCo.,NewDelhi,1994.*
2	*HiroshiYamagata,TheScience andTechnology of Materials in AutomotiveEngines,Woodhead Publishingin Materials,2005.*
3	Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	To understand air standard cycles and to estimate efficiencies of air standard cycles		3	1,2
CO2	To understand the functions of engine block and materials for engine block		3,5	1,2
CO3	To study various components used in automobile and selection of materials		5	2,3
CO4	To understand the functioning of electric vehicles		9,11	5,8

CourseCode	:	**MTPE25**
CourseTitle	:	Metallurgical Failure Analysis
NumberofCredits		3

LTPCBreakup	:	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	:	NIL
CourseType	:	PE

CourseLearningObjectives

To introduce various types of failures involved in metallurgical operations, their identification and remedial measures.

CourseContent

Sources of failure - Deficiencies in Design, Material, Processing, Service and Maintenance. Stages of Failure Analysis, classification and identification ofVarious TypesofFracture-Overview of fracture mechanicsconcept. Ductile andBrittleFracture; General Concepts, fracture Characteristics Revealed byMicroscopy

Fatigue failure - Factors affectingFatigue LifeSome Case Studies of Fatigue Failures; Creep, Stress Rupture, Elevated Temperature Fatigue, Elevated Temperature Effects on Certain Gas Turbine Components AndPetroleum Refinery Components.

Wear failure - typesofWear, Roleof friction inwear, Lubricated andNon-Lubricated Wear, Analyzing Wear Failure. Corrosion Failures- Factors Influencing Corrosion Failures, Analysis ofCorrosion Failures, Stress Corrosion Cracking -Sources. Characteristics, Procedure for Analyzing Stress Corrosion Cracking, various types of Hydrogen Damage Failures.

Causes offailure inforging like material characteristics, deficiencies indesign, Improper Processing,Fabrication orDeterioration resulting fromservice conditions,

Failure ofIron andSteelCastings, effectof Surface Discontinuities, Internal Discontinuities, Microstructure, Improper Composition, Improper Heat Treatment, Stress Concentration and Service Conditions. Failure of Weldments - Reasonsfor Failure procedure forWeld Failure Analysis.

ReferenceBooks

1	Colangelo, V.J., and F.A. Heiser, Analysis of Metallurgical Failures, John Wiley and Sons Inc., New York, USA, 1974.
2	Charlie RBrooks, Ashok ChoudhuryMetallurgical Failure Analysis, McGraw-Hill Publishing Co.USA, 1993
3	ASM Handbook, Vol. 10: Failure Analysis and Prevention, ASM Metals Park, Ohio, 1995.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describe the sources, types and microscopic features of different types of fracture		2	1
CO2	Analyse the factors influence the fatigue and creep failures and their remedial measures		1	2
CO3	Distinguish the role of various factors on the wear and corrosion failures		2,3	1

CO4	Identify the causes for failures in castings, forgings and weldments		1	2,3

CourseCode	**:**	**MTPE26**
CourseTitle	**:**	Biomaterials
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	PE

CourseLearningObjectives

The objectiveofthis courseis toprovidestudents afundamental understandingof different materials for biomedical-applications andtheir*in-vitro*and *in-vivo* characteristics.

CourseContent

Need for biomaterials; Salientpropertiesof importantmaterialclassesfordifferentbio-implant Applications. Introductionbiodegradable implantmaterials.

Processingandpropertiesofdifferentbiomaterials;Nanomaterialsandnanocompositesformedical applications;Nanostructured coatings for bio-implants.

Mechanicalpropertyevaluationandphyisco-chemicalcharacterizationofbiomaterials;*In-vitro*and *In-vivo* evaluationof biomaterials.

Thestructureandcompositionofhardtissues,Bonebiology:Introductiontotissueengineering; Applicationsof tissue engineering;Biomaterials for drugdeliveryapplications.

Biomaterialsworldwidemarket,technologytransferandethicalissues;Standardsforbiomaterials anddevices.

ReferenceBooks

1	*HenchL.Larry,andJonesJ.,(Editors),Biomaterials,ArtificialorgansandTissueEngineering, WoodheadPublishingLimited, 2005.*
2	*HenchL. Larry,&WilsonJ.,(Editors), AnIntroductionto Bioceramics,WorldScientific, 1994.*
3	*Joon Park, Bioceramics, Properties, Characterizations, and Applications, Springe, 2008*
4	*Buddy D. Ratner et al., Biomaterials Science, An Introduction to Materials in Medicine, Third Edition, Academic Press, 2013*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the properties of different biomaterials, know the advantages and disadvantages of different biomaterials and select	4	2	1
CO2	Understand the processing and testing of biomaterials	5	3	1
CO3	Characterize the biomaterials for their physico-chemical properties and analyze the cell-material interactions	5	3	1,2
CO4	Understand the basics of tissue engineering.	3	2	1
CO5	Design and develop new biomaterials for different biomedical applications	4	2	1

CourseCode	**:**	MTPE27
CourseTitle	**:**	Stainless steels and Advanced Ferrous Alloys

NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	Nil					
CourseType	**:**	PE					

CourseLearningObjectives

Tounderstandtheprocessing, physical metallurgy, corrosion behaviour and applicationsofstainless steels.

CourseContent

Overview of Stainless Steel: Types of stainless steels, Alloying elements in Stainless Steel and their effect on microstructure and properties, Major grades of Stainless Steel: Austenitic, Ferritic, Martensitic stainless steels and precipitation hardening grades, Recent and advanced grades of stainless steels: superferritic, superaustenitic, duplex, Lean Duplex (high Mn and high N), Superduplex and Hyperduplex Stainless Steels, Cost implications of alloy addition and substitutes. Applications of Stainless Steel in various Segments: Automotive, Railways& Transport, Architecture, Building & Construction, Reinforcement bars, Roofing sheets, Material Handling applications, Process Industries, Life Cycle Cost Analysis, Physical, Mechanical and Surface Properties required for different applications

Physical metallurgy of Stainless Steel : Relevance of Nickel equivalent and Chromium equivalent, Why FeC diagram is inadequate for Stainless Steel?, Role of alloying elements in ferrite and austenite stabilization, Precipitation in stainless steel (M_7C_3, $M_{23}C_6$, Cr_2N, sigma, chi etc.) and their effect on properties, Deformation behaviour of stainless steels. Role of stacking fault energy and the deformation induced transformation

Stainless Steel (SS) making and processing : Complete overview covering Electric Arc Furnace, Argon oxygen decarburisation, Ladle Refining, Vacuum Oxygen Decarburisation, Vacuum degassing, Ingot casting, Continuous casting, Hot Rolling, Annealing & Pickling, Cold Rolling, Final Annealing and Pickling, Skin Pass Mill, Strip Grinding Line, Inclusion control in stainless steel, Stainless Steel fabrication: Cold roll forming (CRF) process mechanism, Welding of Stainless Steel, Effect of alloying elements on weldability of SS, Schaeffler De Long diagram and the modified versions. Sensitization/Weld decay: Causes, mechanisms, remedies, High temperature sensitization, 475 C embrittlement, σ-phase transformation, Issues faced during fabrication of stainless steel and their solutions: Distortion and Ridging: Causes, mechanisms, remedies, Hot Cracking, Edge cracking, Sliver (surface crack)

Corrosion in Stainless Steel : Major types of corrosion, Galvanic corrosion: Mechanism and prevention, Pitting Corrosion: Mechanism and prevention, Interpretation of PREN, Crack propagation mechanisms, Intergranular, Transgranular

Advanced Ferrous Alloys: Maraging steels, Steels for power plants and nuclear reactors including ODS alloys, Advanced high strength automotive steels, High strength, high toughness steels for strategic application, High silicon steels for electrical application, High Ni steels (1%, 3%, 9%) for cryogenic application, FeCrAl alloys for high temperature application

ReferenceBooks

1	Joseph R. Davis, Stainless Steels, ASM International, 1994
2	Jonathan Carl Beddoes, Jonathan Beddoes, James Gordon Parr, Introduction to Stainless Steels, ASM International, 1999.
3	MårtenGörnerup, Studies of Slag Metallurgy in Stainless Steelmaking, KTH, 1997
4	A. John Sedriks, Corrosion of Stainless Steels, Wiley, 1996

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Explain the various types of stainless steels and their engineering applications		3	1,2

CO2	Understand the influence of various alloying elements on microstructure, precipitation, mechanical properties and deformation mechanisms of stainless steels.	12	3	1,4
CO3	Understand the manufacturing and processing of stainless steels for various applications.		3	1,2
CO4	Analyse and interpret the various types of corrosion in stainless steels and their prevention.	3	7	1,6
CO5	Understand the physical metallurgy of various advanced ferrous alloys like, maraging steels, high N steels, high Si steels, etc.	12	3	1,2

CourseCode	**:**	**MTPE28**					
CourseTitle	**:**	Special Steels and Cast Irons					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC17					
CourseType	**:**	PE					

CourseLearningObjectives

Tobecomefamiliarwitha widearray offerrousalloys includingcarbonsteels,specialsteelsand Cast-iron

CourseContent

Definition of high strengthsteels,problems indevelopinghighstrengthsteels; discussion on fracture toughness; HSLA steels, principleof microalloying andthermomechanical processing;importanceof finegrained steels

Phasediagrams,composition,propertiesandapplicationsof ferritic,austenitic,martensitic, duplex andprecipitationhardenable stainless steels

Dual phase steels, TRIP steels, TWIP steels, UHSS - maraging steels, metallurgical advantages, heat treatment, properties andapplications

Tool steels; classification,composition,and application,constitution diagramofhigh-speed steels,special problems inheattreatmentoftoolsteels

Typesofcastirons-grey,SG, white,malleable;austempered ductileiron;alloycastirons, Ni hard, highsilicon castirons, heatresistantcastirons-highchromecastiron-structure, propertyandengineeringapplications

ReferenceBooks

1	*LeslieW. C., 'ThePhysicalMetallurgyof Steels',McGrawHill,1982*
2	*ASM Hanbook, Vol 1. Properties and Selection: Irons, Steels, and High-Performance Alloys, 1990*
3	*PickeringP.B.,'PhysicalMetallurgyandtheDesignofSteels',AppliedSciencePublishers, 1983*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandprinciples of microalloying and problem associated with developing high strength steels.		3	1,2
CO2	Knowtheproperties, types and applications of stainless steels		3	1,2
CO3	Selectionof advanced and ultra-high strength steels forspecificengineeringapplications		4	2,3
CO4	Choose the suitable tool steel for specific applications based on the property requirements		1,4	2,3
CO5	Select proper alloying and heat treatment procedure to obtain required properties in cast iron.		1,2	3,4

Course Code	:	MTPE29					
CourseTitle	:	Economics of Metal Production Processes					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	MTPC16					
CourseType	:	PE					

CourseLearningObjectives

Tounderstandtheroleofmetallurgicalindustriesintheeconomy;tounderstandhowmetallurgical companiescomeupwithinnovativepracticeswithrespecttorawmaterials,processes,cost,yield andmarketconditions.

CourseContent

Tonnage production, rangeofproductsandannualturnoverofcompaniesinthemetalsand materials sector;Input onmacroeconomicsandgovernment policies

Typicalapproachestocostestimationwithrespecttocapitalexpensesand operating expenses; quantum ofinvestmentassociated withdifferentsectors inthe metallurgicaldomain;approachesto estimationofsavingsandprofits,suchasROI andEBITDA

Naturalresourcesrequiredformajormetallurgicalindustries;trendsinminingandpublicpolicy; Timeframerequired formovingfromideatoactual production, in greenfield sites

Needfordevelopingnewgradesornewvarieties ofproducts,relatedinvestmentrequirements, relatedtechnological initiatives andimpactonprofitability

Sustainabilityintheproductionofmetalsandmaterials;discussiononenergy,environment,waste generation,lossesanddisposal;targetswithrespecttoemissionsandrelated penalties;Conceptof greenmanufacturing

ReferenceBooks

1	Bruce R. BeattieandC. RobertTaylor,The Economicsof Production, reprinted byKrieger PublishingCompany,1993.
2	Philips Maxwell,Mineral Economics- AnIntroduction, inMineralEconomics:Australianand Global Perspectives,AustralianInstitute ofMiningandMaterials, Carlton, Victoria; 2ndEdition, 2013.

3	DavidHumphreys,ChinaChangesEverything, TheRemakingof theMiningIndustry,Palgrave MacMillan,2015.
4	Casestudiesoninitiativesandexperiencesof variousmetallurgical companies
5	Supplementary readingmaterials oncostreduction, quality improvementandinnovative manufacturing

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandterms like tonnage, annual turnover, macroeconomics in metal and materials sector		5	1
CO2	Estimate the cost respect to investment, expenses, savings and profits.			5
CO3	Identify the natural resources available for metallurgical industries and explorenewgradesofmetals andmaterialscompatible with greenmanufacturing			3,6
CO4	Understand the sustainable production of metals and materials		1	7
CO5	Discuss about the energy, environment, waste generation and disposal			6,7

CourseCode	**:**	**MTPE30**					
CourseTitle	**:**	Special CastingTechniques					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC20					
CourseType	**:**	PE					

CourseLearningObjectives

- Toknowtherawmaterialscastingproceduresandparametersofvariousspecialcasting processes.
- Togainknowledgeondesigningappropriateprocesses toproducefordifferentapplications
- Togainknowledgeonusingeconomical designtogivebetterqualitycastings
- Todevelopcomponentsofintricateshapeanddesignbyproperlyselectingthemoulding andcastingtechniques.

CourseContent

Shellmoulding:Processdetails ,types,characteristicsandprocessvariables,types ofsandused andadditives,application

Investmentcasting:Patternmaterial anditsproduction, techniquesof Investmentcasting– Investment,Pattern removal andfiring,pouringandcasting,process variablesand characteristics,application

Die casting:Process details, gravityandpressuredie castingequipmentanddie details, casting techniques,characteristicsof theprocess, application

Centrifugal casting:Process details,centrifugal forcecalculations ,productiontechniques- True, semicentrifugal andcentrifugingprocesses ,processvariables andcharacteristics, application

Squeeze casting,Lowpressuredie casting,thixoandrheocasting,fullmoldprocess ,electro slagcasting,Magneticcasting,Nobakeor pepsetmoulding, castingprocessfor reactivemetals.

ReferenceBooks	
1	*HeineR.,LoperC.R.,RosenthalP.C.,Principlesofmetalcasting.2nd edition,Tata Mcgraw Hill publishers,1985*
2	*JainP.L.,Principlesoffoundry technology, 3rdedition, TataMcgrawHill, 2004*
3	*BeeleyP.R.Foundry Technology ,, Butterworth- Heimannpublishers,London2006*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the process details, types and characteristics of shell moulding and raw materials.		2	1
CO2	Demonstrate the process variables and characteristics of investment casting.		3	1,2
CO3	Explain the process details and applications of die casting techniques and equipment		2	1
CO4	Choose suitable process variables for centrifugal castings of materials.		1	2,3
CO5	Understand the special casting processes like thixo, rheo casting, magnetic casting, no-bake moulding, etc.		2,3	1

CourseCode	**:**	**MTPE31**					
CourseTitle	**:**	ParticulateTechnology					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

Tointroducetheimportancenon-conventional processingroutes for different materials andits importancefor advancedmaterialsmanufacturing.

CourseContent

Introduction –Historical background, important stepsinpowdermetallurgy(P/M)process- Advantage andLimitationsof powdermetallurgyprocessandApplications

Methods–Productionof ceramicpowders-powderproductionbynewermethods such aselectron beamrotatingelectrode,rotatingelectrodeprocess,electronbeamrotatingdiscandtherotatingrod process, automation,rapidsolidificationtechnique. Characteristics:sampling–chemical composition, particleshapeandsize analysis, Surfacearea, packingandflowcharacteristics,Porosity anddensity,compressibility, Strength properties. Blendingandmixingofmetal powders; Compactionofpowders, pressure lessandpressurecompactiontechniques-singleactionand double actioncompaction,ColdIsostaticcompaction,powderrolling, continuouscompaction, explosivecompaction, Hottemperature compaction–Uni axial hotpressing, Hotextrusion, Spark sintering, Hotisostaticpressing, Injectionmoulding–Sintering –Types–Theory of sintering– processvariables,Effects ofsintering– Sinteringatmospheres– metallographic techniquefor sintered products.

Postsinteringoperations–Sizing, coining, repressingandresintering, impregnation, infiltration,Heat treatment, steamtreatment, machining, joining, platingandothercoatings. Products:Porous parts, sintered carbides,cermets,dispersionstrengthenedmaterials,electricalapplications, sinteredfrictionmaterials

Atomisation,Mechanicalalloying,Metal Injectionmoulding, Microwavesinteringandself- propagating hightemperaturesynthesis.

ReferenceBooks

1	Angelo.P.C. and R.Subramanian 'Powdermetallurgy –science, Technology and applications', Prentice hall Publishers, 2008
2	Kuhn H. A., 'PowderMetallurgy Processing-NewTechniquesand Analysis',Oxford &IBH, New Delhi,1978.
3	Randel German, 'PowderMetallurgySciene',2nd ed.,MPIF, 1994
4	Fritz.V.Lenel'PowdermetallurgyPrinciplesandApplications" Metal powderIndustries federation, NewJersey,1980

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describethebasicmechanismof powderproductionforvarietyofmaterials to meetthe demandof theresearch andindustrial needs	5	4	1,2
CO2	Characterizethevarious powders (materials)basedontheengineeringapplications		5	1,3
CO3	Differentiatetheprocessingroutesforvarious powders (materials)andassociatedtechnology			1,2,5

CO5	Applythe powdermetallurgyconceptstodesignnewmaterials for advancedengineering materials			1,3
CO6	Applythe conceptsof particulateprocessingtoproducenon-conventionalmaterials whichare difficult toproduce other techniques			1

CourseCode	**:**	**MTPE32**					
CourseTitle	**:**	Special Topics in Metal Forming					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC22					
CourseType	**:**	PE					

CourseLearningObjectives

Tobecomefamiliarwith formingprocessesapartfrom theconventional formingtechniques.

CourseContent

Highvelocityforming –comparisonwithconventional forming– Explosiveforming-explosives– detonation velocity ofexplosives– energy transfermedia–safety circuit–processparameters–applicationof explosiveforming

Petroforgesystem–rubberpad forming–electro magnetic formingcoilrequirements–effectof workpiecedimensionsandconductivity- applications–electrohydraulic forming–typesof electrodes–applications

Superplasticforming–superplasticity–definition-components– mechanismofsuperplastic deformation –diffusionbonding –superplastic forminganddiffusionbonding–methodsof forming

Severeplasticdeformation–ECAP-types-microstructuralvariationswithprocessingroute–cryo rolling –process- types –stressstraindistribution

Severeplasticdeformationbymechanicalalloying–types–equipment–compaction–sintering–mechanismof sintering

ReferenceBooks

1	*Hosford W.F and Caddell,'Metal formingmechanicsand metallurgy"Prentice Hall, 1983*
2	*Explosive formingprocessandtechniques–A.A.Ezra,Prentice Hall,1980*
3	*ASMmetalsHandbook,Volume5, 1984*
4	*PadmanabhanKA andG.J.Davis,Superplasticity,SpringerVerlag, BerlinHeidberg, NY,1980.*
5	Mahmood Aliofkhazraei (Editor) "Handbook of Mechanical Nanostructuring" Wiley-VCH Verlag GmbH & Co, Germany, 2015

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the non-conventional metal forming methods			1

CO2	Select the appropriate technique for forming components		3	
CO3	Understand superplastic forming techniques		1	
CO4	Understand top down approaches in severe plastic deformation			1
CO5	Understand bottom up approaches in severe plastic deformation			1

CourseCode	**:**	**MTPE33**				
CourseTitle	**:**	Additive Manufacturing				
NumberofCredits		3				
LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3
Prerequisites(Coursecode)	**:**	NIL				
CourseType	**:**	PE				

CourseLearningObjectives

To know the principle methods, areas of usage, possibilities and limitations as well as environmental effects of the Additive Manufacturing technologies

CourseContent

Overview – History – Need-Classification -Additive Manufacturing Technology in product development- Materials for Additive Manufacturing Technology – Tooling – Applications.

Reverse Engineering: Basic Concept – Digitization techniques – Model Reconstruction – Data Processing for Additive Manufacturing Technology: CAD model preparation – Part Orientation and support generation – Model Slicing –Tool path Generation – Softwares for Additive Manufacturing Technology: MIMICS, MAGICS.

Classification – Liquid based system – Stereolithography Apparatus (SLA)- Principle, process, advantages and applications - Solid based system –Fused Deposition Modeling - Principle, process, advantages and applications, Laminated Object Manufacturing

Selective Laser Sintering – Principles of SLS process - Process, advantages and applications, Three Dimensional Printing - Principle, process, advantages and applications- Laser Engineered Net Shaping (LENS), Electron Beam Melting.

Customized implants and prosthesis: Design and production. Bio-Additive Manufacturing- Computer Aided Tissue Engineering (CATE) – Case studies

ReferenceBooks

1	Brent Stucker,DavidRosen, and Ian Gibso, Additive Manufacturing Technologies, Springer, 2010
2	Chua C.K., Leong K.F., and Lim C.S., Rapid prototyping: Principles and applications, Third Edition, World Scientific Publishers, 2010
3	Gebhardt A., Rapid prototyping, Hanser Gardener Publications, 2003.
4	Kamrani A.K. and Nasr E.A., Rapid Prototyping: Theory and practice, Springer, 2006.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describe the need and applications of additive manufacturing		2	1

CO2	Prepare CAD model, model slicing, tool path using different software		5	2,3
CO3	Classify and evaluate the relative merits and demerits of liquid and solid based additive manufacturing system		4	1,2
CO4	Understand the laser based additive manufacturing techniques			1,2
CO5	Fabricate the 3D printed bio products			3,5

CourseCode	**:**	**MTPE34**					
CourseTitle	**:**	Computational Materials Science					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

Tounderstandbasic concepts computational materials science and engineering, different length and time scale computational techniques; To become familiar with some materials modeling and simulation software packages.

CourseContent

Introduction to computational materials science and engineering, different scales, basic procedures. Introduction to ICME, multi-scale modeling, applications

Electronic structure methods – Introduction to quantum mechanics, Density functional theory; Introduction to software package Quantum Espresso/Siesta

Atomic scale methods – Introduction to molecular dynamics, monte carlo methods; Introduction to software package LAMMPS, solving MD problems using LAMMPS

Mesoscopic methods – Introduction to CALPHAD, phase-field methods, introduction to software packagesOpenCalphad/OpenPhase/Thermocalc/MicroSIM

Continuum simulation methods – Introduction to finite element methods, Modeling of stress and temperature distribution during manufacturing processes.

ReferenceBooks

1	Lesar, R., Introduction to computational materials science: Fundamentals to applications, Cambridge University Press, UK, 2013.
2	Lee, J.G., Computational Materials Science: An Introduction, CRC Press, Boca Raton, 2017
3	Horstemeyer, M.F., Integrated Computational Materials Engineering (ICME) for Metals,John Wiley & Sons, Inc., New Jersey, 2012
4	ASM Metals Handbook Vol. 22A-Fundamentals of modeling for metal processing, ASM International, 2009

CourseOutcomes

At the end of the course, students will be able to	PO Correlation		
	Low	Medium	High

CO1	Understand basic procedures of computational materials science and engineering	1	3, 1	5, 2
CO2	Classify different scale modeling techniques in metallurgical and materials engineering		3, 2	5, 1
CO3	Perform simple modeling and simulations in electronic and atomic scale methods		3, 1	5, 4, 2
CO4	Understand thermodynamic modeling and evolution of microstructures using computational methods	1	4, 2	5, 3
CO5	Choose modeling and simulation techniques to computationally solve any metal processing operations	1	4, 2	5, 3, 12

CourseCode	**:**	**MTPE35**					
CourseTitle	**:**	Materials for New and Renewable Energy					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					
CourseLearningObjectives							
Main objective of this subject to create an awareness on energy and its sources. It is also for connecting materials engineering subject in the field of energy generation and harvesting							
CourseContent							

Introduction – Energy demand in India and sources – Renewable energy sources – Wind energy (Principles & types) – Solar energy (PV cells & Solar cells), Electrochemical energy storage and conversion (Batteries, Fuel cells & Supercapacitors) – Hydrogen energy & harvesting (Production, Storage & Energy Conversion) – Thermoelectric materials & energy harvesting.

Solar energy & materials – Nanomaterials for Photovoltaic solar energy conversion systems – Principles of photovoltaic energy conversion (PV) – Types of photovoltics Cells – Physics of photovoltaic cells – Organic photovoltaic cell cells – Thin film Dye Sensitized Solar Cells – Quntum dot (QD) Sensitized Solar Cells (QD-SSC) – Organic-Inorganic Hybrid Bulk Hetero Junction (BHJ-SC) Solar cells – Current status & future trends.

Nanomaterials for Energy Storage (Batteries &Supercapaitors): Systems Issues and Challenges of functional Nanostructured Materials for electrochemical Energy Storage systems – Primary and Secondary Batteries (Lithium ion, Sodium ion, Redox flow, Ni-MH & Metal-Air Batteries) – Cathode & anode materials – Nanostructured Carbon based materials & Nano-Oxides materials (Batteries & Redox capacitors) – Novel hybrid electrode materials (Batteries) – Electrochemical supercapacitors – Electrical double layer model – Principles & materials design – Conducting polymers based materials (Supercapacitors) – Current status & future trends.

Hydrogen storage methods & Materials – Metal hydrides –Carbon based materials, Alantes, etc. Processing and performance Nanomaterials for energy conversion (Fuel cell) systems: Issues & challenges of functional nanostructured materials for electrochemical energy conversion systems – Fuel Cells: Principles & materials for different fuel cells

Thermoelectric (TE): Principles & effects (Seebeck, Peltier effect & Thomson Effect) – Electronic & thermal transport of TE materials – Inter-relation of thermoelectric properties (Seebeck coefficient, ZT, Electrical conductivity, Thermal conductivity & Power factor) – Classification of Thermoelectric materials – Types of materials (Low, Medium & High Temperature) – Processing of thermoelectric materials – Applications – Fabrication & assembly of Thermoelectric devices – Current status and future trends.

ReferenceBooks

1	J. Twidell and T. Weir, Renewable Energy Resources, E & F N Spon Ltd, London, 1986.
2	Electrochemical methods: Fundamentals and Applications, Allen J.Bard and Larry R. Faulkner, 2ndEdition John Wiley & Sons. Inc (2004)
3	Fuel cell technology handbook.Hoogers. CRC Press, 2003
4	Handbook of Nanomaterials for Hydrogen Storage - MieczyslawJurczyk

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	To learn the energy demands and their sources for harvesting	9	6, 7	1, 3, 4
CO2	To understand the solar energy and its efficiency with respect to materials aspects	8,	2, 6	1, 3, 4
CO3	To study the batteries engineering and their future demand	8	2, 6, 7	1, 3, 4, 5
CO4	To learn the technology related to hydrogen storage via materials and applications	8,	2, 7	1, 3, 4, 5

CO5	To understand the energy harvesting engineering, in specific Thermo-electrics	8, 9	2, 6	1, 3, 4,5

CourseCode	**:**	**MTPE36**					
CourseTitle	**:**	Fatigue, Creep and Fracture Mechanics					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC18					
CourseType	**:**	PE					

CourseLearningObjectives

Todeveloptheknowledgeabouttheessentialmechanical propertiesofengineeringmaterials such as fracture, fatigueandcreep andtoapplythemtodesignthematerials for various load-bearing structural engineeringapplications.

CourseContent

Characteristics of fatigue failure, initiation and propagation of fatigue cracks, methods of improving fatigue behaviour, fatigue testing; analysis of fatigue data, fracture mechanics of fatigue crack propagation, corrosion fatigue, case studies

Introduction to creep - creep mechanisms, creep curve, Presentation and practical application of creep data; accelerated creep testing, time-temperature parameters for conversion of creep data; creep resistant alloys, creep testing, stress rapture test,

Introduction, types of fracture in metals, theoretical cohesive strength of metals, Griffith theory of brittle fracture, fracture of single crystals, metallographic aspects of fracture, fractography, fracture under combined stresses.

Brittle fracture problems, notched bar impact tests, instrumented Charpy test, significance of transition temperature curve, metallurgical factors affecting transition temperature, drop-weight test and other large-scale tests, fracture analysis diagram,

Introduction, strain energy release rate, stress intensity factor, fracture toughness and design, K_{IC} plane strain toughness testing, plasticity corrections, crack opening displacement, J integral, R curve, toughness of materials.

ReferenceBooks

1	T.H. Courtney, Mechanical Behaviour of Materials, 2nd Ed, Waveland Press, 2005
2	*DieterG.E., 'Mechanical Metallurgy',3rdEdition, McGrawHillPublications,1988*
3	*Suryanarayana, 'Testing ofMetallicMaterials',Prentice Hall India, 1979*
4	

CourseOutcomes

At the end of the course, students will be able to	PO Correlation

		Low	Medium	High
CO1	Describebasicmechanismsof fatigue behavior ofvarious engineeringmaterials and their importanceinmaterials design		2	1
CO2	Understand and analyse the creep behaviour andalterthemicrostructure for thelifeenhancement ofmaterials atelevated temperatures		2	1
CO3	Understand and analysethevariousmetallurgical factors influencingthefracture behaviour at different temperatures.		2	1
CO4	Understand, evaluate and analyse the impact properties of materials		2	1
CO5	Understand, evaluate and analysethe fracture mechanics of materials		2	1

CourseCode	**:**	**MTPE37**					
CourseTitle	**:**	Metallurgical Waste Management					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

To become familiarize with the waste produced in mining, ore beneficiation, metallurgical operations, e-waste; utilization of waste and their management.

CourseContent

Environmental and health impacts of Mining and Metallurgical waste. Various kind of wastes: Mining and Beneficiation waste production. Ferrous metal waste production. Ferroalloys waste production. Hydrometallurgical waste production. Metal manufacturing and finishing waste production. Post-consumer waste production. E-waste and recovery of metals and useful things from e-waste.

Utilization of mine overburden and waste rock. Potential utilization of mineral beneficiation tailings. Prevention and mitigation of acid mine drainage.

Recycling and reuse of blast furnace ironmaking slags, steel making dusts and sludges. Utilization of steel making dusts – Plasma based processing, hydrometallurgical processing, solidification and stabilization. Recycling and reuse of steelmaking slags

Utilization of Jarosite, goethite produced during extraction of zinc, Utilization of red mud produced in Bayer process: metallurgical utilization through metal recovery, utilization in building and construction, Glass-ceramics and Pigments. Recycling and utilization of surface oxide scale produced during metal forming operation. Metal recovery from pickling and plating sludges.

Waste management and utilization options: zero waste process approach, synergy between residue produces and residue end users. Process integration to mineral waste utilization.Process intensification.

ReferenceBooks

1 Ndlovu, S., G.S. Simate and E. Matinde, Waste production and utilization in the Metal Extraction Industry, CRC Press, 2017

2	Ramachandra Rao, Resource recovery and recycling from metallurgical wastes, Elsevier, 2006
3	K. Hieronymi, R. Kahhat, E. Williams, E-waste Management: From waste to resource, Routledge, New York,2013

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Identify the various kinds of wastes produced during mining, beneficiation, manufacturing, finishing operations and e-wastes		1,2	7
CO2	Understand the utilization of waste produced during mining and mineral beneficiation.		1,2	7
CO3	Classify the wastes produced from iron making, steel making, plasma processing, hydrometallurgical processing.		2	7
CO4	Select a suitable methods to recycle the wastes produced during extraction of non-ferrous metals		5	3,7
CO5	Provide a solution for waste management through process integration and intensification		5	3, 7

CourseCode	**:**	**MTPE38**					
CourseTitle	**:**	Instrumentation and Control Engineering					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	PE					

CourseLearningObjectives

Todevelopthebasicunderstandingofmeasurementsusingdifferenttools andskills to implement knowledgeof techniquestocontrol thesystems.

CourseContent

General conceptsofmeasurements,staticanddynamiccharacteristics, Introductiontocalibration,calibrationstandards.

Temperaturemeasurements:Measurement usingexpansionthermometers,thermocouples, Resistancetemperaturedetectors,thermistors andoptical pyrometers.

Measurement usingstraingauges,Capacitivetransducers,inductivetransducersandPiezoelectric transducers. Introductiontopressure,levelandflowmeasurements.

Basicsofopen loopandclosed loopsystem,classificationofvariables, ON/OFF,P,PI,PIDcontrollersandtheirapplications.

Introduction to Micro Processor and its architecture. Instruction sets. IntroductionProgrammable logiccontrollersandinstructionsets.

ReferenceBooks

1	JohnP. Bentley.,"Principlesof MeasurementSystems"3rdE,AddisonWesley LongmanLtd.,UK.
2	NeubertH.K.P., "InstrumentTransducers:AnIntroductionto theirperformanceandDesign,2nd EditionOxfordUniversity Press, Cambridge,1999.
3	Ramesh Goankar,"Microprocessorarchitecture,Programming and applications,with the
4	Patranabis,"Sensorsand Transducers",WheelerPublishing, 1999.
5	Doebelin E.O,"Measurementsystem-applicationsanddesign",4thEMcGrawHillNewYork,2003

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Differentiatestaticanddynamiccharacteristicsandcalibrationstandards formeasurements.		2	1
CO2	Selectthe suitable temperaturemeasurementmethodfor thesuitable condition.	6		1,2,3
CO3	Applicationof varioustransducersfor directcontactandnon-contactmeasurements.		1	2,4
CO4	DesignandmeasurementsofPC basedmethods, constructionof interfacedevices.	6	2	3,4
CO5	Differentiateloops andvariables andtheireffectiveapplications in various situations.		3,4	1,2,

CourseCode	**:**	MTPE39					
CourseTitle	**:**	Material Sustainability					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	Nil					
CourseType	**:**	PE					

CourseLearningObjectives

To understand the importance of sustainability and sustainable developments in metallurgical and materials engineering domain.

CourseContent

Introduction to sustainability & its factors, requirements for sustainability; Introduction to Sustainable Development (SD): Glimpse into History and Current practices -Broad introduction to SD - its importance, need, impact and implications; definition coined.

Materials supply chain, constraints on materials resources and usage, sustainability reporting, corporate responsibility, life cycle assessment, environmental impact assessment

Case studies on sustainable development: Biopolymers production, Electric vehicles, lightings, recycling of materials

Case studies on sustainable development: Wind Energy, Solar photovoltaic, metal recovery from wastes

Circular materials economy: improved materials technology, better design and longer product life, better business model, better behavior

ReferenceBooks

1	Ashby, M.F., Materials and Sustainable Development, Butterworth-Heinemann, 2015

2	Rogers, P.P., Jalal, K.F., Boyd, J.A., An Introduction to Sustainable Development, Earthscan, 2012

CourseOutcomes	
At the end of the course, students will be able to	
CO1	Understand the concept of sustainability and sustainable development
CO2	Analysis the resources, constraints and usage of materials; life cycle assessment and environmental impact assessment
CO3	Explain the sustainable development occurred in the biopolymer developments, lighting sector and electric vehicles
CO4	Explore the sustainable development in the energy sector and metal recovery from wastes
CO5	Understand the circular materials economy and its components for the implementation

Course Code	**:**	MTPE40					
CourseTitle	**:**	Integrated Computational Materials Engineering					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	Nil					
CourseType	**:**	PE					

CourseLearningObjectives

To become familiar with concepts of integrated computational materials engineering and their industrial applications

CourseContent

Introduction to Integrated Computational Materials Engineering (ICME); Overview of ICME and history; Computer Simulations at Different Time Scales, Multiscale Aspects of Materials
Electronic Structure Calculations - their applications in materials design, Atomistic Modeling and Simulations of Materials – fundamentals and applications of kinetic Monte Carlo, molecular statics, and molecular dynamics simulations
Mesoscale Modeling of Process-Structure Relations in Materials -Phase-field modeling, Cellular Automata, Computational Micromechanics - Discrete Dislocation Dynamics and Crystal Plasticity
Materials Process Modeling - Finite Element/Difference/Volume Methods for Modeling of Casting, Forming and Joining Processes
Case studies on implementation of ICME at different industries

ReferenceBooks

1	Horstemeyer, M.F., Integrated Computational Materials Engineering (ICME) for Metals,John Wiley & Sons, Inc., New Jersey, 2018
2	ASM Metals Handbook Vol. 22A-Fundamentals of modeling for metal processing, ASM International, 2009

CourseOutcomes	
At the end of the course, students will be able to	
CO1	Visualize the concepts of ICME and their importance in manufacturing processes
CO2	Understand the principles and applications of electronic scale and atomic scale simulation techniques
CO3	Perform simulations on microstructure evolution, dislocation dynamics and crystal plasticity
CO4	Model and simulate the different manufacturing processes like casting, forming, joining, etc.

CO5	Implement the ICME concepts in different manufacturing applications

CourseCode	:	MTOE11					
CourseTitle	:	Nanomaterials and Applications					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	NIL					
CourseType	:	OE					

CourseLearningObjectives

Studentswhocompletethiscoursewillbeabletodescribemethodsforproduction,characterization andapplicationsof nanomaterials invarious fields.

CourseContent

Introduction:Conceptofnanomaterials–scale/dimensionalaspects,nanoandnature,effectofsize reductiononvariousproperties,advantagesandlimitations atthenanolevel.

Methodstoproducenanomaterials: Plasmaarching,chemicalvapourdeposition,sol-gelprocess, electrodeposition, ballmilling, severeplasticdeposition, etc.

Characterizationofnanomaterialsandnanostructures: Salientfeaturesandworkingprinciplesof SEM,TEM,STM, AFM, XRD, etc.

Applications:Fullerenes, carbonnanotubes,nanocomposites, molecular machines,nanosensors, nanomedicines,etc.

HealthIssues: Understanding thetoxicity ofnanoparticlsand fibers,exposureto quartz,asbestos,air pollution.Environmentalissues:Effectontheenvironmentalandotherspecies. Societalimplications: Implicationsof nanoscienceandtechnologyin society, government regulations,etc.

ReferenceBooks

1	B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday, Textbook of Nanoscience and Nanotechnology, University Press (I) Pvt. Ltd., 2013.
2	*MickWilsonetal,Nanotechnology:BasicScienceandEmergingTechnologies,OverseasPress, 2005.*
3	*CharlesP.Poole Jr,FrankJ.Owens,Introductionto nanotechnology, Wiley-India(P) Ltd.,2006.*
4	*T. Pradeep, Nano:The Essentials,TataMcGrawHill, 2007.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandtheterminologies used inthe fieldofnanomaterials			1
CO2	Classifydifferentmethodsofmanufacturingof nanomaterials			1,2
CO3	Observethemorphology, phasecompositionof nanomaterials		5	1

CO4	Toselectnanomaterials fordifferentindustrialapplications			2,3
CO5	Tounderstandthehealth issues relatedtonanomaterials		2	6

CourseCode	**:**	MTOE12					
CourseTitle	**:**	Mathematical Techniques in Materials Research					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	OE					

CourseLearningObjectives

Tounderstandhowmathematicsisbeingusedtoadvanceresearchworkinmaterials;topreparethe studentforacareerinmaterialsresearch;tobecomefamiliarwithsomespecificmathematical techniquesusedin materials research

CourseContent

(**Actualcoveragewilldependontheclassandthedraftcourseplan**(preparedwithinputfromthe students))
(Courseinvolveslimitednumberofconventionallectures,considerableself–learning,andactive seriesof student seminarsonselected topics)
Reviewofcertaintopicsfrompriormathematicscourses(suchasexamplesontheapplicationsof differential equations inmetallurgical processes)
Fundamentalinput onthe mathematicsrelated tophysical metallurgy,metallurgicalthermodynamics (suchasthemathematicsbehindcrystalstructures)
Indicativeinputonuse oftechnical softwareusefulinthis domain(suchasMathematica,Matlab)
Discussionofthebasicprinciples relatedtothe topicslistedhere,followedbystudent seminarson selected topics(fromthis list):
Mathematical TechniquesinCrystallography
Stereographic Projection–ConceptandApplications
MathematicsofDiffusioninMaterials
GroupTheoryApplicationsinSolidStateChemistry
Dislocation modelingtostudyfailureofmaterials
Studies onFractal GeometryfortheDevelopingAdvanced Materials
FundamentalsofDensityFunctional Theory
SolidificationDynamicsofBinaryAlloys
Kapoor andFrohbergModel formulticomponent slags
Mathematical AspectsofMetallurgicalThermodynamics
MarkovChains andProcesses
Pseudopotential latticeBoltzmanmodels for complexengineeringfluids
Vector Calculus andthe Behaviourof EngineeringMaterials
ConstitutiveModelingof EngineeringMaterials
Weibull Distributionsandtheir Applications
Basicsof TensorAnalysis

ReferenceBooks

1	OCWLecture NotesonMathematicsforMaterials ScientistsandEngineers,MIT,USA (availableversion)

2	LectureNotesonConstitutiveModelingofEngineeringMaterials, Chalmers Universityof Technology,Goteborg(available version)			
3	Mathematical TechniquesinCrystallographyandMaterials Science,EdwardPrince,Springer Verlag, 1994			
4	Current Literatureinrelatedtopics/reading materialscited inthe class			
CourseOutcomes				
At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	applyconcepts ofhighermathematicsin studyinganddevelopingadvancedmaterialsandprocesses;andworkinter-disciplinaryresearch teams		4,5,9	1,2,3

CourseCode	**:**	MTOE13
CourseTitle	**:**	Designand Selection ofMaterials
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	OE

CourseLearningObjectives

Toknowdifferenttypesofmaterialsandpropertiesandtoselectbettermaterialsfordifferent applications

CourseContent

Technologicallyimportant propertiesofmaterials–Physical,chemical,mechanical, thermal,optical, environmental andelectrical propertiesofmaterials.Materialpropertycharts–Modulus–density, strength-density, fracture toughness-strength,

Typesof design, Designtools andmaterials data–Materials andshape –microscopic andmicro structural shapefactors–limittoshapeefficiencyComparisonofstructuralsections andmaterial indices–casestudies

Service, Fabricationand economic requirementsfor thecomponents–Methodologyfor selectionof materials–Collectionof data onavailability, requirementsandnonfunctionalthings- its importance to the situations–casestudies

Classifyingprocess--systematicselectionofprocess–Selectioncharts–Rankingof processes –case studies–Influenceofmanufacturingaspects andprocessingrouteonpropertiesofmaterials andits influence onselectionofmaterials.

Selectionofmaterials for automobile,nuclear,power generation,aerospace,petrochemical, electronic andminingindustries.

ReferenceBooks

1	*M.F.Ashby,"MaterialsSelectioninMechanicalDesign' –Thirdedition,Elsevierpublishers, Oxford,2005.*
2	*GladiusLewis,"SelectionofEngineeringMaterials",Prentice Hall Inc, NewJersey,USA,1995.*
3	*Charles.J.A. and Crane,F.A.A., "Selection and Use of Engineering Materials", Butterworths, London,1989.*
4	*Angelo P C and Ravisankar B, "Introduction to Steel- Processing, Properties and Applications", CRC Press, Taylor & Francis Group, Florida, U.S.A. 2019*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand types of materials and properties			1
CO2	Know different methods for materials selection	5	2	1
CO3	Selection of materials for Specific engineering applications	11		3
CO4	Know different methods for processes selection	5	2	1
CO5	Understand importance of macro and micro shapes in applications	2	1	

CourseCode	**:**	MTOE14
CourseTitle	**:**	New Product Development
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	OE

CourseLearningObjectives

Exposestudents to thestructured NewProductDevelopment (NPD)Methodologyandhelpthem understandthemethodology;andeffectivelyapplyittoapracticalsituation.

CourseContent

FundamentalsofProduct Development-GlobalTrends Analysis andProductdecision- Typesof varioustrends affectingproductdecision-SocialTrends (Demographic, Behavioral, Psychographic), Technical Trends (Technology, Applications, Tools,Methods),EconomicalTrends(Market,Economy, GDP, IncomeLevels, SpendingPattern, targetcost, TCO),EnvironmentalTrends (Environmental RegulationsandCompliance),Political/PolicyTrends (Regulations,PoliticalScenario,IP Trends and CompanyPolicies) - PESTLEAnalysis
ProductDevelopmentMethodologies andManagement- OverviewofProducts andServices (Consumerproduct,Industrial product,Specialtyproducts etc.,)-Typesof ProductDevelopment (NPD/Re-Engineering(Enhancements,CostImprovements)/ReverseEngineering/DesignPorting&Homologation)-OverviewofProductDevelopmentmethodologies-Product LifeCycle(S-Curve, ReverseBathtubCurve)-ProductDevelopmentPlanningand Management
Requirement EngineeringandManagement-TypesofRequirements(Functional,Performance, Physical,Regulatory, Economical,Behavioral,Technical, Stakeholder,Environmental, Industry specific,Internal-CompanySpecific)- Gathering(VOC),Analysis (QFD),DesignSpecification-TraceabilityMatrixandAnalysis-RequirementManagement- SystemDesign&Modeling-IntroductiontoSystemModeling- SystemOptimization- SystemSpecification- Sub-SystemDesign - InterfaceDesign
Designand Testing–Conceptualization- IndustrialDesignandUser InterfaceDesign- Introductionto ConceptgenerationTechniques- ConceptScreening&Evaluation- ConceptDesign- S/W Architecture-HardwareSchematicsandsimulation-Detailed Design - Component Designand Verification - S/WTesting-HardwareTesting– Prototyping- TypesofPrototypes(Mockups, EngineeringAssessmentPrototype,Alpha, Beta,Gama)- IntroductiontoRapidPrototypingandRapid Manufacturing
SystemIntegrationandBusinessDynamics-Testing, CertificationandDocumentation-Manufacturing/Purchase andAssemblyof Systems- IntegrationofMechanical,Embedded andS/W systems-Productverificationprocessesandstages –Industryspecific(DFMEA,FEA, CFD) -Product validationprocesses andstages - Industryspecific(Sub-systemTesting/IntegrationTesting/ Functional Testing/ PerformanceTesting/ComplianceTesting)-ProductTestingstandards and Certification – Industryspecific-ProductDocumentation - SustenanceEngineeringandEnd-of-Life (EoL)Support–MaintenanceandSupport - Obsolescence Management- ConfigurationManagement
- EoL Disposal;Business Dynamics–EngineeringServicesIndustry-Productdevelopment in Industry versus Academia-verticalspecificproductdevelopment processes- IntellectualPropertyRightsand Confidentiality

ReferenceBooks

1	*Kevin Otto, KristinWood,"Product designtechniquesin reverseengineering andnewproduct development",Pearson, India, 2006*
2	*Ulrich, Karl T. and Eppinger, StevenD,"ProductDesignand Development",3rd Edition, McGraw-Hill, NewYork,2004*

3	*Ullman, DavidG., "TheMechanical Design Process",McGraw-Hill, 4thedition, 2009*
4	*Kenneth B.Kahn, George Castellion, Abbie Griffin, ThePDMA Handbookof New Product Development,2005,JohnWiley &Sons,Inc.Hoboken, NewJersey,USA.*
5	*Merle Crawford,Anthony Di Benedetto,NewProductsManagement,ninth edition, 2008, McGrawHill CompaniesInc.NewYork,USA*
6	*A.K.Chitale, R.C.Gupta, 'Product Designandmanufacturing'*
7	*Handoutsprovided by industrial experts*
8	*ResourceMaterials/'BoK' provided by NASSCOM,related to NPD*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Clear understandingof theNPDMethodology		6	1,3
CO2	Clear understandingof theinfluence of STEEPFactorsfor thesuccessof NewProduct		6	1,3
CO3	Clear understandingof theimportanceof Customerstudy, requirementgatheringandanalysis, PatentStudyandanalysisandConceptGeneration		6	1,3
CO4	ExecutePilotNPDProject		4,6	3
CO5	applyindividual Creativeskills,work asateamtoachievethe resultsandpresentthe projectoutcometomanagement reviewteam		6	3,9

CourseCode	**:**	MTOE15					
CourseTitle	**:**	Introduction to Quality Management					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	OE					

CourseLearningObjectives

- Tolearn importantconcepts in quality;
- Tolearn aboutqualityphilosophy;and
- Tolearn aboutstatistical tools usedin quality

CourseContent

Quality–introduction; philosophicalapproach;costofquality;overviewoftheworksofJuran, Deming, Crosby,Taguchi; PDCA cycle;qualitycontrol; qualityassurance

Quality organization;quality management;qualitysystem;qualityaudit;vendorqualityassurance; totalqualitymanagement;qualityawards;quality certification; typicalprocedureforISO9000, ISO14000, QS9000.

Variations;analysis ofvariance,statisticaltools,statisticalqualitycontrol;controlcharts;process capabilityanalysis;statistical process control.

Inspection;inspectionbysampling;acceptancesampling;statisticalapproaches;single,doubleand multiple samplingplans.

Reliability– concept;differencebetweenreliabilityandquality;differentmeasuresofreliability;time tofailuredistributions;MTBF.

ReferenceBooks

1	*J.M.JuranandF.M.Gryna, 'QualityPlanningandAnalysis',McGrawHill,New York,2nd Edition, 1980*
2	*B.L.Hansen,P.M.Ghare, 'QualityControlandApplication',PrenticeHallofIndia–EasternEconomy Edition,1997.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandthesignificance ofqualitymanagement			1
CO2	Activelyparticipateinqualitysystemscertificationinitiatives		4,5	3
CO3	Qualitativelyusequalityconceptstoreal applications			5
CO4	Performbasiccalculations inSQC / SPC		2	4
CO5	Appreciatethe benefitsofadvanced conceptssuchasSix Sigma		2	1
CO6	Performsimple calculations in reliability			1,2

CourseCode	**:**	MTOE16					
CourseTitle	**:**	SurfaceEngineering					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	OE					

CourseLearningObjectives

To get exposed to various concepts of surface engineering methods and attain comprehensive knowledge in offering suitable solutions to industrial problems.

CourseContent

Introduction to tribology, surfacedegradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, roles of friction and lubrication-overview of different formsof corrosion

Chemical and electrochemical polishing, significance, specific examples, chemical conversion coatings, phosphating, chromating, chemical colouring, anodizing of aluminium alloys, thermochemical processes - industrial practices

Surface pre-treatment, depositionof copper, zinc, nickel and chromium-principles and practices, alloy plating, electro composite plating, properties of electrodeposits, electroless, electroless composite plating; application areas, properties.

Definitions and concepts, physical vapour deposition (PVD), evaporation, sputtering, ion plating, plasma nitriding, process capabilities, chemicalvapour deposition (CVD), metal organic CVD, plasma assisted CVD.

Thermal spraying, techniques, advanced spraying techniques- plasma surfacing, detonation gun and high velocity oxy-fuel processes, laser surface alloying, laser cladding, specific industrial applications, testsforassessmentofwearandcorrosion

ReferenceBooks

1	*SudarshanTS, 'Surface modification technologies - An Engineer's guide', Marcel Dekker, Newyork, 1989*
2	*VargheseC.D, 'Electroplating and Other Surface Treatments- A Practical Guide', TMH,1993*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Surface degradation through various types of wear and corrosion			1, 2
CO2	Principles and practice of mechanical, chemical and electro polishing, chemical conversion coating, anodizing and thermo chemical processes.			1, 2
CO3	Electro deposition of metals and alloys of Cu, Zn, Ni, Cr, etc., with knowledge on prior surface pre-treatment, composite coatings and their industrial applications			1, 2
CO4	Concepts behind PVD, CVD and their various types with suitable industrial illustrations.			1, 2
CO5	Principles and practice of various thermal spray and LASER techniques such as plasma surfacing, D-gun, HVOF, Wire arc LASER –Surfacing, cladding, alloying, texturing		4, 7	12
CO6	Practice of various standard tests and assessment methods for wear and corrosion.		4, 5	3, 6, 12

CourseCode	**:**	MTOE17
CourseTitle	**:**	Process Modelling and Applications
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		1	1	1	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	OE

CourseLearningObjectives

At thecompletionof this course,the studentwillbeable tocomprehendbasic conceptsrelated tp processmodelling;togethands on experienceinsomeaspectsofmodelling;to beable tovisualisemodellingofcomplexindustrial scalemetallurgicalprocesses

CourseContent

Mathematicalmodeling, physical simulation, advantagesandlimitations;process control, instrumentationanddata acquisitionsystems
Reviewoftransportphenomena,reviewofdifferential equations,review ofnumericalmethods; conceptofphysicaldomainandcomputational domain, assumptions andlimitations in numerical solutions, introduction toFEM&FDM
Introductiontosoftware packages –usefulwebsites andgenericinformationaboutdifferent products-ANSYS,Thermocalc, CFD;introductiontoexpertsystemsandartificial intelligence; demonstration/practical trainingin somesoftwarepackages
Physicalmodeling–coldandhot models;casestudiesof watermodels,useof computersforthe constructionof phasediagrams, alloydesign,crystallography, phasetransformations andthermo chemical calculations.
Casestudiesfromliterature–pertainingtomodelingofsolidification/heattransfer,fluidflow, casting, weldingandliquidmetal treatment
Laboratorycomponent:ExercisesusingThermoCalcsoftwareanddatabases(installedinmultiple terminals);andanyother accessiblerelated technicalsoftware

ReferenceBooks

1	*Szekely J.,ThemelisN. J., 'Rate PhenomenainProcessMetallurgy',Wiley,1971*
2	*P.S.GhoshDastidar,"ComputerSimulationofFlowandHeatTransfer",Tata McGrawHill,NewDelhi,1998*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Obtain comprehensive knowledgeofbasicequationsand concepts related to process modellingandcomfortablyinteractwithresearchers andshopfloorengineers		5	1, 10
CO2	Understandterminologiesrelatedtoprocess modelling			1,2
CO3	Becomefamiliarwith useof modellingasa toolforwiderangeofmetallurgicalprocess			3, 4, 5

CourseCode	**:**	MTOE18
CourseTitle	**:**	Intellectual PropertyRights
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	OE

CourseLearningObjectives

ToimpartheknowledgeinIPR andrelatedareaswithcasestudies.

CourseContent

Introduction to IPR; Overview & Importance; IPR in India and IPR abroad; Introduction to Intellectual Property Law. Patents; their definition; granting; infringement; searching & filing; patent landscaping

Industrial Designs; Designs; scope; protection; filing; infringement; difference between Designs & Patents, Introduction to Trademark – Trademark Registration Process – Post registration Procedures – Trade mark maintenance - Transfer of Rights - Infringement – Dilution Ownership of Trademark – Likelihood of confusion - Trademarks claims – Trademarks Litigations – International Trademark Law

Introduction to Copyrights – Principles of Copyright Principles -The subjects Matter of Copyright – The Rights Afforded by Copyright Law – Copyright Ownership, Transfer, and duration – Right to prepare Derivative works – Rights of Distribution – Rights of Perform the work Publicity Copyright Formalities and Registrations – Copyright disputes and International Copyright Law

Introduction to Trade Secret – Maintaining Trade Secret – Physical Security – Employee Limitation - Employee confidentiality agreement - Trade Secret Law - Unfair Competition – Trade Secret Litigation – Breach of Contract. Geographic indication; Meaning, process of securing GI, Well-known GIs in India and abroad, benefits of securing GI

International environment of IPR: World Intellectual Property Organization, Paris Convention, Berne Convention, WTO & TRIPS agreement, Managing intellectual property in a knowledge-based society. IPR and technology transfer, case studies.

ReferenceBooks

1	Deborah Bouchoux: “Intellectual Property”. Third Edition, Cengage learning Inc Pub, Clifton Park, Fourth Edition, 2012.
2	Deborah E. Bouchoux, ―Intellectual Property: The Law of Trademarks, Copyrights, Patents and Trade Secrets, Cengage Learning, Third Edition, 2012.
3	PrabuddhaGanguli,Intellectual Property Rights: Unleashing the Knowledge Economy, McGraw Hill Education, 2011.
4	Edited by Derek Bosworth and Elizabeth Webster, The Management of Intellectual Property, Edward Elgar Publishing Ltd., 2013

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the relevance and importance of IPR for engineers and for business			3,4,6
CO2	Understand the scope of patents, designs, trademark, copyright, geographical indicationsand trade secrets			4,6

CO3	Study the fundamentals of IPR law, including the process of securing the various types of IPR			12

CourseCode	**:**	MTOE19					
CourseTitle	**:**	Business and Entrepreneurship for Engineers					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	OE					

CourseLearningObjectives

- Introduce students to the world of Business, Management and Entrepreneurship
- To understand how start-ups take their ideas to implementation
- To sensitize the engineer to the broader world in which his or her professional work is carried out

CourseContent

Introduction to the course, objectives, deliverables, experiential learning component, team formation, ideation, refinement and project presentation. Business Fundamentals: basic aspects of various topics, including macro economics, micro economics, marketing, accounting, business law, technology innovation, intellectual property rights, technology forecasting, organizational behaviour, war for talent.

The Startup Journey: class sessions; mini-lectures; workshops - format; meetings to mark progress; business idea; obtaining feedback from peers and instructors; refining the thought process and evolving the business idea; liaising with mentors offline (between class sessions); understanding customer need; partnering for success

Business Model Canvas: Startup basics; Ideation and Refinement; Team Formation; Startup Mechanics; and Business Plan

Out of the Building experiential learning: Customer Discovery, Customer Creation and Business Plan Refinement (each student team may need to travel outside the campus for two or three days, for this hands on learning experience)

Validation: Present Business Plan to Peers and Faculty; and then to the External Panel; feedback from the final session

ReferenceBooks

1	Capsules of reading materials and videos shall be made available, as an on line repository of course knowledge; and the usage of this repository by students shall be tracked
2	Reading materials on business fundamentals – as prescribed by the faculty, during lectures; selected chapters from certain books

3	edX Courses on Entrepreneurship (Free access)https://www.edx.org/learn/entrepreneurship
4	edX course by Tarun Khanna, HBS, Entrepreneurship in Emerging Economies (Free access), https://www.edx.org/course/entrepreneurship-emerging-economies
5	Steve Blank – Lean Startup methodology, https://steveblank.com/tools-and-blogs-for-entrepreneurs
6	MIT Open Courseware: Managing Innovation and Entrepreneurship (Free access) https://ocw.mit.edu/courses/sloan-school-of-management/15-351-managing-innovation-andentrepreneurship-spring-2008/
7	Harvard Course on Innovation, Entrepreneurship and Business Transformation, https://canvas.harvard.edu/courses/4156/assignments/syllabus

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the world of business and markets; and how these institutions are shaped and regulated by the political, legal and economic environment; and how companies are founded, grown and developed into profit-maximizing entities		8	2,6
CO2	Learn how to develop a business plan that determines the commercial viability of a product or service in a selected market and geographic location		12	7
CO3	Actually “get out of the building” to interact with prospective customers, generate data, discover customers, and progressively iterate the features of the product or service through a process of hypothesis testing		6	9,10
CO4	Learn how to pitch (sell) the business plan to prospective investors, advisers and other stakeholders		9	10,11

CourseCode	**:**	MTOE21					
CourseTitle	**:**	Artificial Intelligence in Materials Engineering					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	OE					

CourseLearningObjectives

Toexplore the scope of artificial intelligence (AI) in materials engineering and research.

CourseContent

(Considering that AI in Materials Engineering and Research is an emerging field, the following syllabus is intended to provide an outline for the instructor. This syllabus can be suitably navigated to accommodate the recent and relevant advancements.)

Basics of AI – Mathematical Foundation, History and Evolution; Need for AI in Materials Engineering and Research – Data Analysis, Factor Analysis, Image Analysis, Material Discovery

Machine Learning as a subset of AI – Introduction, Types of Data; Supervised Learning – Basics, Regression, Linear and Non-Linear Regression, Gradient Descent, Logistic Regression; Unsupervised Learning – Clustering; Reinforced Learning

Deep Learning – Introduction; Neural Networks – Feedforward, Backpropagation and Parameters; Types – Convolutional and Recurrent Neural Networks; Autoencoders

Quantitative Microstructure Analysis – Computer Vision, Segmentation, Classification, Object Detection and Counting; Data Visualization – Introduction, Types and Techniques

ReferenceBooks

1	Artificial Intelligence - A Modern Approach, Stuart Russell, Pearson Publication, 3rd Edition, 2015.
2	Basics of Artificial Intelligence and Machine Learning, Deeraj Mehrotra, Notion Press, 2019.
3	Artificial Intelligence by Example, Dennis Rothman, Packt Publishing, 2020

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the nature of the data, categorise them, identify its dimensionality and conceive an outcome			3,4,6
CO2	Distinguish the types of machine learning models, explore the potential techniques, make a well-informed choice, and comprehend the performance metrics of the models			4,6
CO3	Appreciate the potential of AI in quantitative analysis of complex and hierarchical microstructures, explore the application of computer vision techniques in microstructural analysis, and elegantly visualise the multidimensional data			12
CO4	Assess the role of AI in materials processing and realise its applicability on a larger scale including industry 4.0			

“OPEN ELECTIVE – ONLINE COURSE TO BE ATTACHED”

CourseCode	**:**	MTMI11
CourseTitle	**:**	Materials Technology
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	MINOR

CourseLearningObjectives

Toimpartknowledgeinmaterial properties andmanufacturing methods. Students will beableto understandvariousmaterial anditsproperties andmanufacturingmethods.

CourseContent

INTRODUCTIONSelectioncriteriaandprocesses:General criteriaof selectionofmaterials in process industries. Properties: Mechanical, Thermal, Chemical, Electrical,Magneticand Technological properties. Processingofmetals andalloys-Casting-hotandcoldrollingforging- extrusion-deep drawing.

FERROUSANDNON-FERROUSMETALS Pureiron,castiron,mildsteel, stainlesssteels,specialalloy steels-iron andironcarbidephasediagram-heattreatmentofplain-carbonsteels.ManufacturingmethodsofLead,Tin andMagnesium.Propertiesandapplications in processindustries

POLYMERS,COMPOSITES,CERAMICS ANDINORGANICMATERIALS

(i)Industrial polymerizationmethods,crystallinityandstereoisomers-ThermosettingandThermo plastics.

(ii)FRP-FiberReinforcedPlastics(FRP),different typesofmanufacturingmethods;asphalt andasphalt mixtures;wood. (iii)Ceramic crystal andsilicatestructures-processingofceramics- cements-glasses enamels-properties. (iv)Cementanditsproperties-manufacturingof cement,special cements, cementconcrete,RCC-Prestressedconcrete.

ADVANCEDMATERIALSSingle crystals-production-properties-applications-memory metals- intelligentmaterials someimportantmetallicandnon-metallicsinglecrystals.

CORROSIONAND PREVENTION Definitionof corrosion-Basic theoriesand mechanismof corrosion-Typesofcorrosion - Anti-Corrosionmethods-Organicpaintsandcoatingsmetal,ceramic coatings.

ReferenceBooks

1	*AshcroftandMermin,"Solid StatePhysics",SaundersCollege Publishing,1976.*
2	*Sidney H Avner, Introductionto PhysicalMetallurgy, 2ndEdition, TataMcGrawHill, 1997*
3	*William D.Callister,Materials Science andEngineering, 2ndEdition,Wiley,2014*
4	*V.Raghavan, Physical Metallurgy:Principlesandpractice, 2ndEdition, PHI,2006*
5	*Fontana M. G., GreeneN.D., 'CorrosionEngineering',2nd Edition,McGrawHill,1983*
6	*Pat.L.Manganon, "Principlesof MaterialsSelectionforEngineering Design",Prentice Hall Int. Inc,1999*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Defineanddifferentiateengineeringmaterialsonthe basis ofstructureandpropertiesfor engineeringapplications.			1,2
CO2	Selectamaterialforaparticular applicationbasedonthe requirements.			2,3
CO3	Predictandapplythenecessaryprotection mechanismtoprevent corrosion		12	3

CourseCode	**:**	MTMI12					
CourseTitle	**:**	FundamentalsofMetallurgy					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	MINOR					

CourseLearningObjectives

Togivebasicideasaboutalloysclassification,materialcharacterizationandprotectionofmaterials

CourseContent

Typeof steels;Plaincarbonsteel, alloysteels, tool steels, Stainless steel

Typesofcastiron;Grey, White,SG,Malleableandalloycastiron

IndustriallyimportantCu,Al, Ti,MgandNi based non-ferrous alloys

Introductiontomaterials characterization- Optical andElectronmicroscopy,andX-raydiffraction.

Degradationof Materials;Corrosionandprotective methods

ReferenceBooks

1	*Sidney H Avner, Introductionto PhysicalMetallurgy, 2ndEdition, TataMcGrawHill, 1997*
2	*William D.Callister,Materials Science andEngineering, 2ndEdition,Wiley,2014*
3	*V.Raghavan, Physical Metallurgy:Principlesandpractice, 2ndEdition, PHI,2006*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandthebasicclassificationand properties of steels andcastiron			1
CO2	Describe the structure, properties and applications of non-ferrous alloys			1
CO3	Characterizethematerialsbymicroscopyand X-raydiffraction		4	1,2
CO4	Identifytheformofcorrosionandsuggestprotectionmethods		4	2,3

CourseCode	**:**	MTMI13
CourseTitle	**:**	Physical MetallurgyandHeat Treatment
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	MINOR

CourseLearningObjectives

Todevelopan understandingof thebasisof physicalmetallurgyandcorrelatestructureofmaterials with theirpropertiesforengineeringapplications.

CourseContent

Introductionto engineeringmaterials.Atomicstructureandinter atomicbonding, theoreticalconceptofcrystallinematerials–typesof packing,voids andpackingfactors foreach of thepackings, conceptofalloy designusinglatticepositions andinterstitialvoids.Planesanddirections andimperfections in solids. Polymorphismandallotropy.

Diffusion,energeticof solidificationNucleationandgrowth-dealinghomogeneous and heterogeneous nucleationandgrowth ofsolids, dendriticgrowthin puremetals,constitutional supercoolinganddendriticgrowth inalloys.

Phasediagrams–solidsolution–types, Hume–Rotheryrule.Phasediagrams–Binary- types–Leverrule. Solidificationof different typesof solidsolutions–Iron-Carbondiagram–Effectofalloying elementonIron-carbondiagram. Ternaryphasediagrams- Understandingof isothermsandisopleths.

Heattreatmentofferrousalloys;Annealing, Normalising, TTTandCCTdiagrams,Hardening–hardenabilitymeasurements,tempering. Thermo mechanicaltreatments. Heattreatment furnaces – atmospheres–quenchingmedia–casehardeningtechniques.

Basic conceptofdislocations their typesanditsinteractions.Dislocations andstrengthening mechanismsstrengtheningbygrain-sizereduction,solidsolutionstrengthening, strainhardening, dispersionhardeningandother recentmodesof hardening.

ReferenceBooks

1	*Avner,S. H.,"Introduction to PhysicalMetallurgy",second edition, McGrawHill, 1985.*
2	*WilliamF.Hosford,Physical Metallurgy, Taylor&FrancisGroup,2008*
3	*Raghavan, V., "Physical Metallurgy",Prentice Hall ofIndia, 1985*
4	*DonaldRAskland andPradeep PPhule"EssentialsofMaterialsScience and Engineering, Baba BarkhaNathPrinters,Delhi.*
5	*WillamD. Callister, Jr. MaterialsScienceandEngineering, Wiley IndiaPvt. Ltd.*
6	*VijendraSingh,PhysicalMetallurgy, StandardPublishers.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describethebasiccrystalstructures(BCC,FCC,andHCP),recognizeothercrystalstructures, andtheir relationshipwiththe properties.			1,2
CO2	Defineanddifferentiateengineeringmaterialsonthebasisofstructureand propertiesfor engineeringapplications.			1,2
CO3	Identify properprocessingtechnologies forsynthesizingandfabricatingdifferentmaterials.			1,2

CO4	Analyse themicrostructureofmetallicmaterials usingphasediagramsand modify the microstructure andproperties usingdifferentheattreatments			2,3
CO5	Understand the various types of strengthening mechanisms to improve the material properties.			1

CourseCode	:	MTMI14					
CourseTitle	:	Deformation Processing					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	NIL					
CourseType	:	MINOR					

CourseLearningObjectives

To knowthe conceptsofmetal formingandassociatetechnologiesandapplythemtothe conventionalandadvancedmaterialsmanufacturingforvariousstructuralapplications.

CourseContent

YieldingcriteriaofvonMisesandTresca.Levy-VonMisesequations andPrantlReusesequationsfor

ideal plastic andelasticplasticsolids respectively. YieldLocus.Methodsof loadcalculationincluding slabmethod,sliplinefieldtheory, FEM, upperandlower bound methods.

Textureeffects.Metallurgical factors affectingrecrystallizationtemperatureandgrainsize.Effectof temperature,strainrate,hydrostatic pressure,Microstructure.Residual stresses,Frictionand lubricationmechanisms.Lubricantsinrolling, forging,extrusion, wiredrawing,sheetmetal forming. Tool design

Typesof rollingmills, Geometrical factorsandforces,Factors affectingrollingloadandminimum

thickness,Rollpass design,wheel andtyreproduction.Rollingdefects, Processesandequipment, Forgeability, effectofvarious factors, definitions.Selectionofequipment,die design, partingline, flash, draft, tolerance.Defects, causesandremedies.

High velocityformingmethods, superplasticforming,hydroforming, isothermal forging.Principles andprocesses. FLDandLDR, CAD,CAMin forminguse ofsoftwareslikeOPTRIS,DEFORM,etc. Workability.

Severe Plastic Deformation – Brief introduction

ReferenceBooks

1	Dieter,G.E.,"MechanicalMetallurgy",McGraw Hill,2001.
2	*ASM "MetalsHandbook,Vol. 14,Forming&Forging",ASM, MetalsPark,Ohio,USA, 1998.*
3	*KurtLange,"HandbookofMetal Forming", Society ofManufacturing Engineers,Michigan, 1985.*
4	*BelzalelAvitzur,"Metal Forming- Processesand Analysis",TataMcGrawHill, 1977.*
5	Mahmood Aliofkhazraei (Editor) "Handbook of Mechanical Nanostructuring" Wiley-VCH Verlag GmbH & Co, Germany, 2015

CourseOutcomes

At the end of the course, students will be able to	PO Correlation		
	Low	Medium	High

CO1	Apply the concept of plastic deformation for metals and alloys to convert them in to useful shapes for intended engineering			1
CO2	Differentiate the various metal forming technology and choose the appropriate one for required engineering applications		3	2
CO3	Analyze various operational and materials parameters influencing the metal forming quality.			2
CO4	Understand the non conventional metal forming methods			1
CO5	Use softwares related to metal forming	2	1	5

CourseCode	**:**	MTMI15					
CourseTitle	**:**	ManufacturingMethods					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	MINOR					

CourseLearningObjectives

Tounderstandthefundamentalsofmanufacturingmethodsintheviewofmetallurgicalperspective with referenceto engineeringapplications

CourseContent

Types of production and production processes, product configuration and manufacturing requirements.

Patternmaking,allowancesandcoremaking.Castingprocessesofferrousandnon-ferrousmetals including diecasting,investmentcasting,centrifugalcasting,loammoulding,transfermoulding. Solidificationprinciples, designofmoulds,riser,sprues andgatingsystem, castingdefects.

Metal joiningprocesses:soldering,brazing,fusionand non-fusion weldingprocesses, various modern weldingprocesses likeTIG,MIG, Submerged ArcWelding, FrictionWelding. Weldingdefects.

Fundamentalsof hotandcold workingprocesses–forging, extrusionandrolling.

Introduction.Production ofmetalpowders.Compactionandsinteringprocesses.Secondaryand finishingoperations. Economics,advantages,andapplicationsof powdermetallurgy.

ReferenceBooks

1	*ManufacturingTechnology:Foundry, FormingandWeldingby P.N.Rao, TMH.*
2	*Principlesof ManufacturingMaterials andProcesses,JamesS.Campbell, TMH.*
3	*WeldingMetallurgy byG.E.Linnert,AWS.*
4	*ProductionEngineeringSciences byP.C.Pandey andC.K.Singh, StandardPublishers Ltd.*
5	*ManufacturingScience byA.GhoshandA.K.Mallick,Wiley Eastern.*

CourseOutcomes

At the end of the course, students will be able to	PO Correlation		
	Low	Medium	High

CO1	Understandthebasicprinciplesofdifferentmanufacturingprocessesinterms ofmetallurgical perspective			1
CO2	Describe the various processes associated with metal casting			1
CO3	Distinguish various metal joining processes			1,2
CO4	Understand the various metal forming processes			1
CO5	List the sequence of operations in fabrication of near net shape products in powder metallurgy route			1

CourseCode	**:**	MTMI16					
CourseTitle	**:**	Testingand Evaluation ofMaterials					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	MINOR					

CourseLearningObjectives

Todevelopthefundamentalknowledgeontestingandevaluationofmaterials,inordertocontrol the qualityin manufacturingandproductionengineeringcomponents.

CourseContent

Visual examination, Basicprinciples ofliquidpenetranttestingandMagneticparticletesting. Radiography- basicprinciple, electromagnetic radiationsources,radiographic imaging, inspection techniques,applications, limitations andsafety.

Eddycurrenttesting- principle, application,limitation;ultrasonictesting- basic propertiesof sound beam,transducers,inspection methods, flawcharacterisationtechnique,immersiontesting, advantage, limitations;acousticemissiontesting.
Leaktesting, HolographyandThermography-principles, proceduresandapplications, Comparison andselectionof NDTmethods;defectsincasting, forging, rollingand others.

MechanicalTesting:Indentationhardnesstests- principle, practice,precautionsanduses;Tensile test-sampletypesanddimensions,stress-straindiagrams for ductileandbrittlematerials, interpretationandestimationoftensileproperties;compression, shear, bendandtorsiontests - principle, practiceanduses;introductiontorelevant standards.

CharpyandIzodimpacttests- techniquesandapplications;lowandhighcyclefatiguetesting methods, S-Ndiagram, applications;creepandcreeprupturetests,timecompensatedparameters; relevantstandards

ReferenceBooks

1	*Baldevraj, Jayakumar T.,ThavasimuthuM., 'PracticalNon-DestructiveTesting',Narosa*
2	*DasA.K., 'Metallurgy ofFailure Analysis',TMH,1992*
3	*ColangeloV. A., 'Analysisof Metallurgical Failures',John Wiley, 1985*
4	*SuryanarayanaA. V.K.,Testingof metallicmaterials,(2ndEdition),BSpublications,2007*
5	*DieterG.E.,Mechanical Metallurgy, (3rdEdition),ISBN:0070168938,McGrawHill, 1988.*

CourseOutcomes

At the end of the course, students will be able to	PO Correlation

		Low	Medium	High
CO1	Differentiatevarious defecttypesanddescribethe maincriteriatoselectthe appropriateNDT methods		5	1,2,3
CO2	SelectsuitableNDTmethodfor specificindustrial application			2,3
CO3	Understandthecriteria toselecttheappropriatedestructivetesting methods and correspondingstandards for a specificapplication		3	1,2
CO4	Carryoutdestructive testingto evaluate themechanical propertiesfor industrialpurposes			2,3

CourseCode	**:**	MTMI17
CourseTitle	**:**	Non-Metallic Materials
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	NIL
CourseType	**:**	MINOR

CourseLearningObjectives

Toprovideanunderstandingof thevarious non-metallic materials,their propertiesandapplications

CourseContent

ClasisificationofEngineeringmaterials–Metals,Ceramics,Polymers(andComposites):Ceramics-Definition,classification;IonicandCovalentceramics;OxideandNon-oxideceramics;Crystallineand Non-Crystallineceramics

Oxideceramics–Examples,Structures, PropertiesandApplications;Indicativedomainsasin refractories,glasses, abrasivesandBiomaterials

Non-oxide ceramics -Examples,Structures, PropertiesandApplications;Indicativeinformation on synthesis/production, indicativeapplicationdomains

Polymers –Basic unit,degreeofpolymerisation, Structure,PropertiesandApplications; ThermoplasticandThermosetpolymers, specialitypolymers

CompositeMaterials–Concept, Definition,Structure,ClassificationandManufacturing.Specific discussion onanytwotypesof particulatecompositesandfibrouscomposites;Novelapplications of special compositesespeciallyinstrategic areas.

ReferenceBooks

1	*VanVlackL.H, ElementsofMaterialsScience andEngineering,6th edition,AddisonWiley,1989*
2	*BillmeyerF., 'Textbookof PolymerScience',WileyInterscience,1994*
3	RichersonD.W.,'ModernCeramicEngineering-Properties Processingand UseinDesign',3rd edition, CRC press,2006
4	Carter,C.Barry,Norton,M.Grant,CeramicMaterials:ScienceandEngineering,2nd Edition, Springer,2013
5	DonaldR.AskelandandPradeepphule, ThescienceandEngineering of Materials. Thomson, 2003

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Selectdifferentmaterialsother thanconventionalmetals andalloys for specific engineering applications	5	3	1,2
CO2	Solvethematerialsproblems associated with theweightreductionthroughtheappropriate choiceofpolymers,ceramics, andcomposites	5	3	1,2
CO3	Describetheselectioncriterion forpolymers,ceramicsandcompositesforvarious engineering applications	5	3	1,2
CO4	Analyze differentmicrostructuresof polymers,ceramics andcomposites andalterthem accordingtoapplicationsrequirements	5	3	1,2

CO5	Emphasis the need of modern materials over conventional metal and alloys	5	3	1,2

CourseCode	:	MTHO11					
CourseTitle	:	Advanced Thermodynamics ofMaterials					
NumberofCredits		4					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	:	MTPC11					
CourseType	:	HONOURS					

CourseLearningObjectives

Tobecomefamiliarwithrecentdevelopmentsinthermodynamicsandapplications;andgetexposed to thermodynamicmodellingactivity

CourseContent

Reviewofthermodynamics –metallurgical,mechanical andstatistical perspectives
Experimentalprocedures relatedtoThermodynamics– calorimetry,activity measurements, interactionco-efficient, andelectrochemical cells
ThermodynamicsofDefects–Theoreticalcalculationsandpractical significance

Applicationofthermodynamicstosurfaces,interfaces,bulkmetallicglasses,high-entropysystems andnovelmaterials

Modelingtechniquesusedinthermodynamics ofmaterials-Inthecontext ofphasediagrams,free energycalculations,electrochemicalcells,corrosion,solution thermodynamics,slagsandalloy development;exposuretotechniquesincomputational materialsscience;introduction to thermodynamicsofnanosystems

ReferenceBooks

1	*D. R. Gaskell,Introductionto the ThermodynamicsofMaterials,4thE,Taylor &Francis,NY2003*
2	*R.T. Dehoff,Thermodynamics in MaterialsScience,1st and2ndEdition,McGraw-Hill, 2006.*
3	*D. V.Ragone,Thermodynamics ofMaterials, Vol.1&2, JohnWiley&Sons,1994.*
4	*RichardA Swalin, Thermodynamics of Solids,JohnWiley &Sons,1994.*
5	*S. A.PorterandK. E. Easterling, PhaseTransformationinMetalsandAlloys,2ndEdition, ChapmanandHall, 1992.*
6	*J.J. Moore, Chemical Metallurgy, 2ndEdition, Butterworths,1990.*
7	*Currentliterature, openwebresources andmaterials forcasestudy*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Perform experiments related to thermodynamics using calorimetry and electrochemical cells	1	5	2,3,4
CO2	Establish the practical significance of defects on properties of engineering materials through thermodynamics		1	2
CO3	Usethermodynamicsasa toolfordevelopingmetals andmaterials	1	2	3,4
CO4	Developnextgenerationmaterialswith superior properties	1	2	3,4

CourseCode	**:**	MTHO12
CourseTitle	**:**	Crystallography
NumberofCredits		3

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	0	0	3	3

Prerequisites(Coursecode)	**:**	MTPC12
CourseType	**:**	HONOURS

CourseLearningObjectives

Tostudystructurepropertycorrelations

CourseContent

Motif,lattices,latticepoints,latticeparameter,Crystalsystems,14 Bravicelattices,Coordination number,numberofatomsperunitcell,packingfactor,Millerindicesofplanesdirections, repeatdistance,lineardensity packingfactor alongadirection, planar density, planarpackingfraction

Radiusrationforcoordinationnumber 2,4,6,8. Interstitialsolidsolution,Interstitialcompounds. AX,AX2,AB03A2B04crystal structures

Frenkel- Schkottyionic defects,Ionicdefect concentration,soluteincorporation, Electronic defectElectronicdefect concentration

BandGap, densityofstates, defects. Defectsandchemical reaction.

Symmetryandcrystallography. Symmetryincrystals.Rotational symmetry,stereographicprojection. Crystallographic point groups, microtranslations, symmetry of reciprocal lattice, systematic absences,spacegroups specialposition

ReferenceBooks

1	Donald E. Sands, Introduction to crystallography, Courier Corporation, 2012
2	DonaldR.AskelandandPradeepphule, ThescienceandEngineering Materials.Thmson,2003
3	CullityB.D., Elementsof X-raydiffraction, Addison-WesleyPublishingcompany 1956

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Recollect the fundamentals of crystal structure and perform relevant numerical calculation		3	1,2
CO2	Distinguish various type of various interstitial solid solution, compounds and intermetallics		1,4	2,3
CO3	Describe the ionic defect concentration and their influence on material properties		3	1,2
CO4	Demonstrate the importance defects on material properties.		4	1
CO5	Understandthecorrelationbetweensymmetryandproperties		3	1,2

CourseCode	**:**	MTHO13
CourseTitle	**:**	AerospaceMaterials
NumberofCredits		4

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	1	0	4	4
Prerequisites(Coursecode)	**:**	NIL				
CourseType	**:**	HONOURS				

CourseLearningObjectives

Tolearn aboutAerospacecomponentsandCriticalrequirementsofmaterials
Todevelopan understandingof thedifferent typeofmaterials used inaerospaceandfutureneeds. Assess thesurfacetestingmethods andcomprehendthe degradationproperties

CourseContent

ClassificationanddifferentcomponentsinAircraft,HelicopterandRocket–PropertiesofMaterials-Airworthiness-Aerospace materialdesigndrivers-QualityStandardsforaerospaceindustry-Materials requirementsfor aerospacestructures, EnginesandRockets

Mechanicalanddurabilitytesting ofaerospace materials–Aerospacematerialscertification- Structuralhealth monitoringandnon-destructivetestingofaircraftcomponents-Corrosionand corrosiontestingof aerospacematerials–Materials selectionfor aerospace,spaceenvironments and its effectonmaterials–stealthtechnology, Yieldstrengthanomaly(Kerf-WilsdorfMechanism)

MaterialsforGasturbine-Ni-basedsuperalloys- Intermetallics-Ti-Alalloy–Bondcoat-Thermalbarrier coating(plasmaspraying)-Materials forRocket combustionchambersandNozzles-Copperalloys-Cobalt base alloy- Stellite-Columbiumalloy

Al-Li alloys-Magnesiumalloys-Titaniumalloys-Superalloys-Stainlesssteels-Maragingsteel

Composites-Polymermatrixcomposites-Carbon-Carboncomposites-Ablativecomposites

ReferenceBooks

1	*AdrianP Mouritz,Introductionto Aerospace Materials, Woodheadpublishing,2012*
2	*Cantor,B.,Assender.H., andGrant.P(Ed),AerospaceMaterials,CRC press,2007*
3	*Reed.R.C., TheSuperalloys –Fundamentalsand Applications,CambridgeUniv.Press,2009*
4	*Campell.F.C., ManufacturingTechnology forAerospace StructuralMaterials,Elsevier,2010*
5	*KrishnadasNair,C.G.Handbookof AircraftMaterials,InterlinePublishing,1993*
6	*BalramGuptha,AerospaceMaterials,Vol. I,II,III, S.Chandpublications,1993*
7	*HorstBuhl,Advanced Aerospace Materials,Springer,2006*
8	*HarveyMFlower,HighPerformancematerials in Aerospace, Springer,2006.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Knowaboutthecomponentsused inAircraft,Rocket andHelicopter		2	1,4
CO2	Understanddifferenttypeof testingmethods for aerospacecomponents		4	1,2
CO3	Choose a suitable base material and coating material for gas turbine applications		1,2	3
CO4	Describe the properties and applications of aluminium, magnesium, titanium and stainless steel in aircrafts.		3	1,2
CO5	Demonstrate the utilization of polymer and ceramic matrix composites in aerospace applications.		3	1,2

CourseCode	**:**	MTHO14
CourseTitle	**:**	Ladle Metallurgy and Continuous Casting ofsteels
NumberofCredits		4

LTPCBreakup	**:**	L	T	P	Contact hours	C
		3	1	0	4	4

Prerequisites(Coursecode)	**:**	MTPC18
CourseType	**:**	HONOURS

CourseLearningObjectives

Todevelopan understandingof thebasicprinciples ofladle metallurgyandcontinuous casting, impart modelingskillsandtoapplythemforindustrialproblemstoenablethemtosolvetheproblems encountered inthesteel industries.

CourseContent

Terminology–scrapbasedoperationVsrefining;trends in qualityof liquidsteel;different approachestorefining; overviewofvarioustreatments includingvacuum,inertgas, injection,electro- slag. Terminologyrelatedtoinjectionmetallurgy;Ladlefurnace;advantagesandapproaches;injectibles – typeofmaterials;discussionof somespecifictreatments;impactonoverall quality;foamingof slags IngotcastingVscontinuouscasting(CC);difficultiesinCC ofsteels;increasingCCoutputinthesteel industry;mouldandmachinedetails includingdifferentcomponentsandconfigurations;SEN,Ladle andTundish

Roleofmouldpowders(fluxes)inCC;physical andchemical interactions duringCC;overviewof defectsin CC;productionstoppagessuchasbreakouts;indicativeheatsizes andmachineoutput; conceptandimplementationofsequencecasting;

Overviewof processmodeling;applicationsin ladle metallurgyandCC;mathematicalmodelingof solidification;physicalmodelingof fluidflowinCC;casestudiesfromcurrent literature

ReferenceBooks

1	*Tupkary R.H., 'Introductionto Modern SteelMaking', Khanna Publishers,2004*
2	*B.Deo,R.Boom,'Fundamentalsofsteelmakingmetallurgy',PrenticeHallInternational,New York,1993*
3	*Continuouscasting–Vol.1,'ChemicalandPhysicalInteractionsduringtransferoperations',Iron andSteelSociety,Warrendale, PA,USA,1983.*
4	*Ahindra Ghosh, 'Textbookof Materials andMetallurgical Thermodynamics',PHILearning,2002.*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understandtheterminologies used inthe fieldofladlemetallurgyandcontinuouscastingof steels		2	1
CO2	Classifydifferentkinds oftreatmentsforthe steelduringmanufacturing		5	1,2
CO3	Compare thecapabilitiesofingotcastingandcontinuous casting		2	4
CO4	Applythe basicmodelingskills in theareaof ladlemetallurgyandcontinuouscasting		3	4,5

CourseCode	**:**	MTHO15					
CourseTitle	**:**	Recent Trends inNanomaterials					
NumberofCredits		4					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	**:**	NIL					
CourseType	**:**	HONOURS					
CourseLearningObjectives							
Toprovideanunderstandingofthevariousconceptsinvolvedinfabricationofnanomaterialandthe focus isontechnologicalapplications invariousfieldsof scienceandengineering.							
CourseContent							

Synthesisof NanomaterialsRecent advancesinPhysical VaporDeposition(PVD),pulsed laser deposition,Magnetronsputtering,Multi BeamEpitaxy, Arc-Discharge,Chemical Vapor Deposition (CVD),AtomicLayerDeposition(ALD)-Microlithography, Vapor(or solution) –liquid–solid(VLSor SLS) growth - pulsedelectrochemical deposition–Super PlasticDeformation, Highenergyballmilling, Chemical-Mechanicalmilling, Electroexplosion,Laserablation.

Nanotechnologyin Electronics andEnergyNanoelectronic devices andcircuits–Semiconductor Memories-DynamicRadomAccessMemory-NonvolatileSemiconductor Memories- QuantumDot based MemoryCell- Sensors;physicalandchemical-Electronic noses- Actuators-MicroandNano-Electromechanicalsystems– LightingandDisplays–Quantumoptical devices-Lasers–Batteries–Supercapacitors- Fuelcells–Roleof nanomaterials in fuel cellapplications-Photovoltaic cells–Applicationof nanotechnologyinsolarcells- Applicationofpower intransportationincludingspace

Nanotechnologyin Biomedical IndustryNanoparticlesandMicro–organism-Biosensors- Bioreceptors andtheir properties- Biochips- Integrated nanosensornetworks for detectionandresponse- Natural nanocompositesystems;spidersilk,bones,shells-Nanomaterialsin bonesubstitutes anddentistry– Tissue Engineering –Neuroscience-Neuro-electronic Interfaces -Nanorobotics—ProteinEngineering –Nanosensorsin Diagnosis–Drugdelivery–Cancertherapyandothertherapeuticapplications.

Nanotechnologyin AgricultureandFoodSectorNanotechnologyin Agriculture-Precisionfarming, Smartdeliverysystems–Insecticides usingnanotechnology– Potentialof nano-fertilizers–Potential benefits inNanotechnologyin Foodindustry–GlobalChallenges- ProductinnovationandProcess improvement-Consumer benefits- Foodprocessing -Packaging- -Packingmaterials;physical properties-Improvementsofmechanicalandbarrierproperties- Antimicrobialfunctionality-Active packagingmaterials- -Informationandcommunicationtechnology-Sensors- RF identification- Food safety-Nanomaterial basedFooddiagnostics –Contaminantdetection–Intelligent packaging- NanoengineeredFoodingredients-Potential riskstoNanofoodtoconsumers

NanotechnologyinDefenceandAerospacePathwaysto Physical protection-Detectionand diagnosticsof chemical andbiologicalagents,methods- Chemical andBiologicalcountermeasures- Decontamination-Postexposureandpreexposureprotectionanddecontamination- Nanotechnology enabled biochemicalweapons- Influenceoperations-Evasionofmedical countermeasures-Nanotechnologybasedsatellitecommunicationsystem- Guidance,Navigationandcontrol-Spacecraftthermal control-mini,micro, nanosatelliteconcepts- FiberopticandChemical microsensors for spacecraftandlaunch support-Micro/Nanopressureandtemperature sensors for spacemissions.

ReferenceBooks

1	B.S. Murty, P. Shankar, Baldev Raj, B B Rath, James Murday, Textbook of Nanoscience and Nanotechnology, University Press (I) Pvt. Ltd., 2013
2	Charles P.Poole, Jr., Frank J. Owens,"Introduction to nanotechnology", Wiley,2003
3	Gunter Schmid, "Nanoparticles:From TheorytoApplications", Wiley-VCHVerlagGmbH &Co., 2004.
4	Bharat Bhushan,"SpringerHandbookof Nanotechnology", Barnes&Noble, 2004.
5	Neelina H.Malsch (Ed.),"Biomedical Nanotechnology", CRCPress2005.
6	W.N. Chang, "Nanofibresfabrication, performanceand applications", Nova SciencePublishers Inc, 2009.
7	MargaretE,Kosal,"Nanotechnologyfor Chemicaland Biological defence", Springer2009.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	chooseatailor madesynthesisrouteaccording totherequirementsoftheendproduct.		1,2	3

CO2	provideinstancesof contemporaryindustrial applicationsof Nanotechnology.		4,12	1,2
CO3	Toprovideanoverview offuturetechnological advancementsandincreasingrole of nanotechnologyin industries.		2,4,6	5,12

CourseCode	**:**	MTHO16					
CourseTitle	**:**	Advanced Solidification Processing					
NumberofCredits		3					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	**:**	MTPC19					
CourseType	**:**	HONOURS					

CourseLearningObjectives

Astudyofimportantthermodynamicfunctionsrelatedtosolidificationofmetalinmoldsinvolving the characteristicsof liquid-solid phase transformations, laws of thermodynamics and other functions.
To analyzesolidificationprocessingof engineeringmaterials in terms of the phase equilibrium, transport, andinterfacephenomenagoverning microstructuredevelopmentinliquid-solid transformations.
Toapplytheseprinciples toindustrialsolidificationprocesses,withemphasison microstructural capabilitiesandlimitations.Assessthesurface testing methodsandcomprehendthedegradation properties

CourseContent

Introductionandimportantthermodynamic functions: Lawsof thermodynamics-enthalpy, heat capacity,applications offirstlawtoopen andclosed systemsincludingchemicalreactions;entropy, freeenergyandtheir interrelationships
Thermodynamicsofsolidification;Nucleationandgrowth;Puremetal solidification, Alloy Solidification,Constitutional undercooling, Mullins-Sekerka instability;Single phasesolidification: Cellularand Dendriticgrowth; Multiphasesolidification: eutectic,peritecticandmonotectic; Modellingof solidification
Heterogeneous systems –equilibriumconstants,Ellingham-Richardsondiagrams,predominantarea diagrams, principlesoffreeenergyminimization;energybalanceof industrialsystems;solutions- chemical potential,Raoult/Henry'slaw,Gibbs-Duhemequations, regularsolutions, quasi chemical theory
EvolutionofPhasediagrams-phaserule,free-energy-compositiondiagrams, solidus-liquidus lines, retrogradesolidus;determinationof activityandotherthermodynamicparameters fromphase diagrams;thermodynamicanalysisof ternaryandmulti component systems, interactionparameters
Principlesof applications- principles ofapplications tomoltenslagsandsilicate melts; electrochemicalmethods andapplications, aqueous systems;Interfaces-energy,shape,segregationat externalandinternal interfaces;solidelectrolytes;Effectof highpressureonphasetransformations; Pointimperfections incrystallinesolids.

ReferenceBooks	
1	SolidificationProcessing;Fleming,M.C., McGraw-Hill,N.Y., 1974
2	FundamentalsofSolidificationbyKurz, W. andFisher,D.J., Trans-TechPub,Switzerland, 1989

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand thermodynamicsofsolidificationprocessesandalloys.			1,2
CO2	Do thermodynamicmodellingof solid-liquidphasechangeandsolutions		2,3	4,5
CO3	Describe kinetics of solidificationsuchasnucleation, growth,and constitutional super coolingand Multiphasesolidification.		4	1,2
CO4	Perform thermodynamicanalysisofternaryandmulticomponentsystem		1,5	2,4

CourseCode	**:**	MTHO17					
CourseTitle	**:**	Recent DevelopmentsinWelding Processes					
NumberofCredits		4					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	**:**	MTPC21					
CourseType	**:**	HONOURS					

CourseLearningObjectives

- Understandthevarious advancements in weldingprocesses.
- Gain knowledgeof the concepts, operating procedures, applications, advantages and limitationsofvariousrecentweldingprocesses.

CourseContent

GMAW,typesofmetal transfer, CO2welding, pulsedandsynergicMIGweldingandsurfacetension transfer, CMT-Concepts,processesandapplications.

KeyholeTIG, Narrowgap TIG, coldandhotwireTIG, dual shieldingTIG,multi cathodeTIG, buried arc TIG, A-TIG, AA-TIG,micro-plasma arcweldingandAC/DCsubmerged arcweldingprocess, twin wire SAW,tandemSAW,metalpoweradditionSAW. coldandhotwire-SAW.

MIAB,MicrowaveweldingConcepts,processesandapplications,typesofmetaltransfer and applications, advances in diffusion welding, advancesinelectronbeamwelding, laser welding, resistancewelding, flashbuttweldingandunderwaterwelding-concepts, typesandapplications. Metalflowphenomenainfrictionstir welding, tooldesign, retreatingtool,frictionstir spotwelding, frictionstir processing, linear friction welding, orbitalfrictionweldingprocessesandapplications. Advancesinadhesivebonding, Brazingandsoldering

Cladding, CVD,PVD,Laserandelectronbeamsurfacemodification,ionimplantation, andCutting

ReferenceBooks	
1	*Parmer R.S., 'Welding Engineering and Technology',Khanna Publishers,1997*
2	*Cary, Howard,"Modern Welding Technology', prentice Hall, 1998*
3	*SchwartzM.,'Materialsand Applications- MetalJoining Manual', McGraw-Hill,1979*

4	*Nadkarni S.V., 'Modern Arc Welding Technology', Oxford IBHPublishers, 1996*
5	*ChristopherDavis,'LaserWelding- A Practical Guide', JaicoPublishing House,1994*
6	*Mishra.R.S andMahoney.M.W,FrictionStir WeldingandProcessing, ASM,2007*

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Explainthevarious advancementsinGMWandtheir applications		2	1
CO2	Explainthevarious advancementsinTIG weldingandtheir applications			1,2
CO3	Explainthevarious advancementsinMIAB,microwavewelding, EBW,Laserandresistance weldingandtheir applications		5	1,2
CO4	Describethevarious advancementsinunderwaterweldingandtheir applications		5	1,4
CO5	Explainthevarious advancementsinFSWandtheir applications			1
CO6	Explainthevarious advancementsinsurfacing methods andtheir applications		3,5	1

CourseCode	**:**	MTHO18					
CourseTitle	**:**	Recent DevelopmentsinForming Processes					
NumberofCredits		4					
LTPCBreakup	**:**	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites(Coursecode)	**:**	MTPC21					
CourseType	**:**	HONOURS					

CourseLearningObjectives

Tounderstandtheconcepts of advancedformingprocessesandtheir applications.

CourseContent

Ringrolling:typesandclassification. Ringrolling of steels andnonferrous alloys-defects,remedialactions.Ringrollingmills.

Incremental bulk forming:Orbital riveting- types,orbital forgingprocesses-types, Advantages and limitations.Pressesandmodifications needed forthe incremental bulk forming.

Superplastic forming:Superplasticity –definition,types, structuralSuperplasticity–Superplastic materials–metals/alloys, compositesandceramics. Superplastic formingmethods. Advantagesand Limitations.

Pressingandsintering:Productionof simple andcomplicatedshapes–sequenceofoperation–sintering –mechanisms-near netshapeproduction- Advantages andlimitations

Isostaticpressing:Definition–stresstensor inIsostaticconditions–types–nearnetshape production-Advantagesandlimitations

ReferenceBooks

1	Numerical Analysis-TheoryandApplication–Edited by john Awreicewicz, In Techpublisher,2011.
2	J.M. Allwood, A.E.Tekkaya,T.F. Stanistreet,The developmentofringrollingtechnology, SteelRes Int,76(2005),pp. 111–120

3	J.M. Allwood, A.E.Tekkaya,T.F. Stanistreet,The developmentofringrollingtechnology-part2: investigationof processbehaviorandproductionequipment,SteelResInt,76(2005),pp. 491–507.
4	Edwards,L. andEndean, M., Manufacturingwith materials,1990,Butterworth Heinemann
5	GrocheP., FritscheD., TekkayaE.A., AllwoodJ.M., HirtG., NeugebauerR., Incremental bulk metal forming, Annals ofthe CIRP,56,2007,635-656.
6	Cubberly, W. H.;Ramon,Bakerjian;Societyof ManufacturingEngineers(1989), Deskedition: Tool andmanufacturingengineershandbook, SME,p.42-17, ISBN 978-0-87263-351-3
7	K.A. Padmanabhan and G.J. Davies“Superplasticity", SpringerVerlag, Berlin-Heidelberg-New York,August1980,
8	AngeloPCandSubramanian R,“PowderMetallurgy:Science Technology and Applications”,PHI, NewDelhi, 2011.

CourseOutcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	UnderstandtheConcepts of the advanced formingprocesses		2	1
CO2	Understandtheapplications ofthe advanced formingprocesses		5	1,3
CO3	Choosesuitablemetal forming process forthe givenmaterial		5	3,4

CourseCode	:	MTHO19					
CourseTitle	:	Atomic-scale simulations of Materials					
NumberofCredits		3					
LTPCBreakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites(Coursecode)	:	Nil					
CourseType	:	HONOURS					

CourseLearningObjectives

Tounderstandand perform atomic scale simulations on different materials

CourseContent

Molecular dynamics

Intoduction - Classical mechanics, molecular statics, molecular dynamics; interatomic potentials, Solution for Newton’s equations of motion – different algorithms,

Initialization and Integration, energy minimization, estimation of thermodynamic properties, structural properties, thermal properties

Atomistic simulations of macromolecules, coarse grain methods, lattice modeling and simulation of polymers

Monte Carlo methods

Introduction, ensembles, algorithms, monte carlo for atomic systems, Modified monte carlo methods- Kinetic monte carlo method

Applications of monte carlo in materials research applications in polymer system, nucleation and grain growth

ReferenceBooks

1	Lesar, R., Introduction to computational materials science: Fundamentals to applications, Cambridge

2	Lee, J.G., Computational Materials Science: An Introduction, CRC Press, Boca Raton, 2017
3	Ohno K, Esfarjani k, Kawazoe Y, Computational materials science: From ab-initio to monte carlo methods, 2nd Ed, Springer-Verlag GmbH Germany, 2018

CourseOutcomes	
At the end of the course, students will be able to	
CO1	Understand the fundamental of molecular dynamics simulations and interatomic potentials.
CO2	Predict the thermodynamic and structural properties of materials through MD simulations.
CO3	Perform molecular dynamics simulations of polymeric materials
CO4	Understand the concepts of monte carlo simulations and its applications
CO5	Utilize the nucleation and grain growth studies using monte carlo method