B.Tech.

in

METALLURGICAL AND MATERIALS ENGINEERING

FLEXIBLE CURRICULUM

(For students admitted from 2024-25 onwards)

DEPARTMENT OF METALLURGICAL AND MATERIALS ENGINEERING

NATIONAL INSTITUTE OF TECHNOLOGY

TIRUCHIRAPPALLI – 620 015

TAMIL NADU, INDIA

(in tune with Institute guidelines (2024) for NEP and multiple exits)

(Board of Studies Meeting, BTech MME August 16 2024)

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

CURRICULUM FRAMEWORK AND CREDIT SYSTEM FOR THE FOUR-YEAR B.Tech. and 3 Year B.Sc. (Engineering) PROGRAMME

COURSE STRUCTURE

Course Category	Courses	No. of Credits	Weightage (%)
GIR (General Institute Requirements)	22	56	34.7
PC (Programme Core)	15	52 – 55**	33.1
Programme Elective (PE) / Open Elective (OE)	12	36	22.3
Essential Laboratory Requirements (ELR)	8 Maximum 2 per session up to 6th semester	16	9.9
Total	**57**	**160+3**	**100**
Minor (Optional)	Courses for 15 credits	15 Additional credits	-
Honors (Optional)	Courses for 15 credits	15 Additional credits	-

1. **A minimum of seven Programme Core, each carrying 4 credits (II, III, IV, V, VI Semester).**
2. **Out of the 12 elective courses (PE / OE), students must complete at least eight Programme Electives (PE).**
3. **For a Minor Degree (MI), students must earn 15 credits in addition to the credit specified by the departments (160 credits), with the details of the Minor only mentioned on the transcript, not the degree certificate.**
4. **To qualify for an Honours Degree (HO), students must: (a) register for at least 12 theory courses and 2 ELRs in their second year, (b) consistently maintain a minimum CGPA of 8.5 during the first four sessions, (c) maintain a minimum CGPA of 8.5 in all sessions excluding honours courses, (d) successfully completed additional courses totaling 15 credits (3 numbers of 4 credit course and 1 number of 3 credit course), and (e) achieve at least a B grade in Honours courses, which must be distinct and at a higher level than PC and PE courses, preferably M. Tech. courses. Honours courses cannot be treated as programme electives and grades from these courses do not factor into CGPA calculations.**
5. **Project work is compulsory for B. Tech. programme. However, those students wish to carry out the intern outside the institute (8th semester) can opt for two electives courses equivalent to 6 credits. But the project work is compulsory for B. Tech. (Honours) degree**

The total minimum credits for completing B.Tech. Programme in Metallurgical and Materials Engineering is **163.**

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Tech.

Semester	GIR		PC		ELR		PE/OE		Total Credits	Credit Distribution
	Course	Credit	Course	Credit	Course	Credit	Course	Credit		
I	7	19	-	-	-	-	-	-	19	**40**
II	8	17	1	4	-	-	-	-	21	
III	1	4	4	14	2	4	1	3	25	**50**
IV	-	-	3	12	2	4	3	9	25	
V	1	3	4	15	2	4	1	3	25	**49**
VI	2	4	3	10	2	4	2	6	24	
VII	2	3	-	-	-	-	4	12	15	**24**
VIII	1	6	-	-	-	-	1	3	9	
Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

CURRICULUM FRAME WORK / FLEXIBLE CURRICULUM / NEP 2020 / NCrF / B.Sc. (Engineering)

	Sem	GIR		PC		ELR		PE/OE		Total Credits	Credit Distri-bution
		Course	Credit	Course	Credit	Course	Credit	Course	Credit		
Same as B.Tech.	**I**	7	19	-	-	-	-	-	-	**19**	**40**
	II	8	17	1	4	-	-	-	-	**21**	
	III	1	4	4	14	2	4	1	3	**25**	**50**
	IV	-	-	3	12	2	4	3	9	**25**	
B.Sc. Exit	**V**	1	3	2	8	2	4	1	3	**18**	**34**
	VI	4@	12	-	-	2	4	-	-	**16**	
After B.Sc. exit and join back for B. Tech.	**VII**	-	-	3	10	-	-	4	12	**22**	**39**
	VIII	1	1	2	7	-	-	3	9	**17**	
	Total	**22**	**56**	**15**	**55**	**8**	**16**	**12**	**36**	**163**	**163**

@(Summer internship (2), Project Work (6) Professional Ethics (3), and Industrial Lecture (1))

Curriculum Framework and Credit System (MME) / 163

Semester I (July Session)

	Course Code	Course Title	Credits	Category
1.	HSIR11	English for Communication (Theory and Laboratory)	4	GIR
2.	MAIR11	Matrices and Calculus	3	GIR
3.	CHIR11	Chemistry	3	GIR
4.	MTIR15	Introduction to Metallurgical and Materials Engineering	2	GIR
5.	EEIR11	Basics of Electrical and Electronics Engineering	2	GIR
6.	MEIR12	Engineering Graphics	3	GIR
7.	CHIR12	Chemistry Laboratory	2	GIR
		Total	**19**	

Semester II (January Session)

Sl. No.	Course Code	Course Title	Credits	Category
1.	MAIR21	Complex Analysis and Differential Equations	3	GIR
2.	PHIR11	Physics (Non-circuit)	3	GIR
3.	CSIR12	Introduction to Computer Programming (Theory and Laboratory)	3	GIR
4.	CEIR11	Basics of Civil Engineering (**for CL, ME, MT, PR**)	2	GIR
5.	ENIR11	Energy and Environmental Engineering	2	GIR
6.	PRIR11	Engineering Practice	2	GIR
7.	PHIR12	Physics Laboratory (Non-circuit)	2	GIR
8.	SWIR11	NSS / NCC / NSO	0	GIR
9.	MTPC11	Programme Core – 1 / Metallurgical Thermodynamics and Kinetics	4	PC
		Total	**21**	

Semester III (July Session)

Sl. No.	Course Code	Course Title	Credits	Category
1.	MAIR41	Fourier Series and Numerical Methods	4	GIR
2.	MTPC12	Programme Core – 2 / Physical Metallurgy	4	PC
3.	MTPC14	Programme Core – 3 / Transport Phenomena	4	PC
4.	MTPC16	Programme Core – 4 / Polymers, Composites and Ceramics	3	PC
5.	MTPC13	Programme Core – 5 / Engg. Mechanics and Strength of Materials	3	PC
6.		Programme Elective – 1	3	PE
7.	MTLR30	Process Metallurgy Laboratory	2	ELR
8.	MTLR31	Polymers, Composites and Ceramics Laboratory	2	ELR
		Total	**25**	

Note: Department(s) to offer Minor (MI) Course and Online Course (OC) to those willing students in addition to 24 credits.

Semester IV (January Session)

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTPC15	Programme Core – 8 / Mechanical Behavior and Testing of Materials	4	PC
2.	MTPC17	Programme Core – 6 / Iron Making and Steel Making	4	PC
3.	MTPC18	Programme Core – 7 / Phase Transformation and Heat Treatment	4	PC
4.		Programme Elective – 2	3	PE
5.		Programme Elective – 3	3	PE
6.		Programme Elective – 4 / Open Elective – 1	3	PE/OE
7.	MTLR32	Metallography and Heat Treatment Laboratory	2	ELR
8.	MTLR33	Materials Testing and Inspection Laboratory	2	ELR
		Total	**25**	

Semester V (July Session) / Continuing B.Tech.

Sl. No.	Course Code	Course Title	Credits	Category
1.	HSIR13	Industrial Economics	3	GIR
2.	MTPC19	Programme Core – 11 / Materials Characterization	4	PC
3.	MTPC20	Programme Core – 9 / Metal Casting Technology	4	PC
4.	MTPC22	Programme Core – 10 / Metal Forming Technology	4	PC
5.	MTPC21	Programme Core – 12 / Materials Joining Technology	3	PC
6.		Programme Elective – 5 / Open Elective – 2	3	PE/OE
7.	MTLR34	Foundry and Welding Laboratory	2	ELR
8.	MTLR35	Metal Forming and Particulate Processing Laboratory	2	ELR
		Total	**25**	

Semester V (July Session) / B.Sc. (Engineering) Exit

Sl. No.	Course Code	Course Title	Credits	Category
1.	HSIR13	Industrial Economics	3	GIR
2.	MTPC19	Programme Core – 9 / Materials Characterization	4	PC
3.	MTPC22	Programme Core – 10 / Metal Forming Technology	4	PC
4.		Programme Elective – 5 / Open Elective – 2	3	PE/OE
5.	MTLR34	Foundry and Welding Laboratory	2	ELR
6.	MTLR35	Metal Forming and Particulate Processing Laboratory	2	ELR
		Total	**18**	

Semester VI (January Session)

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTIR19	Industrial Lecture	1	GIR
2.	MTIR14	Professional Ethics	3	GIR
3.	MTPC25	Programme Core – 13 / Corrosion and Surface Engineering	4	PC
4.	MTPC23	Programme Core – 14 / Non-ferrous Physical Metallurgy	3	PC

5.	MTPC24	Programme Core – 15 / Electrical, Electronic and Magnetic Materials	3	PC
6.		Programme Elective – 6	3	PE
7.		Programme Elective – 7 / Open Elective – 3	3	PE/OE
8.	MTLR36	Non-ferrous Metallography and Characterization Laboratory	2	ELR
9.	MTLR37	Corrosion and Surface Engineering Laboratory	2	ELR
		Total	**24**	

Semester VI (January Session) / B.Sc. (Engineering) Exit

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTIR16	Summer Internship / Industrial Training / Academic Attachment*	2	GIR
2.	MTIR17	**Project Work**	6	GIR
3.	MTIR14	Professional Ethics	3	GIR
4.	MTIR19	Industrial Lecture	1	GIR
5.	MTLR36	**Non-ferrous Metallography and Characterization Laboratory**	2	ELR
6.	MTLR37	Corrosion and Surface Engineering Laboratory	2	ELR
		Total	**16**	

Semester VII (July Session)

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTIR16	Summer Internship / Industrial Training / Academic Attachment*	2	GIR
2.	MTIR18	Comprehensive Viva Voce	1	GIR
3.		Programme Elective – 8	3	PE
4.		Programme Elective – 9	3	PE
5.		Programme Elective – 10 / Open Elective – 4	3	PE/OE
6.		Programme Elective – 11 / Open Elective – 5	3	PE/OE
		Total	**15**	

** Evaluation for Summer Internship*

Semester VII (July Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTPC20	**Programme Core – 11 / Metal Casting Technology**	4	PC
2.	MTPC21	**Programme Core – 12 / Materials Joining Technology**	3	PC
3.	MTPC23	**Programme Core – 13 / Non-ferrous Physical Metallurgy**	3	PC
4.		Programme Elective – 6	3	PE
5.		Programme Elective – 7	3	PE
6.		Programme Elective – 8 / Open Elective – 3	3	PE/OE
7.		Programme Elective – 9 / Open Elective – 4	3	PE/OE
		Total	**22**	

Semester VIII (January Session)

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTIR17	Project Work / Equivalent no. of Electives	**6**	GIR
2.		Programme Elective – 12 / Open Elective – 4	3	PE/OE
		Total	**9**	

Semester VIII (January Session) / Rejoins B.Tech. after B.Sc. (Engineering) exit

Sl. No.	Course Code	Course Title	Credits	Category
1.	MTIR18	Comprehensive Viva Voce	1	GIR
2.	MTPC25	**Programme Core – 14 / Corrosion and Surface Engineering**	4	PC
3.	MTPC24	**Programme Core – 15 / Electrical, Electronic and Magnetic Materials**	3	PC
4.		Programme Elective – 10	3	PE
5.		Programme Elective – 11 / Open Elective – 5	3	PE/OE
6.		Programme Elective – XII / Open Elective – 6	3	PE/OE
		Total	**17**	

Credits:

Semester	I	II	III	IV	V	VI	VII	VIII	Total
B.Tech.	19	21	25	25	25	24	15	9	**163**
B.Sc. *	19	21	25	25	18	16	22	17	**163**

Note:

1. Curriculum should have 7 Programme Core courses shall be of 4 credits each.
2. Out of 12 elective courses (PE/OE), the students should study at least eight Programme Elective courses (PE).
3. Minor (MI): 15 credits over and above the minimum credit as specified by the departments (163). The details of MINOR will be mentioned in the transcript.
4. Honors (HO): 15 credits over and above the minimum credit as specified by the departments (163).

Electives Choices

Option 1 / Regular B.Tech.

To get a B.Tech. degree in Metallurgical and Materials Engineering, possible choices of electives in ProgrammeElectives and Open Electives are,

Programme Electives	Open Electives	Total
8	4	12
9	3	12
10	2	12
11	1	12
12	0	12

Option 2 / B.Sc. (Engineering) Exit (at end of 3rd year)

Programme Electives	Open Electives	Total
3	2	5
4	1	5
5	0	5

Option 3 / B.Tech. with Minor

To get a B.Tech. degree in Metallurgical and Materials Engineering, and Minor in other programmes, possiblechoices of electives in Programme Electives, Open Electives and Minor Electives are,

Programme Electives	Open Electives	Minor Electives	Total
8	4	5	12 + 5
9	3	5	12 + 5
10	2	5	12 + 5
11	1	5	12 + 5
12	0	5	12 + 5

Option 4 / B.Tech. with Honors

To get a B.Tech. Honors degree in Metallurgical and Materials Engineering, possible choices of electives inProgramme Electives, Open Electives, and Honor Electives are,

Programme Electives	Open Electives	Honor Electives	Total
8	4	4	12 + 4
9	3	4	12 + 4
10	2	4	12 + 4
11	1	4	12 + 4
12	0	4	12 + 4

Option 5 / B.Tech. with Honors and Minor

To get a B.Tech. Honors degree in Metallurgical and Materials Engineering, and Minor in other programmes possible choices of electives in Programme Electives, Open Electives, and Honor Electives are,

Programme Electives	Open Electives	Honor Electives	Minor Electives	Total
8	4	4	5	12 + 4 + 5
9	3	4	5	12 + 4 + 5
10	2	4	5	12 + 4 + 5
11	1	4	5	12 + 4 + 5
12	0	4	5	12 + 4 + 5

Note: No Minor or Honors will be awarded for B.Sc. But student can credit Minors and Honors during the 6 semesters, and redeem it to obtain a Minor or Honors after rejoining and completing B.Tech. Also, B.Sc. students shall do Programme Electives in place of their project work in 6th semester.

List of Courses

I. Programme Core (PC)

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

II. Electives

a. Programme Electives

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
32.	MTPE42	Principles of Extractive Metallurgy	MTPC11	3
33.	MTPE43	Modeling in Process Metallurgy	MTPE14	3
34.	MTPE44	Phase Equilibria in Materials	MTPC12	3
35.	MTPE45	Electrochemical Processing of Materials	Nil	3
36.	MTPE46	Design of Machine Elements	Nil	3

b. Open Elective (OE)

The courses listed below are offered by the Department of Metallurgical and Materials Engineering for students of all Departments.

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

c. Minor (MI) (offered for the students of other departments)

Students of other departments who desire B.Tech. Minor in Metallurgical and Materials Engineering can opt to study any 5 of the courses listed below.

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

III. Essential Laboratory Requirement (ELR)

Sl. No.	Course Code	Course Title	Prerequisites	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

IV. ONLINE COURSES (OC)

Note: Course list shall be updated regularly at the start of each Academic Year or Semester by the department NPTEL Coordinator. The students shall be able to select an online course from then available list.

V. Advanced Level Courses For B.Tech. (Honors)

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
12.	MTOH22	Advanced Microscopy Techniques		

VI. MICROCREDITS (MC) (Students can opt 3 courses of 1 credit (4 weeks) each as microcredits instead of 1 OE/OC)

Students are also advised to take 4-week courses from NPTEL/SWAYAM platform

Sl. No.	Course Code	Course Title	Credits
1.	MTMC11	Introduction to Fluid Mechanics	1
2.	MTMC12	Introduction to Mechanical Engineering	1
3.	MTMC13	Introduction to Intellectual Property Rights	1

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**	**4**
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**	**Pass/Fail**
	Total	**22**	**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.	MAIR41	Fourier Series 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**	**4**
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	Pass/Fail
Total			0

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 modelling 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 Sustainability:** 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.

<table>
<tr><td>Course Code</td><td>:</td><td colspan="5">HSIR11</td></tr>
<tr><td>Course Title</td><td>:</td><td colspan="5">English for Communication (Theory & Laboratory)</td></tr>
<tr><td>Number of Credits</td><td></td><td colspan="5">2 + 2</td></tr>
<tr><td rowspan="2">LTPC Breakup</td><td rowspan="2">:</td><td>L</td><td>T</td><td>P</td><td>Contact hours</td><td>C</td></tr>
<tr><td>2</td><td>0</td><td>2</td><td>4</td><td>4</td></tr>
<tr><td>Prerequisites (Course code)</td><td>:</td><td colspan="5">Nil</td></tr>
<tr><td>Course Type</td><td>:</td><td colspan="5">GIR</td></tr>
</table>

Course Learning Objectives

The primary objective is to develop in the undergraduate 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, classroom 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: 3, T: 0, P: 0, Contact hours: 3, C: 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: 3, T: 0, P: 0, Contact hours: 3, C: 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 Polymerization Mechanism- - 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 Laboratory					
Number of Credits		2					
LTPC Breakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co/Pre-requisites (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	T	P	Contact hours	C	
		2	0	0	2	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 nanotechnology, 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	:	Basics of Electrical and Electronics Engineering
Number of Credits		2
LTPC Breakup	:	L: 2, T: 0, P: 0, Contact hours: 2, C: 2
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

L	T	P	Contact hours	C
2	0	0	2	2

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

- 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.
- Provide neat structure of industrial drawing.
- Enables the knowledge about position of the component and its forms Interpretation of technical graphics assemblies.
- 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: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

L	T	P	Contact hours	C
3	0	0	3	3

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 (Non-circuit)					
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 Laboratory (Non-Circuit)
Number of Credits		2
LTPC Breakup	:	L: 0, T: 0, P: 2, Contact hours: 2, C: 2
Co/Pre-requisites (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	:	CSIR12
Course Title	:	Introduction to Computer Programming (Theory and Laboratory)
Number of Credits		3
Prerequisites (Course code)	:	Nil
Course Type	:	GIR

LTPC Breakup :

L	T	P	Contact hours	C
2	0	2	4	3

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 (**for CL, ME, MT, PR)**					
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	:	ENIR11
Course Title	:	Energy and Environmental Engineering
Number of Credits		2
LTPC Breakup	:	L: 2, T: 0, P: 0, Contact hours: 2, C: 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.

<table>
<tr><td>Course Code</td><td>:</td><td colspan="6">PRIR11</td></tr>
<tr><td>Course Title</td><td>:</td><td colspan="6">Engineering Practice</td></tr>
<tr><td>Number of Credits</td><td></td><td colspan="6">2</td></tr>
<tr><td rowspan="2">LTPC Breakup</td><td rowspan="2">:</td><td>L</td><td>T</td><td>P</td><td>Contact hours</td><td>C</td><td rowspan="2"></td></tr>
<tr><td>0</td><td>0</td><td>2</td><td>2</td><td>2</td></tr>
<tr><td>Prerequisites (Course code)</td><td>:</td><td colspan="6">Nil</td></tr>
<tr><td>Course Type</td><td>:</td><td colspan="6">GIR</td></tr>
</table>

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, chiselling 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

Course Code	:	MTPC11				
Course Title	:	Metallurgical Thermodynamics and Kinetics				
Number of Credits		4				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	1	0	4	4
Prerequisites (Course code)	:	NIL				
Course Type	:	PC				

Course Learning Objectives

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

Course Content

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

Second law, entropy of irreversible processes, combined statements of 1stand 2ndlaws - 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.

Reference Books

1	*Tupkary R.H., 'Introduction to Metallurgical Thermodynamics', 1stEdition, TU Publishers, 1995*
2	*Upadhyaya G.S., Dube R.K., 'Problems in Metallurgical Thermodynamics and Kinetics', 1stEdition, Pergamon Press, 1977*
3	*Ahindra Ghosh, 'Text book of Materials and Metallurgical Thermodynamics', PHI Learning, 2002.*

Course Outcomes

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
Course Title	:	Physical Metallurgy
Number of Credits		4
Prerequisites (Course code)	:	NIL
Course Type	:	PC

LTPC Breakup :

L	T	P	Contact hours	C
3	1	0	4	4

Course Learning Objectives

To develop an understanding of the basic principles of physical metallurgy and apply those principles to engineering applications.

Course Content

Crystallography - co-ordination number, effective number of atoms, packing factor, crystal system relevant to metals, indexing of crystal planes and directions in cubic and hexagonal system, linear and planar density, interplanar spacing.

Crystal imperfections and its types; point defects, dislocations- unit dislocation, partial dislocation, motion of dislocations, slip and twin crystal orientation, concept of texture, grain and grain boundaries, methods of grainsize determination.

Self-diffusion, diffusion in alloy, diffusion mechanisms, activation energy, laws of diffusion- Fick's I law,
II law, inter-diffusion and Kirkend all effect, types of diffusion and examples of diffusion; problems based on diffusion.

Solid solutions and its types and intermediate phases- Hume Rothery's rule-
solidification of metals and alloys, cooling curves, concepts of phase diagrams,
coring and segregation as applied to various binary systems, ternary systems.

Thermodynamic properties of binary metallurgical systems, free energy – composition curves and their relation to phase diagrams of different types; ternary phase diagram - Gibbs phase triangle.

Reference Books

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

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the geometry and crystallography of crystalline materials; Identify planes and directions in crystal systems.	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	Apply thermodynamic concepts in the construction of phase diagrams	5	2, 4	1

Course Code	:	MTPC13					
Course Title	:	Engineering Mechanics and Strength of Materials					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course code)	:	NIL					
Course Type	:	PC					

Course Learning Objectives

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.

Course Content

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.

Reference Books

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.

Course Outcomes

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

Course Code	:	MTPC14
Course Title	:	Transport Phenomena
Number of Credits		4
LTPC Breakup	:	L: 3, T: 1, P: 0, Contact hours: 3, C: 4
Prerequisites (Course code)	:	NIL
Course Type	:	PC

Course Learning Objectives

To understand basic concepts related to heat flow, fluid flow, mass transfer, in the context of metallurgical processes; to become familiar with the mathematical treatment and equations related to above transport phenomena; to comprehend the science behind process modelling.

Course Content

Fluid Flow- Viscosity –differential mass and momentum balances–overall momentum balance–mechanical energy balance–applications

Heat Transfer –heat conduction equation– applications – steady and transient heat conduction. Two-dimensional heat conduction

Convective heat transfer –concept of heat transfer coefficient–forced and free convection; Radiation – view factor - radiative heat exchange between surfaces

Mass Transfer- Diffusion: Diffusivity in gases, liquids, solids–convective mass transfer–concept of mass transfer coefficient

Dimensionless analysis–Rayleigh's method, Buckingham method–use of differential equations – similarity criteria– applications in physical modelling

Reference Books

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

Course Outcomes

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

Course Code	:	MTPC15					
Course Title	:	Mechanical Behaviour and Testing of Materials					
Number of Credits		4					
LTPC Breakup	:	L	T	P	Contact hrs	C	
		3	1	0	4	4	
Prerequisites (Course code)	:	MTPC12					
Course Type	:	PC					

Course Learning Objectives

To know the fundamental concepts of mechanical behavior of materials, various mechanical testing practices and to apply them to design the materials for various load-bearing structural engineering applications.

Course Content

Elastic and plastic deformation, stress-strain relationship; plastic deformation of metallic materials, Mohr's circle, yielding criterion- Von Mises, and maximum-shear-stress/Tresca yielding criterion, failure criteria under combined stresses

Elements of theory of plasticity, dislocation theory, properties of dislocation, stress fields around dislocations, elementary dislocation interactions; application of dislocation theory to work hardening and strengthening mechanisms.

Engineering stress-strain curve, true stress-strain curve, instability intension, stress distribution at the neck, ductility measurement, effect of strain rate and temperature on flow properties, testing machines, Tensile properties of important materials.

Introduction, Brinell, Vickers and Rockwell hardness tests, Meyer hardness, analysis of indentation by an indenter, relationship between hardness and the flow curve, microhardness tests, hardness conversion; hardness at elevated temperatures. Introduction to torsion, torsional stresses for large plastic strains, types of torsion failures torsion test vs. tension test, hot torsion testing.

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; super plasticity.

Reference Books

1	Dieter G.E., 'Mechanical Metallurgy', 3rd Edition, McGraw Hill 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 of Metallic Materials', BS Publications, 2018

Course Outcomes

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

Course Code	:	MTPC16
Course Title	:	Polymers, Composites and Ceramics
Number of Credits		4
LTPC Breakup	:	L: 3, T: 1, P: 0, Contact hours: 4, C: 4
Prerequisites (Course code)	:	Nil
Course Type	:	PC

Course Learning Objectives

To develop the basic knowledge of materials particularly ceramics, polymers and composites other than conventional metals and alloys to apply them to advance engineering applications

Course Content

Introduction - as a material, classification, types of polymerizations, mechanisms, statistical approach, catalysts in polymerization, molecular weight determination, methods of molecular weight characterization

Plastic compounding of plastics mechanical, thermal, optical, electrical properties with reference to important engineering plastics- LDPE, HDPE, PVC, polyester, phenol formaldehyde, alkyds, cellulose, elastomers

Fabrication technology and polymer processing, moulding practices, extrusion; application of polymers and plastic fibers, elastomers, adhesives, bio-medical applications, fiber reinforced plastics, conducting polymers

Introduction to ceramic materials; general properties of ceramics; and classification of ceramic materials; Bonding and structure of oxide and non-oxide ceramic materials;

Introduction to ceramics processing; Structure–property correlation in ceramic materials; Selection of ceramic materials for different applications

Reference Books

1. *Billmeyer F., 'Textbook of Polymer Science', 3rd Ed., Wiley Interscience, 2007*
2. *Richerson D.W., 'Modern Ceramic Engineering- Properties Processing and Use in Design', 3rd edition, CRC press, 2006*
3. *Carter, C. Barry, Norton, M.Grant, Ceramic Materials: Science and Engineering, 2nd Edition, Springer, 2013*

Course Outcomes

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 material 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

Course Code	:	MTLR30					
Course Title	:	Process Metallurgy Laboratory					
Number of Credits		2					
LTPC Breakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co/Pre-requisites (Code)	:	NIL					
Course Type	:	ELR					

Course Learning Objectives

To learn about the properties of minerals; to become familiar with equipment used in mineral processing, by means of experiments/demonstration of laboratory scale equipment.

Course Content

List of experiments:

1. Observation of mineral samples
2. Determination of Crushing efficiency of Jaw crusher
3. Determination of Particle Size Distribution using Sieve Analysis
4. Estimation of Screening Rate
5. Estimation of Settling rate in Sedimentation
6. Demonstration of Froth Floatation
7. Viscosity Measurement
8. Proximate analysis of coal
9. Determination of mixing time in Gas-stirred ladle
10. Determination of Circulation rate in RH degasser
11. Top jetting and bottom stirring in Basic oxygen furnace

Reference Books

1	Gupta O. P. 'Elements of Fuels, Furnaces and Refractories', 2nd Edition, Khanna Publishers, 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.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the principles of particle size control and separation in minerals processing		3	1,2,4
CO2	Perform sieve analysis to determine the particle size distribution of any given sample.		4	1,2
CO3	Perform analysis of solid and liquid fuel properties			
CO4	Understand the principles of gas stirring in various units of steelmaking		3	1,2

Course Code	:	MTLR31
Course Title	:	Polymers, Composites and Ceramics Laboratory
Number of Credits		2
LTPC Breakup	:	L: 0, T: 0, P: 2, Contact hours: 3, C: 2
Co/Pre-requisites (Code)	:	MTPC16
Course Type	:	ELR

Course Learning Objectives

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

Course Content

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

Reference Books

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.

Course Outcomes

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

Course Code	:	MAIR41
Course Title	:	Fourier Series and Numerical Methods
Number of Credits		4
LTPC Breakup	:	L: 3, T: 1, P: 0, Contact hours: 4, C: 4
Prerequisites (Course Code)	:	MAIR21 and MAIR11
Course Type	:	GIR

Course Learning Objectives

1. To express periodic and non-periodic functions in terms of sinusoidal functions.
2. To provide the basic concepts of numerical methods in view of solving linear systems and nonlinear equations.
3. To introduce several methods for the interpolation of data from chemical engineering problems
4. To learn various numerical computational techniques and apply to engineering problems.
5. To train students with mathematical aspects so as to comprehend, analyze, design and create novel products and solution for the real-life problems.

Course Content

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 (PDEs); 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 ordinary differential equations (ODEs) by Euler's method, Modified Euler's method and 4th order Runge-Kutta method.

Reference Books

1	K. E. Atkinson. An introduction to numerical analysis, 2ed. Wiley & Sons, Inc, 1989.
2	R. Haberman. Applied partial differential equations: with Fourier series and boundary value problems, 4ed. Pearson, 2013.
3	M. K. Jain, S. R. K. Iyengar, and R. K. Jain. Numerical methods: For scientific and engineering computation, 7ed. New Age International Publishers, 2019.
4	E. Kreyszig, Advanced Engineering Mathematics, 10 ed. Wiley, 2011.
5	K. Sankar Rao. Introduction to partial differential equations, 3ed. PHI Learning Pvt Ltd, 2010.
6	S. S. Sastry. Introductory methods of numerical analysis, 5ed. PHI Learning Pvt Ltd, 2012.
7	Grewal, B.S., Higher Engineering Mathematics, Khanna Publishers, 2017

Course Outcomes

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

CO1	he ability to express non-periodic functions in terms of Fourier series expansion.
CO2	the knowledge about partial differential equations (PDEs) and how they serve as mathematical models for physical processes such as heat transfer problems in one-dimensional and two-dimensional cases, and one-dimensional wave equation.
CO3	the capability to adopt methodologies to solve the system of linear equations numerically for exact/approximate solutions.
CO4	the capacity to evaluate the difficult definite integrals and find approximate solutions for first order ODEs using various numerical techniques.

Course Code	:	MTPC17					
Course Title	:	Iron Making and Steel Making					
Number of Credits		4					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites (Course Code)	:	MTPC11, MTPC14					
Course Type	:	PC					

Course Learning Objectives

To know the importance of Iron and Steel making and to apply them for the advancement of the production feasibilities in steel industries to compete with the modern-day manufacturing routes.

Course Content

Classification of furnaces; different kinds of furnaces; heat balance, energy conservation and energy audit; parts, construction and design aspects of blast furnace, ancillary equipment; blast furnace instrumentation.

Blast furnace reactions; Gruner's theorem, carbon deposition, the partitioning of solute elements between the iron and the slag; reactions in blast furnace; blast furnace slags; mass balance and heat balance.

Blast furnace (B/F) operations; B/F irregularities and remedial measures, B/F refractories and causes of failure, modern trends in B/F technology; overview of direct reduction processes, electric smelting; production of DRI (HBI/Sponge iron).

Review of traditional steel making; physical chemistry and thermodynamics; air/O_2 impurity interaction, slag-metal interaction, role of slags in refining, continuous casting; foaming slag; removal of S and P; de-oxidizers, alloying.

Open hearth F/C; Bessemer converters; bottom-blown and top-blown processes; slag practices and sequencing; LD, VD, AOD, and VOD; ladle metallurgy; electric arc furnace and DRI usage; energy environmental and quality considerations.

Reference Books

1	*Thupkary R.H, 'Introduction to Modern Iron Making', Khanna Publications, Delhi, 2004*
2	*Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004*
3	*Gupta O. P., 'Elements of Fuels, Furnace and Refractories', 2ndEdition, Khanna Publishers, 1990*
4	*Bashforth G.R, 'Manufacture of Iron and Steel', Volume I- IV, Asia Publications, 1996*
5	*Ghosh A, Chatterjee A, Iron Making and Steel Making: Theory and Practice, PHIEEE, 2008.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Classify different kinds of furnaces and their ancillary equipment used for Iron & Steel making.		2	1
CO2	Analyze various factors influencing the quality of the product in the blast furnace during Iron & Steel making.		2, 3	1, 4
CO3	Analyze the irregularities and causes of failures in the blast furnace and apply the remedial measures for immediate rectification.		4	1, 3
CO4	Understand the physical chemistry and thermodynamics of iron and steel making		3	1, 2
CO5	Compare the traditional steelmaking to modern day manufacturing routes for the improvement of quality	12	5	1

Course Code	:	MTPC18
Course Title	:	Phase Transformation and Heat Treatment
Number of Credits		4
Prerequisites (Course Code)	:	MTPC12
Course Type	:	PC

LTPC Breakup :

L	T	P	Contact hours	C
3	1	0	4	4

Course Learning Objectives

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

Course Content

Introduction and classification of phase transformations.
Diffusion in solids: phenomenological approach and atomistic approach.
Nucleation and growth theories of vapor to liquid, liquid to solid, and solid to solid transformations; homogeneous and heterogeneous strain energy effect during nucleation; interface-controlled growth and diffusion-controlled growth; overall transformation kinetics.

Principles of solidification, evolution of microstructures in pure metals and alloys.
Precipitation from solid solution: types of precipitation reactions, crystallographic description of precipitates, precipitation sequence and age hardening, spinodal decomposition.

Iron-carbon alloy system:
Iron-carbon diagram, nucleation and growth of pearlite, cooling of hypo-eutectoid, eutectoid, and hyper-eutectoid steels, development of microstructures in cast irons.
Heat treatment of steels: TTT and CCT diagrams, bainitic transformation, martensitic transformation, hardenability, role of alloying elements in steels.

Conventional heat treatment of steels.
Massive transformation. Order-disorder transformation.
Phase transformations in and heat treatment of some common non-ferrous metals and alloys.

Types of furnaces and furnace atmospheres; quenching media; types of quenching, mechanism of quenching, quenching characteristics, choice of quenchants.
Surface hardening of steels - carburizing, nitriding, carbonitriding, and others.
Various thermo-mechanical treatments; designing for heat treatment, defects in heat-treated parts, causes for the defects in heat-treated parts and remedies.

Reference Books

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., ‘Engineering Physical Metallurgy’, 2ndEdition, University Press of the Pacific, 2000
4	Prabhu Dev K. H., ‘Handbook of Heat Treatment of Steel’, McGraw Hill Education, 2003

Course Outcomes

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

Course Code	:	MTPC19
Course Title	:	Material Characterization
Number of Credits		4
LTPC Breakup	:	L: 3, T: 1, P: 0, Contact hours: 4, C: 4
Prerequisites (Course Code)	:	Nil
Course Type	:	PC

Course Learning Objectives

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

Course Content

Specimen preparation techniques for optical microscopy:
Principles of optical microscopy, bright and dark field illumination, polarized and interference contrast microscopy; quantitative metallography.

Interaction of electron beam with materials:
Transmission electron microscopy (TEM) – bright and dark field imaging and diffraction techniques; specimen preparation for TEM; applications of TEM.
Scanning electron microscopy (SEM) – construction and working of SEM, various imaging techniques, applications; EDS and WDS, EPMA.

X-ray diffraction (XRD):
Construction and operation of diffractometer and diffraction pattern; uses of diffraction pattern in powder method – identification of crystal structure, estimation of relative amount of phases, order-disorder transformation, determination of solvus line, estimation of crystallite size and strain; residual stress measurement.

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:
Differential thermal analysis (DTA), differential scanning calorimetry (DSC), thermogravimetric analysis (TGA).
Scanning probe microscopy – Atomic force microscopy (AFM), scanning tunnelling microscope (STM), Field ion microscopy.

Reference Books

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

Course Outcomes

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

Course Code	:	MTLR32					
Course Title	:	Metallography and Heat Treatment Laboratory					
Number of Credits		2					
LTPC Breakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co/Pre-requisites (Code)	:	MTPC17					
Course Type	:	ELR					

Course Learning Objectives

- 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

Course Content

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

Course Outcomes

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

Course Code	:	MTLR33					
Course Title	:	Materials Testing and Inspection Laboratory					
Number of Credits		2					
LTPC Breakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co/Pre-requisites (Code)	:	MTPC18					
Course Type	:	ELR					

Course Learning Objectives

To know the concepts of mechanical testing and to apply them for the destructive and non-destructive testing of various structural engineering applications.

Course Content

List of Experiments

1. Tensile testing using UTM
2. Tensile testing using Hounsfield tensometer
3. Hardness testing using Brinell and Rockwell methods
4. Hardness testing using Vickers method and microhardness testing
5. Impact testing of metals – Izod/Charpy
6. Compression testing
7. Creep and torsion testing
8. Liquid penetrant testing
9. Magnetic particle testing
10. Ultrasonic testing – defect location and wear estimation

Course Outcomes

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
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hrs: 3, C: 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, Elasticities, Forecasting techniques, Consumer behaviour. Production, Cost, and Market structure: Variable proportions, Returns to Scale, Isoquants Analysis, Production Function, 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, Nama Kumari 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
O4	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

Course Code	:	MTPC20
Course Title	:	Metal Casting Technology
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PC

LTPC Breakup :

L	T	P	Contact hrs	C
3	0	0	3	3

Course Learning Objectives

To know the basic concepts of metal casting technology and to apply them to produce new materials.

Course Content

Introduction to casting and foundry industry:
Basic principles of casting processes; sequence in foundry operations; patterns; moulding practice; ingredients of mouldings and cores; sand testing; different moulding processes.
Types of furnaces used in foundry:
Furnaces for melting; melting practice for steel, cast iron, aluminium alloys, copper alloys, and magnesium alloys; safety considerations; fluxing, degassing, and inoculation.
Casting methods:
Sand casting, permanent mould casting, die casting, centrifugal casting, plaster mould casting, investment casting, continuous casting, squeeze casting, full mould process, strip casting.
Overview of pouring and solidification:
Concept of shrinkage, Chvorinov's rule, chilling; gating systems, functions of riser, types of riser, bottom pouring and top pouring, yield calculations, visualization of mould filling (modelling), methoding.
Concepts of solidification:
Directional solidification, role of chilling; filtration of liquid metals; consumables; details of inoculation and modification – with respect to cast irons and Al-Si system; casting defects; soundness of casting and its assessment.

Reference Books

1. *Heine R.W., Loper C.R., Rosenthal P.C., 'Principles of Metal Casting', 2nd Edition, McGraw Hill Education, 2017*
2. *Jain P. L., 'Principles of Foundry Technology', 3rdEdition, Tata McGrawHill, 1995*
3. *Srinivasan N.K., 'Foundry Technology', Khanna Publications, 1986*

Course Outcomes

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 the appropriate furnace for the production of new materials		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 the microstructure of the cast materials for different applications by changing the solidification pattern.		5	3, 4

Course Code	:	MTPC21
Course Title	:	Materials Joining Technology
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	PC

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To know the concepts of different materials joining technology with emphasis on the underlying science and engineering principles of every process.

Course Content

Classification of welding processes:
Arc physics, power sources, working principle, advantages, and limitations of arc welding processes – MMAW, GTAW, GMAW, SAW, ESW & EGW.

Working principle, advantages, and limitations of solid-state welding processes:
Friction, friction stir, explosive, diffusion, and ultrasonic welding.

Working principle, advantages, and limitations of power beam processes:
Plasma arc welding, electron beam & laser beam welding.

Principles of operation, process characteristics, types, and applications:
Resistance welding, gas welding, brazing, soldering, and joining of non-metallic materials.

Welding metallurgy:
Introduction, thermal cycles, prediction of peak temperature, preheat and cooling rate, PWHT (Post Weld Heat Treatment).
Weldability of carbon steel, stainless steel & aluminum.
Hot & cold cracking phenomena, weld defects, causes, and their remedies.

Reference Books

1	*Parmer R.S., 'Welding processes", Khanna Publishers, 1997*
2	*Robert W Messler, Jr. "Principles of welding, Processes, physics, chemistry and metallurgy", Wiley, 2004.*
3	*Larry Jeffus, "Welding Principles and Applications" Fifth edition, Thomson, 2002*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Learn the working principle, merits, and demerits of fusion welding processes.	6, 7	3	1, 2, 9
CO2	Learn the working principle, merits, and demerits of solid-state welding processes.	6, 7	3	1, 2, 9
CO3	Understand the working principle and importance of welding allied processes.	6, 7	3	1, 2, 9
CO4	Solve welding heat flow related problems.	5	2	1, 3, 4,
CO5	Learn weldability and welding-related problems of different materials.	5, 6	3, 7, 12	1, 2, 4,

Course Code	:	MTPC22
Course Title	:	Metal Forming Technology
Number of Credits		4
LTPC Breakup	:	L: 3, T: 1, P: 0, Contact hours: 4, C: 4
Prerequisites (Course Code)	:	MTPC18
Course Type	:	PC

Course Learning Objectives

To know the concepts of metal forming and associated technologies and apply them to the conventional and advanced materials manufacturing for various structural applications.

Course Content

Classification of metal forming processes, hot, cold and warm working, flow curve for materials, effect of temperature, strain rate and microstructural variables; residual stresses, experimental techniques; yielding theories; processing maps
Classification of forging processes, forging equipment, forging defects, plane strain forging analysis, open die forging and closed die forging operations, force calculations
Classification of rolling processes, rolling mills, cold rolling, hot rolling, rolling of bars, billets and shapes, defects in rolled products, gauge control systems, process variables in rolling
Types of extrusion, process variables, extrusion defects, force calculation, wire, rod, and tube drawing, lubrication processes
Shearing, blanking, bending, stretch forming, deep drawing, defects in formed products, explosive forming, electro-hydraulic and magnetic forming processes, formability diagrams
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

Reference Books

1	Dieter G.E, 'Mechanical Metallurgy', 3rdEdition, McGrawHill Education, Indian Edition, 2017
2	Higgins R.A, 'Engineering Metallurgy', VolumeII, ELBS, 1975
3	Harris J.N, 'Mechanical Working of Metals-Theory and Practice', Pergamon Press, 1983
4	Mahmood Aliofkhazraei (Editor) "Handbook of Mechanical Nano structuring" Wiley-VCH Verlag GmbH & Co, Germany, 2015

Course Outcomes

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	:	PRIR14					
Course Title	:	Professional Ethics					
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

Identifythecorevaluesthatshapetheethicalbehaviorofanengineer.Tocreateanaware nesson professional ethics and Human Values and to appreciate the rights of others

Course Content

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., .

Reference Books

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.

Course Outcomes

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

Course Code	:	MTLR34					
Course Title	:	Foundry and Welding Laboratory					
Number of Credits		2					
LTPC Breakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co/Pre-requisites (Code)	:	MTPC20, MTPC21					
Course Type	:	ELR					

Course Learning Objectives

To know the concepts of sand casting and materials joining technology and to apply them for the advanced manufacturing processing for various engineering applications.

Course Content

List of experiments

Foundry

1. Determination of permeability, shear strength and compression strength of the given foundry sand
2. Determination of clay content for the given moulding sand sample and also to study the variation of compression strength for various moisture contents
3. Determination of the grain fineness of the given foundry sand
4. Prepare the mould for the given pattern with core using two boxes and three-box moulding process
5. Determination of flowability for the given foundry sand
6. Foundry melting practice – demonstration

Welding

1. Arc striking practice
2. Bead-on-plate welding
3. Effect of welding parameters on weld bead
4. GTA welding (Demonstration)
5. Microstructural observation of weldments
   - Carbon steel
   - Stainless steel
   - Aluminium alloy
   - Titanium alloy
   - Dissimilar joints

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Determine the properties of foundry sand		2, 3	1, 4
CO2	Understand the foundry melting practice		4	1, 2, 3
CO3	Develop basic welding skills in manual arc welding processes	9, 11	4	1, 2, 3
CO4	Analyze the weldment microstructure	9, 11	4, 5	1, 2, 3
CO5	Analyze the various metallurgical factors affecting mechanical properties of different metals and alloys	9, 11	4, 5	1, 2, 3

Course Code	:	MTLR35
Course Title	:	Metal Forming and Particulate Processing Laboratory
Number of Credits		2
LTPC Breakup	:	L: 0, T: 0, P: 2, Contact hours: 2, C: 2
Co/Pre-requisites (Code)	:	MTPC22
Course Type	:	ELR

Course Learning Objectives

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

Course Content

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)

Course Outcomes

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

Course Code	:	MTPC23					
Course Title	:	Non-Ferrous Physical Metallurgy					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	MTPC12					
Course Type	:	PC					

Course Learning Objectives

To comprehend the basic principles of non-ferrous materials and apply those principles to demanding engineering applications.

Course Content

Aluminium and its alloys; physical, chemical and mechanical properties, classifications, heat treatable and non-heat-treatable types – structural features corrosion behaviour; cladding and other methods of corrosion protection.

Titanium and its alloys; physical, chemical and mechanical properties of titanium, effect of other elements on its properties, types of titanium alloys, microstructural features, properties and applications.

Magnesium and its alloys; structure, properties and applications of magnesium and some its alloys; metallurgy of magnesium castings; Copper and its alloys, electrical conductivity as influenced by other elements, alloys for high conductivity.

Lead, tin, zinc, zirconium, other non-ferrous alloys, relevant phase diagrams and microstructural features, properties and applications

Nickel and its alloys: physical, chemical and mechanical properties, microstructural features. Creep resistant materials, structure-property relationship, high temperature applications, superalloys, applications based on structure and properties, Intermetallics.

Reference Books

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*

Course Outcomes

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
Course Title	:	Electrical, Electronic and Magnetic Materials
Number of Credits		3
Prerequisites (Course Code)	:	Nil
Course Type	:	PC

LTPC Breakup

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To understand the basic principles and physical origins of electronic, magnetic & optical properties of materials and to study the various materials which exhibit these functional properties.

Course Content

Free electron theory – Band theory – discussion on specific materials used as conductors. Dielectric phenomena – concept of polarization – frequency and temperature dependence – dielectric loss – dielectric breakdown – ferro electricity – piezoelectricity and pyroelectricity – BaTiO3 – structure and properties.

Origin of Magnetism – Introduction to dia, para, ferri and ferromagnetism – Curie temperature – Magnetic anisotropy – hard and soft magnetic materials – iron based alloys – ferrites and garnets – rare earth alloys – fine particle magnets.

Concept of superconductivity – BCS theory of superconductivity – Types of superconductors – YBCO – structure and properties – specific superconducting materials – Fabrication and engineering applications.

Semiconducting materials and types; simple, compound and oxide semiconductors – semiconducting materials in devices – Production of silicon starting materials – methods for crystal growth for bulk single crystals – zone melting – Czochralski method – Epitaxial films by VPE, MBE and MOCVD techniques – Lithography.

Principles of photoconductivity, luminescence – photodetectors – Optical disc and optoelectronic materials – LCD, LED and diode laser materials – electrooptic modulators – Kerr and Pockel's effect – LiNbO3.

Reference Books

1	*Electronic, Magnetic, and Optical Materials, Pradeep Fulay , Jung-Kun Lee, CRC press, 2016*
2	*Kittel C., 'Introduction to Solid StatePhysics', 7th Edition, 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, 6th edition, AddisonWiley, 1989*
6	*RaghavanV, MaterialsScience andEngineering–AFirstCourse, Prentice Hall India, 2004.*

Course Outcomes

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

Course Code	:	MTPC25
Course Title	:	Corrosion and Surface Engineering
Number of Credits		4
LTPC Breakup	:	L: 3, T: 1, P: 0, Contact hours: 4, C: 4
Prerequisites (Course Code)	:	NIL
Course Type	:	PC

L	T	P	Contact hours	C
3	1	0	4	4

Course Learning Objectives

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

Course Content

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 behaviour of 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 remedies

Purpose of testing, 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 India Corrosion 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

Reference Books

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

Course Outcomes

	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

Course Code	:	MTLR36					
Course Title	:	Non-Ferrous Metallography and Characterization Laboratory					
Number of Credits		2					
LTPC Breakup	:	L	T	P	Contact hours	C	
		0	0	2	2	2	
Co/Pre-requisites (Code)	:	MTPC19, MTPC24					
Course Type	:	ELR					

Course Learning Objectives

- To evaluate the various microstructures of the non-ferrous metals and alloys using microscope and apply the concepts to make tailor-made materials for given engineering design and applications.
- To develop the knowledge of heat treatment and associated procedure of various non-ferrous engineering materials and apply them to study how it influences the microstructure and results in different mechanical behavior.

Course Content

List of Experiments

1. Electrochemical polishing/etching for metallography
2. Microstructure of copper alloys
3. Microstructure of aluminium alloys(as received and Heat-treated conditions: Solutionizing and Ageing)
4. Microstructure of lead alloys
5. Microstructure of magnesium alloys (as received and Heat-treated conditions: Solutionizing and Ageing)
6. Heat treatment of titanium alloys
7. Microstructure of superalloys
8. Heat treatment of superalloys
9. Stereographic projection
10. Indexing of x-ray diffraction pattern

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Differentiate variety of microstructure of non- ferrous materials(Al, Mg, Ti etc) using microscope		1	2, 3
CO2	Provide the comprehensive metallography procedure for a given non- ferrous metal or alloy		1	2, 3
CO3	Analyze the microstructure of the given non- ferrous metal or alloy using microscope		1	2, 4
CO4	Classify different heat treated microstructure of non-ferrous metals and alloys		1	2, 3
CO5	Index the x-ray diffraction pattern of BCC and FCC materials and estimate lattice parameter.		1, 5	2, 4

Course Code	:	**MTLR37**
Course Title	:	Corrosion and Surface Engineering Laboratory
Number of Credits		2
LTPC Breakup	:	L: 0, T: 0, P: 2, Contact hours: 2, C: 2
Co/Pre-requisites (Code)	:	MTPC25
Course Type	:	ELR

L	T	P	Contact hours	C
0	0	2	2	2

Course Learning Objectives

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.

Course Content

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 potentiostatic polarization 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

Course Outcomes

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

Course Code	:	**MTPE11**
Course Title	:	Mineral Processing and Metallurgical analysis
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

Theoretical aspects of common mineral processing techniques and the associated equipment used in mining and pre-extraction practices.

Course Content

Principles of combustion, testing of fuels, -Coal -Manufacture of metallurgical coke and its properties-typical energy consumption in metallurgical processes, overview of different raw materials (including fluxes) in metals processing

Physical properties of minerals, physical and chemical characteristics of industrial minerals such as magnetite, haematite, galena, chalcopyrite, azurite, sphalerite, monazite, cassiterite, chromite, bauxite and ilmenite

Mineral Processing: economics of reprocessing; 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. Use of flowsheets (specific examples from metals processing), wet and dry sampling. Introduction to hydrometallurgy.

Principles of chemical analysis-ores, metals, alloys, details of specific chemical analysis techniques, introduction to common analysis techniques used in metallurgical industries.

Reference Books

1	Gupta O. P., 'Elements of Fuels, Furnaces and Refractories', 2nd Edition, Khanna Publishers, 1990
2	Gaudin A.M., 'Principles of Mineral Dressing', 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 Text Book of Quantitative Inorganic Analysis', 3rd Edition, ELBS, Longman, 1978

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the principles of combustion and manufacturing of coke	7	12	1, 2
CO2	Describe the physical and chemical properties of various 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	Know and understand the various concentration techniques used in the mineral processing industries	6, 7	4	1, 3
CO5	Understand the common analysis techniques used in metallurgical industries	10	4	5, 12

Course Code	:	**MTPE12**
Course Title	:	Non-Ferrous Extractive Metallurgy
Number of Credits		3
Prerequisites (Course Code)	:	MTPE11
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

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.

Course Content

Principles of pyrometallurgy, chemistry of roasting, drying and calcination; classification of pyrometallurgical processes, use of 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

Reference Books

1. *Ray H. S., Sridhar R., Abraham K.P, 'Extraction of Non-ferrous Metals', 1st Edition, Affiliated East West Press, 1987*
2. *Rosenquist T., 'Principles of Extractive Metallurgy', 2nd Edition McGrawHill, 1983*
3. *Raghavan R., 'Extractive Metallurgy of Non-Ferrous Metals', Vijay Nicole Imprints, 2015.*

Course Outcomes

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					
Course Title	:	Manufacturing Processes					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	PE					

Course Learning Objectives

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

Course Content

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

Reference Books

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.

Course Outcomes

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			

Course Code	:	**MTPE14**
Course Title	:	Non-destructive Testing
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hrs	C
3	0	0	3	3

Course Learning Objectives

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.

Course Content

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 - basic principle, electromagnetic radiation sources, types and use of filters and screens, geometric factors, inverse square law, film characteristics, penetrameters, exposure charts, radiographic equivalence, radiographic imaging, inspection techniques, applications, limitations and safety. 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, flaw characterization technique, immersion testing, thickness measurement. Types of scanning, test block, IIW - reference blocks. Time of flight diffraction (TOFD), phased array ultrasonic testing.
Eddy current testing - principle, application, limitation; acoustic emission testing - principles, applications, merits and demerits; leak testing, holography and thermography - principles, procedures and applications.
Comparison and selection of NDT methods; defects in casting, forging, rolling and others. Introduction to ASNT codes and certification of NDT personnel.

Reference Books

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: Non-destructive Evaluation and Quality Control, ASM International, Metals Park, Ohio, USA, 1992.

Course Outcomes

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

Course Code	:	**MTPE15**					
Course Title	:	Welding Metallurgy					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	MTPC21					
Course Type	:	PE					

Course Learning Objectives

- To gain understanding of heat flow and temperature distribution on weld components based on weld geometry
- To understand the solidification structure and growth morphology on weld joints in relation to the welding parameters
- Study phase transformations in weld joints with aid of CCT, Schaffler and Delong diagrams
- Gain knowledge of process, difficulties, and microstructures formed during welding of some specific alloys such as Cu, Al, Ti and Ni alloys and the remedial measures to minimize or eliminate the occurrence of weld defects.

Course Content

Heat flow – temperature distribution – cooling rates – influence of heat input, joint geometry, plate thickness, preheat, significance of thermal severity number
Weld metal solidification – epitaxial growth – columnar structures and growth morphology – effect of welding parameters – gas/metal and slag/metal reactions
Weldability of carbon steels, low alloy steels, welding of stainless steels and cast irons
Welding of non-ferrous alloys: Al, Ti, Mg and Ni alloys – processes, difficulties, microstructures, defects and remedial measures

Origin of defects – significance – remedial measures, hot cracking, cold cracking, lamellar tearing, reheat cracking – weldability tests – effect of metallurgical parameters.

Reference Books

1	*Sindo Kou., 'Welding Metallurgy', 2nd Edition, Wiley Interscience, 2002*
2	*Granjon H., 'Fundamentals of Welding Metallurgy', Jaico Publishing House, 1994*
3	*Kenneth Easterling, 'Introduction to Physical Metallurgy of Welding', 2nd Edition, Butterworth Heinmann, 1992*
4	*Saferian D., 'The Metallurgy of Welding', Chapmanand Hall, 1985*
5	*Jackson M.D., 'Welding Methods and Metallurgy', Grffin, London, 1967*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the influence of heat input and temperature distribution across a welded structure based on weld geometry and the importance of preheating and PWHT.	10	4, 5,	1, 2, 3,
CO2	Learn the solidification concepts of welds.	12	4, 5	1, 2, 3
CO3	Learn weldability of various ferrous alloys.	7, 12	4, 5	1, 2,
CO4	Understand the weldability issues of non-ferrous materials.	7, 12	4, 5	1, 2,
CO5	Identify the origin and types of various defects of welds and its susceptibility tests.	7, 9, 12	4, 5, 8	1, 2,

Course Code	:	**MTPE16**
Course Title	:	Materials for extreme environments
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

Students should be capable of understanding various extreme environmental conditions and choosing suitable materials for different conditions.

Course Content

Fundamentals of high temperature deformation, creep – Mechanism – Deformation Mechanism Maps Superplasticity – Engineering materials applied in extreme environments: structural materials at high temperatures such as gas turbine applications

Introduction to radiation resistance materials; radiation damage – half-life period – irradiation damage resistance – BCC structures and ferritic grade steels for radiation damage resistance applications – Liquid sodium storage materials in nuclear industry – nuclear waste disposal.

Space environment – anomalous behavior of materials in space – Engineering materials applied in extreme environments: spacecraft materials – reusable space vehicles – carbon-carbon composites (CCC).

Understanding high strain rate deformation – Elastic wave propagation – Materials under thermo-mechanical extremes (static vs dynamic; high-pressure phases; shock; detonation; cavitation; super-cooled liquids and glasses) – Shock resistant materials – Armor grade materials.

Materials for cryogenic applications – DBTT – FCC structures – Deformation behavior in cryogenic temperatures – cryorolling.

Reference Books

1. G.E. Dieter, “Mechanical Metallurgy”, McGraw Hill Publishers, NY, 2002
2. Vincenzo Schettino and Roberto Bini, Materials Under Extreme Conditions, Imperial College Press, winter2012.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Can understand the behaviour of high temperature materials		2	1
CO2	Capable of assessing behaviour of various irradiation damage resistance materials		3	1, 2
CO3	Can understand the space environment and choosing materials for space applications		2	1
CO4	Analyse the high strain rate deformation behaviour and capable of choosing or fabricating materials		1	2, 3
CO5	Capable of understanding deformation at cryogenic temperatures		2	1

Course Code	:	**MTPE17**
Course Title	:	Thermodynamics of Solidification
Number of Credits		3
Prerequisites (Course Code)	:	MTPC11, MTPC20
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

- A study of important thermodynamic functions related to solidification of metal in molds involving the characteristics of liquid-solid phase transformations, laws of thermodynamics, and other functions.
- To analyze solidification processing of engineering materials in terms of the phase equilibrium, transport, and interface phenomena governing microstructure development in liquid-solid transformations.

Course Content

Introduction and important thermodynamic functions:
Laws of thermodynamics – enthalpy, heat capacity, applications of first law to open and closed systems including chemical reactions; entropy, free energy and their interrelationships
Thermodynamics of solidification:
Nucleation and growth; Pure metal solidification, Alloy Solidification, Constitutional undercooling, Mullins-Sekerka instability; Single phase solidification: Cellular and Dendritic growth; Multiphase solidification: eutectic, peritectic and monotectic; Modelling of solidification
Heterogeneous systems:
Equilibrium constants, Ellingham-Richardson diagrams, predominant area diagrams, principles of free energy minimization; energy balance of industrial systems; solutions – chemical potential, Raoult/Henry's law, Gibbs-Duhem equations, regular solutions, quasi chemical theory
Evolution of Phase Diagrams:
Phase rule, free-energy–composition diagrams, solidus-liquidus lines, retrograde solidus; determination of activity and other thermodynamic parameters from phase diagrams; thermodynamic analysis of ternary and multi-component systems, interaction parameters
Principles of Applications:
Principles of applications to molten slags and silicate melts; electrochemical methods and applications, aqueous systems; Interfaces – energy, shape, segregation at external and internal interfaces; solid electrolytes; Effect of high-pressure on phase transformations; Point imperfections in crystalline solids.

Reference Books

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

Course Outcomes

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

Course Code	:	**MTPE18**					
Course Title	:	Design aspects of Welding and Casting					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hrs	C	
		3	0	0		3	
Prerequisites (Course Code)	:	MTPC20, MTPC21					
Course Type	:	PE					

Course Learning Objectives

To select the proper design for various casting techniques and to minimize the defects. Knowledge of the various welding codes used in industry parlance.

Course Content

Designing for economical moulding – designing for sand moulding – investment castings. Design for economical coring – general rules for designing cored holes. Design problems involving thin sections, uniform sections, unequal sections. Considering metal flow, riser location, feed path, mould-metal temperature effect.

Design problems involving junctions, distortion – possible design remedies. Dimensional variations and tolerances – influence of cores – influence of location of cores. Dimensions for inspection and machining. Surface finish ISI specification, effect of mould material, parting line, fillet influences. Design of gating and risering for ferrous and non-ferrous metals.

Types of joints, joint efficiency, edge preparation, types of loads, design for static loading, design for cyclic loading, rigid structures, primary and secondary welds, treating a weld as a line, structural tubular connections, influence of specifications on design, symbols for welding and inspection, estimating and control of welding costs. Residual stresses, causes and effects, methods to measure residual stresses, weld distortion.

Boiler and pressure vessel codes, structural welding codes, pipelines codes.

Welding procedure specifications, welding procedure qualifications, welder performance qualifications, welding variables, filler metal qualifications, qualification of welding inspectors, welding supervisors and welding engineers, qualification of NDT personnel.

Reference Books

1	"*Casting. Design Hand Book", American Society for Metals, 1962*
2	*Matousek R., "Enginering Design"., Blackwell Scientific Publications., 1962*
3	*Heine, Loperand Rosenthal, "Principles of Metal Casting", Tata McGraw Hill Publishing Co, 1995.*
4	*Harry Peck, "Designing for Manufacture", Pitman Publications, 1983.*
5	*O.W. Blodgett, Design of weldments,* James F. Lincoln Arc Welding Foundation, 1963

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Select the appropriate design for the particular casting process.		1	2, 3
CO2	Minimize the defects by proper selection of casting systems.		1	2, 3
CO3	Select an appropriate joint design to reduce weld distortion and residual stresses.		1	2, 3
CO4	Choose the appropriate codes for the production of pipeline and structural materials.		1	2, 3
CO5	Categorize welding procedures for different applications.		1, 10	2, 3

Course Code	:	**MTPE19**
Course Title	:	Alloy Development
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: , C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

Course Learning Objectives

To study the fundamentals, classification, and properties of applications of various ferrous and non-ferrous systems.

Course Content

Metals vs Alloys; superiority of alloys over pure elemental metals; strategies for alloying; concepts such as strengthening mechanisms. Thermodynamics aspects of alloying; relation between alloy composition, structure and properties. ICME approach to alloy design and development.

Ferrous systems – Effect of specific alloying elements; alloy grades of cast irons, carbon steels; role of heat treatment.

Ferrous systems – Highly alloyed steels; specific examples; Effect of alloying elements on phase transformations; development of novel grades of steels such as maraging steels, IF steels, AHS steels, PH steels, DP steels and Duplex stainless steels, role of heat treatment.

Non-Ferrous systems based on Aluminium, Titanium and Copper; typical alloying elements and their effects; relevant phase diagrams; input on heat treatment.

Use of alloying elements for grain refinement; Inclusion engineering; concept of ODS alloys; special cases such as High Entropy Alloys and Bulk metallic glasses.

Reference Books

1	*Alloying: Understanding the Basics Edited by Joseph R. Davis, ASM International*
2	Phase Transformations in Metals and Alloys, Third Edition by DavidA.Porter, KennethE. Easterling, *CRC Press*
3	*Bain, E.C. and Paxton, H.W. Alloying Elements in Steels, ASM, Metal Park, Ohio*
4	*Lakhtin, Yu, M., Engineering Physical Metallurgy and Heat Treatment, Mir Publishers, Moscow.*

Course Outcomes

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 element to develop a highly alloyed steels with specific properties		1	2
CO4	Develop a non-ferrous alloy system 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

Course Code	:	**MTPE20**
Course Title	:	Ceramic Materials
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To study the fundamentals (structure, properties and processing) of ceramic materials to understand its advantages and limitations and to apply those fundamentals for selecting and developing ceramic materials for different engineering applications.

Course Content

Ceramics as a class of engineering materials; general characteristics of ceramics; classification of ceramics; production of ceramic powders; bonding in ceramic Materials, variations in properties as a function of bonding; concept of co-ordination number, ratio of ionic radii and corresponding crystal structures of oxides, silicates, other non-oxide ceramics, theoretical density of ceramics, polymorphism in ceramics.

Defects in crystalline ceramics, non-stoichiometry, Kroger-Vink notations, significance of defects with respect to applications; Glasses: types, structure, bridging and non-bridging oxygen, significance of oxygen to silicon ratio, commercial oxide glasses, devitrification; Introduction to glass–ceramics and tempering of glasses.
Introduction to ceramics processing, densification methods, theory of sintering, crystalline and non-crystalline phases in ceramic microstructures; mechanical properties of ceramic materials and testing of ceramic materials; Toughening Mechanisms.
Electrical, magnetic and optical properties of important ceramic systems, correlation of properties with structure.
Classification of refractories, characteristics of refractories. Production of refractories, properties and applications of various refractories. Ceramics for sensor applications, Introduction to bio-ceramics and bio-glass. Applications of bioceramics.

Reference Books

1	*Richerson D. W., 'Modern Ceramic Engineering– Properties, Processing and Use in Design', 3rd edition, CRC press, 2006*
2	*Yet-MingChiang, Dunbar P. Birnie and W.DavidKingery, Physical Ceramics: Principlesfor Ceramic Science and Engineering JohnWiley & Sons, 1996*
3	*Carter, C. Barry, Norton, M. Grant, Ceramic Materials: Science and Engineering, 2ndEd, Springer, 2013*
4	*KingeryW. D., Bowen, H. K.and UlhmenD. R., 'Introduction to Ceramics', 2ndE, JohnWiley, 1991*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Know the structure and properties of different ceramic materials	5	3	1
CO2	Understand the phase diagrams and comprehend the phase transformations in ceramic materials	5	3	1
CO3	Understand the testing methods for evaluating the mechanical properties of ceramic materials	5	3	1
CO4	Understand and design the electrical, magnetic and optical properties of ceramic systems	5	2, 3	1

CO5	Select ceramic materials and to develop new ceramics for different engineering applications	5	2, 3	1

Course Code	:	**MTPE21**
Course Title	:	Ceramic Processing
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	MTPC15
Course Type	:	PE

Course Learning Objectives

To know manufacture of different type of Ceramic materials and develop for specific engineering

Course Content

Surface and interfaces, grain boundaries, interfacial energy and wetting; phase equilibria in ceramic system - single component SiO2 transformations in silica; two component systems

Overview of ceramic processing - emphasis on powder processing route - crushing, grinding, sizing, pre-consolidation by pressing, casting, plastic forming, tape forming and spraying -- sintering stages, mechanisms, solid state sintering, liquid phase sintering.

Hot pressing - reaction sintering - self-sustaining high temperature synthesis - high pressure synthesis - fusion cast ceramics - slurry casting - overview of refractory processing - sol-gel processing - ceramic coatings - manufacture of glasses

Principles, properties, applications and processing for important systems such as: silicon carbide, silicon nitride, boron carbide, boron nitride, cermets, molybdenum di-silicide and ceramic fibres

Principles, properties, applications and processing of important systems such as: zirconia, stabilized zirconia, sialons, magnetic ceramics, superconducting ceramics, semiconductors, glass ceramics, bio ceramics

Reference Books

1	*McColmJ., 'Ceramic Science for Materials Technology', Leonard Hill, 1983*
2	*Richerson D.W., 'Modern Ceramic Engineering- Properties Processing and Use in Design', Marcel Deckker, 1982*
3	*Kingery W. D., Bowen H.K., Uhlman D.R., 'Introduction to Ceramics', 2ndEd, John Wiley, 1976*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Define the type of component system present in the refractory materials.	5	2	1
CO2	Select the powder processing route to prepare the ceramics.	5	2	1
CO3	Differentiate pressing and casting techniques for the ceramic materials.	1	2	5
CO4	Develop refractory materials for specific applications.	5	2	1
CO5	Apply the principle and evaluate the properties of materials.	1	2	3

Course Code	:	**MTPE22**					
Course Title	:	High Temperature Materials					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	MTPC12					
Course Type	:	PE					

Course Learning Objectives

To study the high temperature sustainability of various materials in critical high temperature applications.

Course Content

Factors influencing functional life of components at elevated temperature, definition of creep curve, various stages of creep, metallurgical factors influencing various stages, effect of stress, temperature and strain rate

Introduction to transient creep, time hardening, strain hardening, expressions for rupture life for creep, ductile and brittle materials, Monkman-Grant relationship

Various types of fracture, brittle to ductile from low temperature to high temperature, cleavage fracture, ductile fracture due to microvoid coalescence, diffusion controlled void growth; fracture maps for different alloys and oxides

Oxidation, Pilling-Bedworth ratio, kinetic laws of oxidation, defect structure and control of oxidation by alloy additions, hot gas corrosion deposit, modified hot gas corrosion, fluxing mechanisms, effect of alloying elements on hot corrosion

Iron base, nickel base and cobalt base superalloys, composition control, solid solution strengthening, precipitation hardening by gamma prime, grain boundary strengthening, TCP phase embrittlement, solidification of single crystals

Reference Books

1	*Raj R., 'Flow and Fracture and Elevated Temperatures', American Society for Metals, 1985*
2	*Hertzberg R.W., 'Deformation and Fracture Mechanics of Engineering Materials', 4thEdition, John Wiley, 1996*
3	*Courtney T.H, 'Mechanical Behaviour of Materials', McGrawHill, 1990*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand and analyse the basic mechanisms of high temperature deformation.			1
CO2	Evaluate the long-term high temperature life of components.	4	2	1
CO3	Analyze the fracture phenomena in various materials during high temperature failures.		2	1
CO4	Apply basic understanding of high temperature phenomena like oxidation and hot corrosion to identify suitable materials for specific high temperature applications.		2	1
CO5	Study the high temperature behaviour of various high temperature materials and design new materials for high temperature applications.	3		1

Course Code	:	**MTPE23**
Course Title	:	Emerging Materials
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To define new engineering materials and apply for multi-functional areas.

Course Content

Techniques of rapid solidification, production of metallic glasses, atomic arrangement, comparison with crystalline alloys – mechanical, electrical, magnetic, superconducting and chemical properties and applications.

Phase diagrams of ferritic, martensitic and austenitic stainless steels, duplex stainless steels, precipitation hardenable stainless steels, mechanical and metallurgical properties of stainless steels, HSLA steels, micro-alloyed steels.

Aluminium alloys, magnesium alloys and titanium alloys; metallurgical aspects, mechanical properties and applications.

Development of superalloys – iron base, nickel base and cobalt base – properties and their applications; materials for cryogenic service, materials in nuclear field, materials used in space.

Carbonaceous materials – including nanotubes and fullerenes; shape memory alloys, functionally gradient materials, high temperature superconductors – biomaterials.

Reference Books

1	*SukhDevSehgal, Lindberg R.A., 'Materials, their Nature, Properties and Fabrication', SChand, 1973*
2	*Polmear I. J. 'Light alloys: Metallurgy of Light Metals', 3rd Edition, Arnold, 1995*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describe the processing route, mechanical, electrical, magnetic and chemical properties of metallic glasses.			1
CO2	Analyse the Phase diagram and Microstructure of different type of stainless-steel materials.		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

Course Code	:	**MTPE24**
Course Title	:	Automotive Materials
Number of Credits		3
LTPC Breakup	:	
Prerequisites (Course Code)	:	MTPC12
Course Type	:	PE

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To understand the working principles of automobiles, different systems in automobiles and materials used in automobile components fabrication

Course Content

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.

Reference Books

1	*Ganesan. V, Internal Combustion Engines, Tata-McGraw Hill Publishing Co., New Delhi, 1994.*
2	*Hiroshi Yamagata, The Science and Technology of Materials in Automotive Engines, Woodhead Publishing in Materials, 2005.*
3	Sheldon S. Williamson, Energy Management Strategies for Electric and Plug-in Hybrid Electric Vehicles, Springer, 2013

Course Outcomes

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

Course Code	:	**MTPE25**
Course Title	:	Metallurgical Failure Analysis
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

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

Course Content

Sources of failure - Deficiencies in Design, Material, Processing, Service and Maintenance. Stages of Failure Analysis, classification and identification of Various Types of Fracture-Overview of fracture mechanics concept. Ductile and Brittle Fracture; General Concepts, fracture Characteristics Revealed by Microscopy

Fatigue failure - Factors affecting Fatigue Life Some Case Studies of Fatigue Failures; Creep, Stress Rupture, Elevated Temperature Fatigue, Elevated Temperature Effects on Certain Gas Turbine Components and Petroleum Refinery Components.

Wear failure – types of Wear, Role of friction in wear, Lubricated and Non-Lubricated Wear, Analyzing Wear Failure. Corrosion Failures- Factors Influencing Corrosion Failures, Analysis of Corrosion Failures, Stress Corrosion Cracking -Sources. Characteristics, Procedure for Analyzing Stress Corrosion Cracking, various types of Hydrogen Damage Failures.

Causes of failure in forging like material characteristics, deficiencies in design, Improper Processing, Fabrication or Deterioration resulting from service conditions,

Failure of Iron and Steel Castings, effect of Surface Discontinuities, Internal Discontinuities, Microstructure, Improper Composition, Improper Heat Treatment, Stress Concentration and Service Conditions. Failure of Weldments – Reasons for Failure procedure for Weld Failure Analysis.

Reference Books

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

Course Outcomes

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

Course Code	:	**MTPE26**
Course Title	:	Bio materials
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

The objective of this course is to provide students a fundamental understanding of different materials for biomedical-applications and their *in-vitro* and *in-vivo* characteristics.

Course Content

Need for biomaterials; Salient properties of important material classes for different bio-implant Applications. Introduction biodegradable implant materials.
Processing and properties of different biomaterials; Nano materials and nano composites for medical applications; Nano structured coatings for bio-implants.
Mechanical property evaluation and physico-chemical characterization of bio materials; In-vitro and In-vivo evaluation of biomaterials.
The structure and composition of hard tissues, Bone biology: Introduction to tissue engineering; Applications of tissue engineering; Biomaterials for drug delivery applications.
Biomaterials worldwide market, technology transfer and ethical issues; Standards for biomaterials and devices.

Reference Books

1	*Hench L. Larry, and Jones J., (Editors), Biomaterials, Artificial organs and Tissue Engineering, Woodhead Publishing Limited, 2005.*
2	*Hench L. Larry, &WilsonJ., (Editors), An Introduction to Bioceramics, World Scientific, 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*

Course Outcomes

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

Course Code	:	MTPE27					
Course Title	:	Stainless steels and Advanced Ferrous Alloys					
Number of Credits	:	3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	Nil					
Course Type	:	PE					

Course Learning Objectives

To understand the processing, physical metallurgy, corrosion behaviour and applications of stainless steels.

Course Content

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: super ferritic, super austenitic, duplex, Lean Duplex (high Mn and high N), Super duplex and Hyper duplex 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, Trans granular

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

Reference Books

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	Mårten Görnerup, Studies of Slag Metallurgy in Stainless Steelmaking, KTH, 1997
4	A. John Sedriks, Corrosion of Stainless Steels, Wiley, 1996

Course Outcomes				
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

Course Code	:	**MTPE28**
Course Title	:	Special Steels and Cast Irons
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	MTPC17
Course Type	:	PE

Course Learning Objectives

To become familiar with a wide array of ferrous alloys including carbon steels, special steels and Cast-iron

Course Content

Definition of high strength steels, problems in developing high strength steels; discussion on fracture toughness; HSLA steels, principle of microalloying and thermomechanical processing; importance of fine-grained steels

Phase diagrams, composition, properties and applications of ferritic, austenitic, martensitic, duplex and precipitation hardenable stainless steels

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

Tool steels; classification, composition, and application, constitution diagram of high-speed steels, special problems in heat treatment of tool steels

Types of cast irons-grey, SG, white, malleable; austempered ductile iron; alloy cast irons, Ni hard, high silicon cast irons, heat resistant cast irons-high chrome cast iron-structure, property and engineering applications

Reference Books

1	*Leslie W. C., 'The Physical Metallurgy of Steels', Mc GrawHill, 1982*
2	*ASM Handbook, Vol 1. Properties and Selection: Irons, Steels, and High-Performance Alloys, 1990*
3	*Pickering P.B., 'Physical Metallurgy and the Design of Steels', Applied Science Publishers, 1983*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand principles of microalloying and problem associated with developing high strength steels.		3	1, 2
CO2	Know the properties, types and applications of stainless steels		3	1, 2
CO3	Selection of advanced and ultra-high strength steels for specific engineering applications		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
Course Title	:	Economics of Metal Production Processes
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	MTPC16
Course Type	:	PE

Course Learning Objectives

To understand the role of metallurgical industries in the economy; to understand how metallurgical companies come up with innovative practices with respect to raw materials, processes, cost, yield and market conditions.

Course Content

Tonnage production, range of products and annual turnover of companies in the metals and materials sector; Input on macroeconomics and government policies
Typical approaches to cost estimation with respect to capital expenses and operating expenses; quantum of investment associated with different sectors in the metallurgical domain; approaches to estimation of savings and profits, such as ROI and EBITDA
Natural resources required for major metallurgical industries; trends in mining and public policy; Timeframe required for moving from idea to actual production, in greenfield sites
Need for developing new grades or new varieties of products, related investment requirements, related technological initiatives and impact on profitability
Sustainability in the production of metals and materials; discussion on energy, environment, waste generation, losses and disposal; targets with respect to emissions and related penalties; Concept of green manufacturing

Reference Books

1	Bruce R. Beattie and C. Robert Taylor, The Economics of Production, reprinted by Krieger Publishing Company, 1993.
2	Philips Maxwell, Mineral Economics- An Introduction, in Mineral Economics: Australian and Global Perspectives, Australian Institute of Mining and Materials, Carlton, Victoria; 2ndEdition, 2013.
3	David Humphreys, China Changes Everything, The Remaking of the Mining Industry, Palgrave MacMillan, 2015.
4	Case studies on initiatives and experiences of various metallurgical companies
5	Supplementary reading materials on cost reduction, quality improvement and innovative manufacturing

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand terms 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 explore new grades of metals and materials compatible with green manufacturing			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

Course Code	:	**MTPE30**
Course Title	:	Special Casting Techniques
Number of Credits		3
Prerequisites (Course Code)	:	MTPC20
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

- To know the raw materials, casting procedures and parameters of various special casting processes.
- To gain knowledge on designing appropriate processes to produce for different applications.
- To gain knowledge on using economical design to give better quality castings.
- To develop components of intricate shape and design by properly selecting moulding and casting techniques.

Course Content

Shell moulding: Process details, types, characteristics and process variables, types of sand used and additives, application
Investment casting: Pattern material and its production, techniques of investment casting – investment, pattern removal and firing, pouring and casting, process variables and characteristics, application
Die casting: Process details, gravity and pressure die casting equipment and die details, casting techniques, characteristics of the process, application
Centrifugal casting: Process details, centrifugal force calculations, production techniques – true, semicentrifugal and centrifuging processes, process variables and characteristics, application
Squeeze casting, Low pressure die casting, thixo and rheocasting, full mold process, electro slag casting, magnetic casting, no bake or pepset moulding, casting process for reactive metals.

Reference Books

1	*Heine R., Loper C.R., Rosenthal P.C., Principlesofmetalcasting.2nd edition, Tata Mcgraw Hill publishers, 1985*
2	*JainP.L., Principles of foundry technology, 3rdedition, TataMcgrawHill, 2004*
3	*Beeley P.R. Foundry Technology, , Butterworth- Heiman publishers, London2006*

Course Outcomes

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

Course Code	:	**MTPE31**					
Course Title	:	Particulate Technology					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hrs	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	PE					

Course Learning Objectives

To introduce the importance of non-conventional processing routes for different materials and its importance for advanced materials manufacturing.

Course Content

Introduction – Historical background, important steps in powder metallurgy (P/M) process – Advantages and Limitations of powder metallurgy process and Applications

Methods – Production of ceramic powders – powder production by newer methods such as electron beam rotating electrode, rotating electrode process, electron beam rotating disc and the rotating rod process, automation, rapid solidification technique.

Characteristics: sampling – chemical composition, particle shape and size analysis, surface area, packing and flow characteristics, porosity and density, compressibility, strength properties.
Blending and mixing of metal powders; Compaction of powders, pressure less and pressure compaction techniques – single action and double action compaction, Cold Isostatic compaction, powder rolling, continuous compaction, explosive compaction, Hot temperature compaction – Uniaxial hot pressing, Hot extrusion, Spark sintering, Hot isostatic pressing, Injection moulding – Sintering – Types – Theory of sintering – process variables, Effects of sintering – Sintering atmospheres – metallographic technique for sintered products.

Post sintering operations – Sizing, coining, repressing and resintering, impregnation, infiltration, Heat treatment, steam treatment, machining, joining, plating and other coatings.
Products: Porous parts, sintered carbides, cermets, dispersion strengthened materials, electrical applications, sintered friction materials

Atomisation, Mechanical alloying, Metal Injection moulding, Microwave sintering and self-propagating high temperature synthesis.

Reference Books

1	Angelo. P.C. and R. Subramanian 'Powder metallurgy –science, Technology and applications', Prentice hall Publishers, 2008
2	Kuhn H. A., 'Powder Metallurgy Processing-New Techniques and Analysis', Oxford &IBH, New Delhi, 1978.
3	Randel German, 'Powder Metallurgy Sciene', 2^{nd}ed., MPIF, 1994
4	Fritz. V. Lenel 'Powder metallurgy–Principles and Applications" Metal powder Industries federation, New Jersey, 1980

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describe the basic mechanism of powder production for a variety of materials to meet the demand of research and industrial needs.	5	4	1, 2
CO2	Characterize the various powders (materials) based on engineering applications.		5	1, 3

CO3	Differentiate the processing routes for various powders (materials) and associated technology.			1, 2, 5
CO5	Apply the powder metallurgy concepts to design new materials for advanced engineering materials.			1, 3
CO6	Apply the concepts of particulate processing to produce non-conventional materials which are difficult to produce by other techniques.			1

Course Code	:	**MTPE32**
Course Title	:	Special Topics in Metal Forming
Number of Credits		3
Prerequisites (Course Code)	:	MTPC22
Course Type	:	PE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To become familiar with forming processes apart from the conventional forming techniques.

Course Content

High velocity forming – comparison with conventional forming – Explosive forming – explosives – detonation velocity of explosives – energy transfer media – safety circuit – process parameters – application of explosive forming

Petroforge system – rubber pad forming – electromagnetic forming coil requirements – effect of workpiece dimensions and conductivity – applications – electrohydraulic forming – types of electrodes – applications

Superplastic forming – superplasticity – definition – components – mechanism of superplastic deformation – diffusion bonding – superplastic forming and diffusion bonding – methods of forming

Severe plastic deformation – ECAP – types – microstructural variations with processing route – cryo rolling – process – types – stress strain distribution

Severe plastic deformation by mechanical alloying – types – equipment – compaction – sintering – mechanism of sintering

Reference Books

1	*Hosford W.F and Caddell, 'Metal forming mechanics and metallurgy" Prentice Hall, 1983*
2	*Explosive forming process and techniques–A.A. Ezra, Prentice Hall, 1980*
3	*ASM metals Handbook, Volume5, 1984*
4	*Padmanabhan KA andG.J.Davis, Superplasticity, Springer Verlag, Berlin Heidberg, NY, 1980.*
5	Mahmood Aliofkhazraei (Editor) "Handbook of Mechanical Nanostructuring" Wiley-VCH Verlag GmbH & Co, Germany, 2015

Course Outcomes

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

Course Code	:	**MTPE33**					
Course Title	:	Additive Manufacturing					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	PE					

Course Learning Objectives

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

Course Content

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 Modelling - 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

Reference Books

1	Brent Stucker, David Rosen, 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.

Course Outcomes

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

Course Code	:	**MTPE34**
Course Title	:	Computational Materials Science
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

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

Course Content

Introduction to computational materials science and engineering, different scales, basic procedures. Introduction to ICME, multi-scale modelling, 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 packages Open Calphad /Open Phase/Thermocalc/MicroSIM

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

Reference Books

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 modelling for metal processing, ASM International, 2009

Course Outcomes

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

Course Code	:	**MTPE35**
Course Title	:	Materials for New and Renewable Energy
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

Course Learning Objectives

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

Course Content

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 photovoltaics Cells – Physics of photovoltaic cells – Organic photovoltaic cell cells – Thin film Dye Sensitized Solar Cells – Quantum 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 &Supercapacitors): 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.

Reference Books

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 – Mieczyslaw Jurczyk

Course Outcomes				
At the end of the course, students will be able to		PO Correlation		
		Lo w	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,	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

Course Code	:	**MTPE36**					
Course Title	:	Fatigue, Creep and Fracture Mechanics					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hrs	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	MTPC18					
Course Type	:	PE					

Course Learning Objectives

To develop the knowledge about the essential mechanical properties of engineering materials such as fracture, fatigue and creep and to apply them to design the materials for various load-bearing structural engineering applications.

Course Content

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.

Reference Books

1	T.H. Courtney, Mechanical Behaviour of Materials, 2^{nd} Ed, Waveland Press, 2005
2	*Dieter G.E., 'Mechanical Metallurgy', 3rdEdition, McGrawHill Publications, 1988*
3	*Suryanarayana, 'Testing of Metallic Materials', Prentice Hall India, 1979*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describe basic mechanisms of fatigue behavior of various engineering materials and their importance in materials design.		2	1
CO2	Understand and analyse the creep behaviour and alter the microstructure for the life enhancement of materials at elevated temperatures.		2	1
CO3	Understand and analyse the various metallurgical factors influencing the fracture behaviour at different temperatures.		2	1
CO4	Understand, evaluate and analyse the impact properties of materials.		2	1
CO5	Understand, evaluate and analyse the fracture mechanics of materials.		2	1

Course Code	:	**MTPE37**					
Course Title	:	Metallurgical Waste Management					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	PE					

Course Learning Objectives

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

Course Content

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.

Reference Books

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

Course Outcomes

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 method 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

Course Code	:	**MTPE38**
Course Title	:	Instrumentation and Control Engineering
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	PE

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To develop the basic understanding of measurements using different tools and skills to implement knowledge of techniques to control the systems.

Course Content

General concepts of measurements, static and dynamic characteristics, Introduction to calibration, calibration standards.

Temperature measurements: Measurement using expansion thermometers, thermocouples, Resistance temperature detectors, thermistors and optical pyrometers.

Measurement using Strain Gauges, Capacitive Transducers, Inductive Transducers, and Piezoelectric Transducers.

Introduction to Pressure, Level, and Flow Measurements.

Basics of Open-Loop and Closed-Loop Systems, Classification of Variables, ON/OFF, P, PI, and PID Controllers and Their Applications.

Introduction to Micro Processor and its architecture. Instruction sets. Introduction Programmable logic controllers and instruction sets.

Reference Books

1	John P. Bentley., "Principles of MeasurementSystems"3rdE, Addison Wesley Longman Ltd., UK.
2	Neubert H.K.P., "Instrument Transducers: An Introduction to their performance and Design, 2nd Edition Oxford University Press, Cambridge, 1999.
3	Ramesh Goankar, “Microprocessor architecture, Programming and applications, with the
4	Patranabis, "Sensors and Transducers", Wheeler Publishing, 1999.
5	Doebelin E.O, “Measurement system-applications and design”, 4thEMcGrawHillNewYork, 2003

Course Outcomes

At the end of the course, students will be able to		PO Correlation Low	Medium	High
CO1	Differentiatestaticanddynamiccharacteristicsandcalibrationstandards For measurements.		2	1
CO2	Select the suitable temperature measurement method for the suitable condition.	6		1, 2, 3
CO3	Application of various transducers for direct contact and non- contact measurements.		1	2, 4
CO4	Design and measurements of PC based methods, construction of interface devices.	6	2	3, 4
CO5	Differentiate loops and variables and their effective applications in various situations.		3, 4	1, 2,

Course Code	:	MTPE39					
Course Title	:	Sustainable Materials					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	Nil					
Course Type	:	PE					

Course Learning Objectives

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

Course Content

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

Reference Books

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

Course Outcomes

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					
Course Title	:	Integrated Computational Materials Engineering					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	Nil					
Course Type	:	PE					

Course Learning Objectives

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

Course Content

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 Modelling and Simulations of Materials – fundamentals and applications of kinetic Monte Carlo, molecular statics, and molecular dynamics simulations
Mesoscale Modelling of Process-Structure Relations in Materials -Phase-field modelling, Cellular Automata, Computational Micromechanics - Discrete Dislocation Dynamics and Crystal Plasticity
Materials Process Modelling - Finite Element/Difference/Volume Methods for Modelling of Casting, Forming and Joining Processes
Case studies on implementation of ICME at different industries

Reference Books

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 modelling for metal processing, ASM International, 2009*

Course Outcomes

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

Course Code	:	MTPE42				
Course Title	:	Principles of Extractive Metallurgy				
Number of Credits	:	3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Pre-requisites (Course code)	:	NIL				
Course Type	:	PE				

Course Learning Objectives

To comprehend the principles of metal extraction and to familiarize with the various unit operations and unit processes relevant to the domain.

Course Content

Types and occurrence of metal bearing minerals, Unit-operations for physical separation of minerals – Crushing, Grinding, Screening, Classification, Unit-operations for concentration of minerals – Dense media separation, Gravity separation, Magnetic separation, Electrostatic separation and Froth flotation, Mass balances on various mineral processing circuits.

Fundamentals of mass and heat balances in metal extraction processes, Principles of Heterogenous Kinetics of gas-solid and fluid-fluid reactions, Ellingham diagrams.

Pyrometallurgy – Unit Process of Calcination, Roasting, Smelting, Refining, Slags and Refractories, Halide metallurgy. Application in the extraction of Copper, Zinc, Mg, Ti and Li and production of Ferro-alloys,

Hydrometallurgy – Leaching, Reduction of metal ions from leach liquor, E-pH diagrams Application in Gold, Nickel, Alumina extraction

Electrometallurgy – Electrolytic Cell Reduction and Refining, Application in Aluminum extraction; Environmental Concern and Sustainable Metal Extraction

Reference Books

1. 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.
2. Ray H. S., Sridhar R., Abraham K.P, ‘Extraction of Non-ferrous Metals’, 1st Edition, Affiliated East West Press, 1987.
3. Rosenquist T., ‘Principles of Extractive Metallurgy’,2nd Edition McGraw Hill, 1983.
4. Principles of Extractive Metallurgy by H. S. Ray and A. Ghosh, 2nd Edition, New Age Intl. (P) Ltd, 1991.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the appropriate routes of physical separation and concentration of minerals			1,2
CO2	Solve problems on Heat and mass balances		12	1,2
CO3	Understand the principles of pyrometallurgy and the general procedure involved in the extraction of various metals.			1,2
CO4	Understand the principles of hydrometallurgy			1,2,3
CO5	Understand the principles of electrometallurgy and Sustainability aspects in metal extraction		6	7, 12

Course Code	:	MTPE43				
Course Title	:	Modeling in Process Metallurgy				
Number of Credits	:	3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Pre-requisites (Course code)	:	MTPE14				
Course Type	:	PE				

Course Learning Objectives

To learn the principles of physical and mathematical modeling
To gain experience in solving simple non-linear and set of equations
To gain hands-on experience in using the related software packages
To familiarize with the common methods and strategies in modeling industrial processes

Course Content

Overview of Physical and Mathematical modeling principles, advantages and limitations

Physical modeling pricinples – Similarity criteria, Hot and Cold models, Pilot scale models, Dimensional Analysis, case studies related to steelmaking processes.

Mathematical modeling principles – Static vs dynamic models, Goals and Strategies, Turbulent and multiphase flows, Coupled phenomena, Governing equations, boundary conditions, overview of solution methodologies, Boussinesq approximation, convergance criteria, numerical stability criteria, steady and transient problems, heating of slab example, Monte Carlo Simulation.

Introduction to CFD software (ANSYS Fluent and open source softwares) – CAD geometry building, solution and postprocessing exercises – Practise problems – 2D laminar pipe flow and 2D plane channel turbulent flow, near wall treatment, validation with benchmark cases,

Mathematical modeling of industrial processes – Mixing behavior in Ladle (batch process), Residence time distribution in tundish (continuous process), Continuous casting process complexities, Alloy melting, Mass balance model of a gas circuit in DR process, Kinetic modeling of ladle refining process, Thermal and Mechanical Simulation of welding processes.

Reference Books

1.	Szekely J., Themelis N. J., ‘Rate Phenomena in Process Metallurgy’, Wiley, 1971
2.	Dipak Mazumdar and James W. Evans, ‘Modeling of Steelmaking Processes’, CRC Press, 2009
3.	S. K. Dutta, ‘Fundamental of Transport Phenomena and Metallurgical Process Modeling’, Springer, 2021
4.	‘CFD Modeling and Simulation in Materials Processing’, Proceedings of Symposium held during TMS 2012, Annual Meeting and Exhibition, Orlando USA.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	To assess the similarity criteria to build valid physical models			
CO2	To formulate the appropriate building blocks of mathematical models			
CO3	To understand the basics of iterative solutions of a set of non-linear equations			
CO4	To visualise modeling of complex industrial scale materials processing			

Course Code	:	MTPE44				
Course Title	:	Phase Equilibria in Materials				
Number of Credits	:	3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Pre-requisites (Course code)	:	MTPC12				
Course Type	:	PE				

Course Learning Objectives

To comprehend the principles of Multi-phase equilibrium and to familiarize with the various Phase diagrams in the Materials Engineering and microstructures of different materials.

Course Content

Introduction to Thermodynamic equilibrium, Free energy functions, Heterogenous equilibrium, free energy of phase mixtures, single component system and the effect of curvature on the melting temperature

Binary Isomorphous systems, Equilibrium & non-equilibrium solidifications, Conditions for Phase equilibrium, Free energy curves, solute redistribution, Zone refining, Constitutional supercooling and formations of cells and dendrites.

Binary eutectic, peritectic, metatectic, monotectic and syntectic systems, partitions-less solidification theory of extended solid solubility, free energy composition diagrams for eutectic, peritectic, metatectic, monotectic and syntectic alloys, growth of eutectics, isothermal diffusion for eutectics and peritectic systems.

Solid state transformations, numerical methods of phase diagram calculations, calculation of slopes of phase boundaries for eutectic, peritectic, metatectic, monotectic and syntactic systems and quantitative microscopy

Introduction to ternary systems, three phase equilibrium, Gibbs triangle, space model, isothermal and vertical sections, four phase equilibrium in ternary systems, selected examples (Fe-Cr-Ni, SiO_2-MgO-Al_2O_3 systems)

Reference Books

1. Alloy phase equilibria, Allan Prince, Elsevier publications 1966
2. Phase diagrams in Metallurgy, F. Rhines, McGraw Hill publications, 1956
3. Introduction to Phase Equilibria in ceramic systems, F.A. Hummel, Marcel Dekker, Inc, 1984
4. Physical Metallurgy principles, R. Abbaschian and R.E Reed-Hill, University series in basic engineering, 1991

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the basic thermodynamics and free energy functions			1,2
CO2	Comprehend the principles of construction of Binary isomorphous phase diagrams		12	1,2
CO3	Understand the principles of Binary eutectic, peritectic, metatectic, monotectic and syntectic systems		12	1,2
CO4	Solve problems on Binary eutectic, peritectic, metatectic, monotectic and syntectic phase diagrams		12	1,2,3
CO5	Understand the principles of Ternary phase diagrams, and multi-phase equilibriums		6,12	1,2,12

Course Code	:	MTPE45				
Course Title	:	Electrochemical Processing of Materials				
Number of Credits	:	3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Pre-requisites (Course code)	:	Nil				
Course Type	:					

Course Learning Objectives

To acquire knowledge on principles and application of electrochemical techniques in the processing of materials

Course Content

Thermodynamic and Transport properties of electrolytes - aqueous and molten; solution models: Debye-Hückel (aqueous), Temkin (molten salts); electrode potentials (the underlying physics, i.e., electron excess or electron deficiency on the electrode); emf series (aqueous and molten salts); reference electrodes (thermodynamics and kinetics).

Fundamental aspects of electrochemical processes – Electrode-electrolyte interface, nature of the double layer; kinetics of electrode processes, charge transfer at the electrode/electrolyte interface, cell potential, current distribution and analytical techniques

DC methods such as cyclic voltammetry, linear sweep voltammetry, intermittent titration techniques, potentiodynamic polarization, chronopotentiometry, chronoamperometry, galvanostatic cycling with potential limitation. AC methods, i.e., AC voltammetry and electrochemical impedance spectroscopy, including fitting and analysis equivalent circuits.

Various electrochemical processing techniques such as winning, refining, plating, synthesis, recycling. Important process parameters like current efficiency, voltage efficiency, power efficiency; energy balances; materials issues and environmental issues.

Case studies on corrosion & surface engineering, energy conversion & storage and electrochemical recycling.

Reference Books

1. Bard, A. J., and L. R. Faulkner. Electrochemical Methods. 2nd Edition. New York: Wiley, 2000.
2. Fontana. M.G., Corrosion Engineering, Tata McGraw Hill, 3rd Edition, 2005.
3. Crompton R.G., Batchelur-Mculey C., Dikinson E. J. F., Understanding Voltammetry. Imperial College Press, 2012.
4. Barsoukov E., McDonald J.R., Impedance Spectroscopy Theory, Experiment, and Applications, Wiley-Interscience, 2nd Edition, 2005.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand basic properties of electrolytes, electrode potentials, reference electrodes	4	2	5
CO2	Understand fundamental principles of electrode-electrolyte interface and electrode kinetics	4	2	4
CO3	Learn thoroughly DC and AC electrochemical techniques	5	3	1
CO4	Learn thoroughly electrochemical processing techniques	5	3	1
CO5	Explore application oriented/practical case studies	4	2	3

Course Code	:	MTPE46				
Course Title	:	Design of Machine Elements				
Number of Credits	:	3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Pre-requisites (Course code)	:	Nil				
Course Type	:	PE				

Course Learning Objectives

To know the basics of the design of springs, joints, shafts bearings, gears and flywheels

Course Content

INTRODUCTION AND DESIGN OF SPRINGS: Introduction to machine elements and design - standards and codes - fatigue theory - design against fluctuating loads. Springs: Types of springs - Material for helical Springs - Terms used in compression springs - stresses in helical springs-deflection in helical springs-buckling of compression springs.
DESIGN OF JOINTS: Introduction to bolted and riveted joints - Welded joints: types of welded joints - weld symbols - strength of transverse fillet welded joints-strength of parallel fillet welded joints - Special cases of fillet welded joints - strength of butt joints.
DESIGN OF SHAFTS: Types of Shafts - stresses in Shafts - shafts subjected to twisting moment, bending moment and Combined Twisting Moment & Bending Moment - Shafts Subjected to fluctuating loads - Design of Shafts.
DESIGN OF BEARINGS: Classification of Bearings - Sliding contact bearings: Hydrodynamic Lubricated Bearings, Sommerfeld
Number - Design Procedure for Journal Bearings. Rolling Contact Bearings: Types of Rolling Contact Bearings. Static and Dynamic Load Rating, Reliability of Bearings - Materials and manufacture of Ball and Roller Bearings.
DESIGN OF GEARS AND FLYWHEELS: Gear fundamentals - Terms used in Gears - Law of Gearing-Introduction to spur gear, helical gear, bevel gear, worm and worm wheel. Causes of Gear Tooth Failure. Introduction to flywheels, Coefficient of Fluctuation of Speed, Energy Stored in a Flywheel, Stresses in a Flywheel Rim and Flywheel Arms. Selection and treatment of materials for gears and Flywheels.

Reference Books

1.	Khurmi R S, Gupta J K, "Machine Design", Eurasia Publishing House, 2005
2.	RobertL Mott, "Machine Elements in Mechanical Design", Pearson Prentice Hall, 2017
3.	Bhandari V B, "Design of Machine Elements", Tata McGraw Hill, New Delhi, 2017.
4.	Shigley, Mischke, "Mechanical Engineering Design", Tata McGraw Hill, New Delhi,2008.
5.	Faculty of Mechanical Engineering, "Design Data Book", PSG College of Technology, Coimbatore, 2010.
6.	Allen S Hall, Alfred R Holowenko, Herman G Laugblin, “Schaum's Outlines of Theory and Problems of Machine Design", Tata McGraw Hill ,2006.

Course Code	:	MTOE11				
Course Title	:	Nanomaterials and Applications				
Number of Credits		3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Prerequisites (Course Code)	:	NIL				
Course Type	:	OE				

Course Learning Objectives

Students who complete this course will be able to describe methods for production, characterization, and applications of nanomaterials in various fields. .

Course Content

Introduction: Concept of nanomaterials – scale/dimensional aspects, nano and nature, effect of size reduction on various properties, advantages and limitations at the nano level.

Methods to produce nanomaterials: Plasma arcing, chemical vapour deposition, sol-gel process, electrodeposition, ball milling, severe plastic deformation, etc.

Characterization of nanomaterials and nanostructures: Salient features and working principles of SEM, TEM, STM, AFM, XRD, etc.

Applications: Fullerenes, carbon nanotubes, nanocomposites, molecular machines, nano sensors, nanomedicines, etc.

Health Issues: Understanding the toxicity of nanoparticles and fibers, exposure to quartz, asbestos, air pollution.

Environmental Issues: Effect on the environment and other species.

Societal Implications: Implications of nanoscience and technology in society, government regulations, etc.

Reference Books

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	*Mick Wilsonetal, Nano technology: Basic Science and Emerging Technologies, Overseas Press, 2005.*
3	*Charles P. Poole Jr, Frank J. Owens, Introduction to nanotechnology, Wiley-India(P) Ltd., 2006.*
4	*T. Pradeep, Nano: The Essentials, Tata McGrawHill, 2007.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the terminologies used in the field of nanomaterials			1
CO2	Classify different methods of manufacturing of nanomaterials			1, 2
CO3	Observe the morphology, phase composition of nanomaterials		5	1
CO4	To select nanomaterials for different industrial applications			2, 3
CO5	To understand the health issues related to nanomaterials		2	6

Course Code	:	MTOE12
Course Title	:	Mathematical Techniques in Materials Research
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	OE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

To understand how mathematics is being used to advance research work in materials; to prepare the student for a career in materials research; and to become familiar with some specific mathematical techniques used in materials research.

Course Content

(Actual coverage will depend on the class and the draft course plan (prepared with input from the students)) (Course involves limited number of conventional lectures, considerable self–learning, and active series of student seminars on selected topics) Review of certain topics from prior mathematics courses (such as examples on the applications of differential equations in metallurgical processes) Fundamental input on the mathematics related to physical metallurgy, metallurgical thermodynamics (such as the mathematics behind crystal structures) Indicative input on use of technical software useful in this domain (such as Mathematica, MATLAB) Discussion of the basic principles related to the topics listed here, followed by student seminars on selected topics (from this list):

Mathematical Techniques in Crystallography
Stereographic Projection – Concept and Applications
Mathematics of Diffusion in Materials
Group Theory Applications in Solid State Chemistry
Dislocation modelling to study failure of materials
Studies on Fractal Geometry for the Developing Advanced Materials
Fundamentals of Density Functional Theory
Solidification Dynamics of Binary Alloys
Kapoor and Frohberg Model for multicomponent slags
Mathematical Aspects of Metallurgical Thermodynamics
Markov Chains and Processes
Pseudopotential lattice Boltzmann models for complex engineering fluids
Vector Calculus and the Behaviour of Engineering Materials
Constitutive Modelling of Engineering Materials
Weibull Distributions and their Applications
Basics of Tensor Analysis

Reference Books

1	OCW Lecture Notes on Mathematics for Materials Scientists and Engineers, MIT, USA (available version)
2	Lecture Notes on Constitutive Modelling of Engineering Materials, Chalmers University of Technology, Goteborg (available version)
3	Mathematical Techniques in Crystallography and Materials Science, Edward Prince, Springer Verlag, 1994
4	Current Literature in related topics/reading materials cited in the class

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Apply concepts of higher mathematics in studying and developing advanced materials and processes; and work in inter-disciplinary research teams		4, 5, 9	1, 2, 3

Course Code	:	MTOE13
Course Title	:	Design and Selection of Materials
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hrs: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	OE

Course Learning Objectives

To know different types of materials and properties and to select better materials for different applications.

Course Content

Technologically important properties of materials – Physical, chemical, mechanical, thermal, optical, environmental and electrical properties of materials. Material property charts – Modulus–density, strength–density, fracture toughness–strength.

Types of design, Design tools and materials data – Materials and shape – microscopic and microstructural shape factors – limit to shape efficiency. Comparison of structural sections and material indices – case studies.

Service, Fabrication and economic requirements for the components – Methodology for selection of materials – Collection of data on availability, requirements and non-functional things – its importance to the situations – case studies.

Classifying process – systematic selection of process – Selection charts – Ranking of processes – case studies – Influence of manufacturing aspects and processing route on properties of materials and its influence on selection of materials.

Selection of materials for automobile, nuclear, power generation, aerospace, petrochemical, electronic and mining industries.

Reference Books

1	*M.F. Ashby, "Materials Selection in Mechanical Design' –Third edition, Elsevier publishers, Oxford, 2005.*
2	*Gladius Lewis," Selection of Engineering Materials", Prentice Hall Inc, New Jersey, 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*

Course Outcomes

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	

Course Code	:	MTOE14					
Course Title	:	New Product Development					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	OE					

Course Learning Objectives

Exposes students to the structured New Product Development (NPD) Methodology and helps them understand the methodology; and effectively apply it to a practical situation.

Course Content

Fundamentals of Product Development - Global Trends Analysis and Product decision - Types of various trends affecting product decision - Social Trends (Demographic, Behavioral, Psychographic), Technical Trends (Technology, Applications, Tools, Methods), Economical Trends (Market, Economy, GDP, Income Levels, Spending Pattern, target cost, TCO), Environmental Trends (Environmental Regulations and Compliance), Political/Policy Trends (Regulations, Political Scenario, IP Trends and Company Policies) - PESTLE Analysis
Product Development Methodologies and Management - Overview of Products and Services (Consumer product, Industrial product, Specialty products etc.,) - Types of Product Development (NPD/Re-Engineering (Enhancements, Cost Improvements)/Reverse Engineering/Design Porting & Homologation) - Overview of Product Development methodologies - Product Life Cycle (S-Curve, Reverse Bathtub Curve) - Product Development Planning and Management
Requirement Engineering and Management - Types of Requirements (Functional, Performance, Physical, Regulatory, Economical, Behavioral, Technical, Stakeholder, Environmental, Industry specific, Internal-Company Specific) - Gathering (VOC), Analysis (QFD), Design Specification - Traceability Matrix and Analysis - Requirement Management - System Design & Modelling - Introduction to System Modelling - System Optimization - System Specification - Sub-System Design - Interface Design
Design and Testing – Conceptualization - Industrial Design and User Interface Design - Introduction to Concept generation Techniques - Concept Screening & Evaluation - Concept Design - S/W Architecture - Hardware Schematics and simulation - Detailed Design - Component Design and Verification - S/W Testing - Hardware Testing – Prototyping - Types of Prototypes (Mockups, Engineering Assessment Prototype, Alpha, Beta, Gamma) - Introduction to Rapid Prototyping and Rapid Manufacturing
System Integration and Business Dynamics - Testing, Certification and Documentation - Manufacturing / Purchase and Assembly of Systems - Integration of Mechanical, Embedded and S/W systems - Product verification processes and stages – Industry specific (DFMEA, FEA, CFD) - Product validation processes and stages - Industry specific (Sub-system Testing / Integration Testing / Functional Testing / Performance Testing / Compliance Testing) - Product Testing standards and Certification – Industry specific - Product Documentation - Sustenance Engineering and End-of-Life (EoL) Support – Maintenance and Support - Obsolescence Management - Configuration Management - EoL Disposal; Business Dynamics – Engineering Services Industry - Product development in Industry versus Academia - vertical specific product development processes - Intellectual Property Rights and Confidentiality

Reference Books

1	*Kevin Otto, Kristin Wood, “Product design techniques in reverse engineering and new product development”, Pearson, India, 2006*
2	*Ulrich, Karl T. and Eppinger, Steven D, “Product Design and Development”, 3rd Edition, McGraw-Hill, New York, 2004*

3	*Ullman, David G., "The Mechanical Design Process", McGraw-Hill, 4thedition, 2009*
4	*Kenneth B. Kahn, George Castellion, Abbie Griffin, The PDMA Handbook of New Product Development, 2005, John Wiley &Sons, Inc. Hoboken, New Jersey, USA.*
5	*Merle Crawford, Anthony Di Benedetto, New Products Management, ninth edition, 2008, McGrawHill Companies Inc. New York, USA*
6	*A.K. Chitale, R.C. Gupta, 'Product Design and manufacturing'*
7	*Handouts provided by industrial experts*
8	*Resource Materials/ 'BoK' provided by NASSCOM, related to NPD*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Clear understanding of the NPD Methodology		6	1, 3
CO2	Clear understanding of the influence of STEEP Factors for the success of New Product		6	1, 3
CO3	Clear understanding of the importance of Customer study, requirement gathering and analysis, Patent Study and analysis and Concept Generation		6	1, 3
CO4	Execute Pilot NPD Project		4, 6	3
CO5	Apply individual Creative skills, work as a team to achieve the results and present the project outcome to management review team		6	3, 9

Course Code	:	MTOE15
Course Title	:	Introduction to Quality Management
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	OE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

- To learn important concepts in quality;
- To learn about quality philosophy; and
- To learn about statistical tools used in quality

Course Content

Quality – introduction; philosophical approach; cost of quality; overview of the works of Juran, Deming, Crosby, Taguchi; PDCA cycle; quality control; quality assurance

Quality organization; quality management; quality system; quality audit; vendor quality assurance; total quality management; quality awards; quality certification; typical procedure for ISO 9000, ISO 14000, QS 9000.

Variations; analysis of variance, statistical tools, statistical quality control; control charts; process capability analysis; statistical process control.

Inspection; inspection by sampling; acceptance sampling; statistical approaches; single, double and multiple sampling plans.

Reliability – concept; difference between reliability and quality; different measures of reliability; time to failure distributions; MTBF.

Reference Books

1	*J.M. Juranand F.M. Gryna, 'Quality Planning and Analysis', McGraw Hill, New York, 2nd Edition, 1980*
2	*B.L. Hansen, P.M. Ghare, 'Quality Control and Application', Prentice Hall of India–EasternEconomy Edition, 1997.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the significance of quality management			1
CO2	Actively participate in quality systems certification initiatives		4, 5	3
CO3	Qualitatively use quality concepts to real applications			5
CO4	Perform basic calculations in SQC / SPC		2	4
CO5	Appreciate the benefits of advanced concepts such as Six Sigma		2	1
CO6	Perform simple calculations in reliability			1, 2

Course Code	:	MTOE16
Course Title	:	Surface Engineering
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	OE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

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

Course Content

Introduction to tribology, surface degradation, wear and corrosion, types of wear, adhesive, abrasive, oxidative, corrosive, erosive and fretting wear, roles of friction and lubrication-overview of different forms of 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, deposition of 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, chemical vapour 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, tests for assessment of wear and corrosion

Reference Books

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

Course Outcomes

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

Course Code	:	MTOE17					
Course Title	:	Process Modelling and Applications					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		1	1	1	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	OE					

Course Learning Objectives

At the completion of this course, the student will be able to comprehend basic concepts related to process modelling; to get hands-on experience in some aspects of modelling; and to be able to visualize modelling of complex industrial scale metallurgical processes.

Course Content

Mathematical modelling, physical simulation, advantages and limitations; process control, instrumentation and data acquisition systems.

Review of transport phenomena, review of differential equations, review of numerical methods; concept of physical domain and computational domain, assumptions and limitations in numerical solutions, introduction to FEM & FDM.

Introduction to software packages – useful websites and generic information about different products – ANSYS, Thermocalc, CFD; introduction to expert systems and artificial intelligence; demonstration/practical training in some software packages.

Physical modelling – cold and hot models; case studies of water models, use of computers for the construction of phase diagrams, alloy design, crystallography, phase transformations and thermochemical calculations.

Case studies from literature – pertaining to modelling of solidification/heat transfer, fluid flow, casting, welding and liquid metal treatment.

Laboratory component: Exercises using ThermoCalc software and databases (installed in multiple terminals); and any other accessible related technical software.

Reference Books

1	*Szekely J., Themelis N. J., 'Rate Phenomena in Process Metallurgy', Wiley, 1971*
2	*P.S. Ghosh Dastidar, "Computer Simulation of Flow and Heat Transfer", Tata McGrawHill, NewDelhi, 1998*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Obtain comprehensive knowledge of basic equations and concepts related to process modelling, and comfortably interact with researchers and shop floor engineers.		5	1, 10
CO2	Understand terminologies related to process modelling			1, 2
CO3	Become familiar with the use of modelling as a tool for a wide range of metallurgical processes.			3, 4, 5

Course Code	:	MTOE18					
Course Title	:	Intellectual Property Rights					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	OE					

Course Learning Objectives

To impart the knowledge in IPR and related areas with case studies.

Course Content

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.

Reference Books

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. Prabuddha Ganguli, 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

Course Outcomes

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 indications and trade secrets			4, 6
CO3	Study the fundamentals of IPR law, including the process of securing the various types of IPR			12

Course Code	:	MTOE19					
Course Title	:	Business and Entrepreneurship for Engineers					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	OE					

Course Learning Objectives

- 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

Course Content

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

The Start-up 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: Start-up basics; Ideation and Refinement; Team Formation; Start-up 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

Reference Books

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 Start-up 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

Course Outcomes				
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

Course Code	:	MTOE21
Course Title	:	Artificial Intelligence in Materials Engineering
Number of Credits		3
Prerequisites (Course Code)	:	NIL
Course Type	:	OE

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

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

Course Content

(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

Reference Books

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

Course Outcomes

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

	Course code	Course Name	Duration	UG/PG	Semester
1	MTOC01	Materials Design for Electronic, Electromechanical and Optical Functions	12 Weeks	UG	**V / VII**
2	MTOC02	Artificial Intelligence and Machine Learning in Materials Engineering	12 Weeks	UG	**V / VII**
3	MTOC03	Physics of Materials	12 Weeks	UG	**III / V / VII**
4	MTOC04	Aluminium based Alloys and Metal Matrix Composites	12 Weeks	UG	**V / VII**
5	MTOC05	Surface Mining Technology	12 Weeks	UG	**III / V / VII**
6	MTOC06	Fundamentals of Composite and Cellular Materials	12 Weeks	UG	**V / VII**
7	MTOC07	Corrosion/Environmental Degradation/Surface Engineering	12 Weeks	UG	**VII**
8	MTOC08	Mine Closure and Sustainability Planning	12 Weeks	UG	**III / V / VII**
9	MTOC23	Nanomaterials and their Properties	12 Weeks	UG	**III / V / VII**
10	MTOC24	Introductory Materials Informatics	12 Weeks	UG	**III / V / VII**
11	MTOC25	X-ray Crystallography & Diffraction	12 Weeks	UG	**V / VII**
12	MTOC26	Crystals, Symmetry and Tensors	12 Weeks	UG	**V / VII**
13	MTOC27	Phase Diagrams in Single Component and Binary Systems	12 Weeks	UG	**V / VII**
14	MTOC28	Phase Field Modelling: The Materials Science, Mathematics and Computational Aspects	12 Weeks	UG	**V / VII**
15	MTOC30	Computational Thermodynamics and Kinetics of Materials	12 Weeks	UG	**III / V / VII**
16	MTOC31	Fracture, Fatigue and Failure Of Materials	12 Weeks	UG	**V / VII**
17	MTOC32	Environmental Degradation and Surface Engineering	12 Weeks	UG	**V / VII**
18	MTOC33	Mechanical Behavior of Polymers and Composites	12 Weeks	UG	**V / VII**
19	MTOC35	Wild Life Ecology	12 Weeks	UG	**III / V / VII**
20	MTOC09	Advanced Manufacturing and Process Modelling	12 weeks	UG/PG	VI, VIII
21	MTOC10	Advances in Additive Manufacturing of Materials: Current status and emerging opportunities	12 Weeks	PG	IV, VI, VIII
22	MTOC11	Aqueous Corrosion and Its Control	12 Weeks	UG/PG	VI, VIII
23	MTOC12	Bulk Material Transport and Handling Systems	12 Weeks	UG/PG	VI, VIII
24	MTOC13	Carbon Materials and Manufacturing	12 Weeks	PG	IV, VI, VIII

25	MTOC14	Clean Coal Technology	12 weeks	UG/PG	IV, VI, VIII
26	MTOC15	Crystal Symmetry, X-Ray Diffraction and Physical Properties	12 Weeks	UG/PG	IV, VI, VIII
27	MTOC16	Dealing with materials data : collection, analysis and interpretation	12 Weeks	PG	IV, VI, VIII
28	MTOC17	Diffusion in Solids	12 Weeks	UG/PG	IV, VI, VIII
29	MTOC18	Introduction to materials science and engineering	12 Weeks	UG	IV, VI, VIII
30	MTOC19	Mineral Economics and Business	12 Weeks	UG	IV, VI, VIII
31	MTOC20	Phase Diagrams in Materials Science and Engineering	12 Weeks	UG/PG	IV, VI, VIII
32	MTOC21	Principles of Extractive Metallurgy	12 Weeks	UG	IV, VI, VIII
33	MTOC22	Surface Engineering for Corrosion and Wear Resistance Application	12 Weeks	UG/PG	IV, VI, VIII

Course Code	:	MTMI11				
Course Title	:	Materials Technology				
Number of Credits		3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Prerequisites (Course Code)	:	NIL				
Course Type	:	MINOR				

Course Learning Objectives

To impart knowledge in material properties and manufacturing methods. Students will be able to understand various materials, their properties, and manufacturing methods

Course Content

INTRODUCTION
Selection criteria and processes: General criteria of selection of materials in process industries. Properties: Mechanical, Thermal, Chemical, Electrical, Magnetic and Technological properties. Processing of metals and alloys – Casting, hot and cold rolling, forging, extrusion, deep drawing.

FERROUS AND NON-FERROUS METALS
Pure iron, cast iron, mild steel, stainless steels, special alloy steels – iron and iron carbide phase diagram – heat treatment of plain-carbon steels. Manufacturing methods of Lead, Tin and Magnesium. Properties and applications in process industries.

POLYMERS, COMPOSITES, CERAMICS AND INORGANIC MATERIALS
(i) Industrial polymerization methods, crystallinity and stereoisomers – Thermosetting and Thermoplastics.
(ii) FRP – Fiber Reinforced Plastics (FRP), different types of manufacturing methods; asphalt and asphalt mixtures; wood.
(iii) Ceramic crystal and silicate structures – processing of ceramics – cements – glasses – enamels – properties.
(iv) Cement and its properties – manufacturing of cement, special cements, cement concrete, RCC – Prestressed concrete.

ADVANCED MATERIALS
Single crystals – production, properties, applications – memory metals – intelligent materials – some important metallic and non-metallic single crystals.

CORROSION AND PREVENTION
Definition of corrosion – Basic theories and mechanism of corrosion – Types of corrosion – Anti-Corrosion methods – Organic paints and coatings – metal, ceramic coatings.

Reference Books

1	*Ashcroft and Mermin,* Solid State Physics*, Saunders College Publishing, 1976.*
2	*Sidney H. Avner,* Introduction to Physical Metallurgy*, 2nd Edition, Tata McGraw Hill, 1997.*
3	*William D. Callister,* Materials Science and Engineering*, 2nd Edition, Wiley, 2014.*
4	*V. Raghavan,* Physical Metallurgy: Principles and Practice*, 2nd Edition, PHI, 2006.*
5	*Fontana M. G., Greene N. D.,* Corrosion Engineering*, 2nd Edition, McGraw Hill, 1983.*
6	*Pat L. Manganon,* Principles of Materials Selection for Engineering Design*, Prentice Hall Int. Inc, 1999.*

Course Outcomes				
At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.			1, 2
CO2	Select a material for a particular application based on the requirements.			2, 3
CO3	Predict and apply the necessary protection mechanisms to prevent corrosion.		12	3

Course Code	:	MTMI12
Course Title	:	Fundamentals of Metallurgy
Number of Credits		3

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Prerequisites (Course Code)	:	NIL
Course Type	:	MINOR

Course Learning Objectives

To give basic ideas about alloys classification, material characterization, and protection of materials.

Course Content

Types of steels: Plain carbon steel, alloy steels, tool steels, stainless steel.

Types of cast iron: Grey, white, SG (Spheroidal Graphite), malleable, and alloy cast iron.

Industrially important non-ferrous alloys: Cu, Al, Ti, Mg, and Ni based alloys.

Introduction to materials characterization: Optical and electron microscopy, and X-ray diffraction.

Degradation of materials: Corrosion and protective methods.

Reference Books

1	*Sidney H. Avner,* Introduction to Physical Metallurgy*, 2nd Edition, Tata McGraw Hill, 1997.*
2	*William D. Callister,* Materials Science and Engineering*, 2nd Edition, Wiley, 2014.*
3	*V. Raghavan,* Physical Metallurgy: Principles and Practice*, 2nd Edition, PHI, 2006.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the basic classification and properties of steels and cast iron.			1
CO2	Describe the structure, properties, and applications of non-ferrous alloys.			1
CO3	Characterize the materials by microscopy and X-ray diffraction.		4	1, 2
CO4	Identify the form of corrosion and suggest protection methods.		4	2, 3

Course Code	:	MTMI13					
Course Title	:	Physical Metallurgy and Heat Treatment					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	MINOR					

Course Learning Objectives

To develop an understanding of the basis of physical metallurgy and correlate the structure of materials with their properties for engineering applications.

Course Content

Introduction to engineering materials:
Atomic structure and inter-atomic bonding, theoretical concept of crystalline materials – types o packing, voids and packing factors for each of the packings, concept of alloy design using lattice positions and interstitial voids. Planes and directions and imperfections in solids. Polymorphism and allotropy.
Diffusion, energetics of solidification:
Nucleation and growth – dealing with homogeneous and heterogeneous nucleation and growth o solids, dendritic growth in pure metals, constitutional supercooling and dendritic growth in alloys.
Phase diagrams:
Solid solution – types, Hume–Rothery rules.
Phase diagrams – Binary types – Lever rule.
Solidification of different types of solid solutions – Iron-Carbon diagram – Effect of alloying elements on Iron-Carbon diagram.
Ternary phase diagrams – Understanding of isotherms and isopleths.
Heat treatment of ferrous alloys:
Annealing, Normalising, TTT and CCT diagrams, Hardening – hardenability measurements tempering. Thermomechanical treatments. Heat treatment furnaces – atmospheres – quenching media – case hardening techniques.
Basic concepts of dislocations:

Their types and interactions. Dislocations and strengthening mechanisms – strengthening by grain-size reduction, solid solution strengthening, strain hardening, dispersion hardening and other recen modes of hardening.

Reference Books

1	*Avner, S. H.,* Introduction to Physical Metallurgy*, 2nd edition, McGraw Hill, 1985.*
2	*William F. Hosford,* Physical Metallurgy*, Taylor & Francis Group, 2008.*
3	*Raghavan, V.,* Physical Metallurgy*, Prentice Hall of India, 1985.*
4	*Donald R. Askland and Pradeep P. Phule,* Essentials of Materials Science and Engineering*, Baba Barkha Nath Printers, Delhi.*
5	*William D. Callister, Jr.,* Materials Science and Engineering*, Wiley India Pvt. Ltd.*
6	*Vijendra Singh,* Physical Metallurgy*, Standard Publishers.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Describe the basic crystal structures (BCC, FCC, and HCP), recognize other crystal structures, and understand their relationship with material properties.			1, 2

CO2	Define and differentiate engineering materials on the basis of structure and properties for engineering applications.			1, 2
CO3	Identify proper processing technologies for synthesizing and fabricating different materials.			1, 2
CO4	Analyse the microstructure of metallic materials using phase diagrams and modify the microstructure and properties using different heat treatments.			2, 3
CO5	Understand the various types of strengthening mechanisms to improve material properties.			1

Course Code	:	MTMI14
Course Title	:	Deformation Processing
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hrs: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	MINOR

Course Learning Objectives

To know the concepts of metal forming and associated technologies, and apply them to conventional and advanced materials manufacturing for various structural applications.

Course Content

Yielding criteria: Von Mises and Tresca. Levy-Von Mises equations and Prantl-Reuss equations for ideal plastic and elastic-plastic solids, respectively. Yield locus.
Methods of load calculation: Including slab method, slip line field theory, FEM, upper and lower bound methods.
Texture effects: Metallurgical factors affecting recrystallization temperature and grain size. Effect of temperature, strain rate, hydrostatic pressure, microstructure.
Residual stresses, friction and lubrication mechanisms: Lubricants in rolling, forging, extrusion, wire drawing, sheet metal forming. Tool design.
Types of rolling mills: Geometrical factors and forces, factors affecting rolling load and minimum thickness, roll pass design, wheel and tyre production. Rolling defects, processes and equipment.
Forgeability: Effect of various factors, definitions. Selection of equipment, die design, parting line, flash, draft, tolerance. Defects, causes and remedies.
High velocity forming methods: Superplastic forming, hydroforming, isothermal forging. Principles and processes.
FLD and LDR, CAD, CAM in forming: Use of software like OPTRIS, DEFORM, etc. Workability.
Severe Plastic Deformation: Brief introduction.

Reference Books

1. *Dieter, G.E.,* Mechanical Metallurgy*, McGraw Hill, 2001.*
2. *ASM,* Metals Handbook, Vol. 14, Forming & Forging*, ASM, Metals Park, Ohio, USA, 1998.*
3. *Kurt Lange,* Handbook of Metal Forming*, Society of Manufacturing Engineers, Michigan, 1985.*
4. *Belzalel Avitzur,* Metal Forming – Processes and Analysis*, Tata McGraw Hill, 1977.*
5. *Mahmood Aliofkhazraei (Editor),* Handbook of Mechanical Nano structuring*, Wiley-VCH Verlag GmbH & Co, Germany, 2015.*

Course Outcomes

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 into useful shapes for intended engineering purposes.			1
CO2	Differentiate the various metal forming technologies and choose the appropriate one for required engineering applications.		3	2
CO3	Analyze various operational and material parameters influencing metal forming quality.			2
CO4	Understand the non-conventional metal forming methods.			1
CO5	Use software related to metal forming.	2	1	5

Course Code	:	MTMI15					
Course Title	:	Manufacturing Methods					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	MINOR					

Course Learning Objectives

To understand the fundamentals of manufacturing methods from a metallurgical perspective with reference to engineering applications.

Course Content

Types of production and production processes:
Product configuration and manufacturing requirements
Pattern making, allowances, and core making:
Casting processes of ferrous and non-ferrous metals including die casting, investment casting, centrifugal casting, loam moulding, transfer moulding. Solidification principles, design of moulds, risers, sprues, and gating systems. Casting defects.
Metal joining processes:
Soldering, brazing, fusion and non-fusion welding processes, various modern welding processes like TIG, MIG, Submerged Arc Welding, Friction Welding. Welding defects.
Fundamentals of hot and cold working processes:
Forging, extrusion, and rolling.
Introduction to powder metallurgy:
Production of metal powders. Compaction and sintering processes. Secondary and finishing operations. Economics, advantages, and applications of powder metallurgy.

Reference Books

1	*Manufacturing Technology: Foundry, Forming and Welding* by P. N. Rao, TMH.
2	*Principles of Manufacturing Materials and Processes* by James S. Campbell, TMH.
3	*Welding Metallurgy* by G. E. Linnert, AWS.
4	*Production Engineering Sciences* by P. C. Pandey and C. K. Singh, Standard Publishers Ltd.
5	*Manufacturing Science* by A. Ghosh and A. K. Mallick, Wiley Eastern.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the basic principles of different manufacturing processes in terms of a metallurgical 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 via the powder metallurgy route.			1

Course Code	:	MTMI16					
Course Title	:	Testing and Evaluation of Materials					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	NIL					
Course Type	:	MINOR					

Course Learning Objectives

To develop the fundamental knowledge on testing and evaluation of materials, in order to control quality in manufacturing and production engineering components.

Course Content

Visual examination, Basic principles of liquid penetrant testing and Magnetic particle testing. Radiography - basic principle, electromagnetic radiation sources, radiographic imaging, inspection techniques, applications, limitations and safety.
Eddy current testing - principle, application, limitation; ultrasonic testing - basic properties of sound beam, transducers, inspection methods, flaw characterisation technique, immersion testing, advantage, limitations; acoustic emission testing.
Leak testing, Holography and Thermography - principles, procedures and applications, Comparison and selection of NDT methods; defects in casting, forging, rolling and others.

Mechanical Testing: Indentation hardness tests - principle, practice, precautions and uses; Tensile test - sample types and dimensions, stress-strain diagrams for ductile and brittle materials, interpretation and estimation of tensile properties; compression, shear, bend and torsion tests - principle, practice and uses; introduction to relevant standards.

Charpy and Izod impact tests - techniques and applications; low and high cycle fatigue testing methods, S-N diagram, applications; creep and creep rupture tests, time compensated parameters; relevant standards

Reference Books

1	*Baldevraj, Jayakumar T., Thavasimuthu M., 'Practical Non-Destructive Testing', Narosa*
2	*Das A.K., 'Metallurgy of Failure Analysis', TMH, 1992*
3	*ColangeloV. A., 'Analysis of Metallurgical Failures', John Wiley, 1985*
4	*Suryanarayana A. V.K., Testing of metallic materials, (2ndEdition), BS publications, 2007*
5	*Dieter G.E., Mechanical Metallurgy, (3rdEdition), ISBN:0070168938, McGrawHill, 1988.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Differentiate various defect types and describe the main criteria to select the appropriate NDT methods.		5	1, 2, 3
CO2	Select suitable NDT methods for specific industrial applications.			2, 3
CO3	Understand the criteria to select the appropriate destructive testing methods and corresponding standards for a specific application.		3	1, 2
CO4	Carry out destructive testing to evaluate the mechanical properties for industrial purposes.			2, 3

Course Code	:	MTMI17
Course Title	:	Non-Metallic Materials
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hrs: 3, C: 3
Prerequisites (Course Code)	:	NIL
Course Type	:	MINOR

Course Learning Objectives

To provide an understanding of the various non-metallic materials, their properties and applications

Course Content

Classification of Engineering materials – Metals, Ceramics, Polymers (and Composites):
Ceramics – Definition, classification; Ionic and Covalent ceramics; Oxide and Non-oxide ceramics; Crystalline and Non-Crystalline ceramics.
Oxide ceramics – Examples, Structures, Properties and Applications; Indicative domains as in refractories, glasses, abrasives and Biomaterials.

Non-oxide ceramics – Examples, Structures, Properties and Applications; Indicative information on synthesis/production, indicative application domains.

Polymers – Basic unit, degree of polymerisation, Structure, Properties and Applications; Thermoplastic and Thermoset polymers, speciality polymers.

Composite Materials – Concept, Definition, Structure, Classification and Manufacturing. Specific discussion on any two types of particulate composites and fibrous composites; Novel applications of special composites especially in strategic areas.

Reference Books

1	*VanVlack L.H, Elements of Materials Science and Engineering, 6th edition, Addison Wiley, 1989*
2	*Billmeyer F., 'Textbook of Polymer Science', Wiley Interscience, 1994*
3	Richerson D.W., 'Modern Ceramic Engineering-Properties Processing and Use in Design', 3rd edition, CRC press, 2006
4	Carter, C. Barry, Norton, M.Grant, Ceramic Materials: Science and Engineering, 2nd Edition, Springer, 2013
5	Donald R.Askeland and Pradeepphule, The science and Engineering of Materials. Thomson, 2003

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Select different materials other than conventional metals and alloys for specific engineering applications.	5	3	1, 2
CO2	Solve the materials problems associated with weight reduction through the appropriate choice of polymers, ceramics, and composites.	5	3	1, 2
CO3	Describe the selection criteria for polymers, ceramics, and composites for various engineering applications.	5	3	1, 2
CO4	Analyze different microstructures of polymers, ceramics, and composites and alter them according to application requirements.	5	3	1, 2
CO5	Emphasis the need of modern materials over conventional metal and alloys	5	3	1, 2

Course Code	:	MTHO11				
Course Title	:	Advanced Thermodynamics of Materials				
Number of Credits		4				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	1	0	4	4
Prerequisites (Course Code)	:	MTPC11				
Course Type	:	HONOURS				

Course Learning Objectives

To become familiar with recent developments in thermodynamics and their applications; and get exposed to thermodynamic modelling activity.

Course Content

Review of thermodynamics – metallurgical, mechanical, and statistical perspectives. Experimental procedures related to thermodynamics – calorimetry, activity measurements, interaction coefficient, and electrochemical cells.

Thermodynamics of defects – theoretical calculations and practical significance.

Application of thermodynamics to surfaces, interfaces, bulk metallic glasses, high-entropy systems, and novel materials.

Modelling techniques used in thermodynamics of materials – in the context of phase diagrams free energy calculations, electrochemical cells, corrosion, solution thermodynamics, slags, and alloy development; exposure to techniques in computational materials science; introduction to thermodynamics of nano systems.

Reference Books

1	*D. R. Gaskell, Introduction to the Thermodynamics of Materials, 4thE, Taylor &Francis, NY2003*
2	*R.T. Dehoff, Thermodynamics in Materials Science, 1st and2ndEdition, McGraw-Hill, 2006.*
3	*D. V. Ragone, Thermodynamics of Materials, Vol.1&2, John Wiley & Sons, 1994.*
4	*Richard A Swalin, Thermodynamics of Solids, John Wiley &Sons, 1994.*
5	*S. A. Porterand K. E. Easterling, Phase Transformation in Metals and Alloys, 2ndEdition, Chapman and Hall, 1992.*
6	*J.J. Moore, Chemical Metallurgy, 2ndEdition, Butterworths, 1990.*
7	*Current literature, open web resources and materials for case study*

Course Outcomes

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	Use thermodynamics as a tool for developing metals and materials	1	2	3, 4
CO4	Develop next generation materials with superior properties	1	2	3, 4

Course Code	:	MTHO12
Course Title	:	Crystallography
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course Code)	:	MTPC12
Course Type	:	HONOURS

Course Learning Objectives

To study structure property correlations

Course Content

Motif, lattices, lattice points, lattice parameter, Crystal systems, 14 Bravice lattices, Coordination number, number of atoms per unit cell, packing factor, Miller indices of planes directions, repeat distance, linear density packing factor along a direction, planar density, planar packing fraction

Radius ration for coordination number 2, 4, 6, 8. Interstitial solid solution, Interstitial compounds. AX, AX2, AB03A2B04crystal structures

Frenkel- Schottky ionic defects, Ionic defect concentration, solute incorporation, Electronic defect Electronic defect concentration

Band Gap, density of states, defects. Defects and chemical reaction.

Symmetry and Crystallography:
Symmetry in crystals. Rotational symmetry, stereographic projection. Crystallographic point groups, micro translations, symmetry of reciprocal lattice, systematic absences, space groups, special positions.

Reference Books

1	Donald E. Sands, Introduction to crystallography, Courier Corporation, 2012
2	Donald R. Askeland and Pradeep Phule, The science and Engineering Materials. Thomson, 2003
3	Cullity B.D., Elements of X-ray diffraction, Addison-Wesley Publishing company 1956

Course Outcomes

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	Understand the correlation between symmetry and properties		3	1, 2

Course Code	:	MTHO13					
Course Title	:	Aerospace Materials					
Number of Credits		4					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites (Course Code)	:	NIL					
Course Type	:	HONOURS					

Course Learning Objectives

The objective is to learn about aerospace components and the critical requirements of materials. It also aims to develop an understanding of the different types of materials used in aerospace applications and to anticipate future material needs. Additionally, the course will help assess surface testing methods and provide insight into the degradation properties of aerospace materials.

Course Content

Classification and different components in aircraft, helicopters, and rockets; properties of materials; airworthiness; aerospace material design drivers; quality standards for the aerospace industry. It includes an overview of material requirements for aerospace structures, engines, and rockets.

Mechanical and durability testing of aerospace materials; aerospace materials certification; structural health monitoring and non-destructive testing of aircraft components; corrosion and corrosion testing of aerospace materials. The course also covers materials selection for aerospace and space environments, and their effects on materials. Special topics include stealth technology and the yield strength anomaly (Kerf–Wilsdorf Mechanism).

Materials for gas turbines include Ni-based superalloys, intermetallics, Ti-Al alloys, bond coats, and thermal barrier coatings (plasma spraying). Materials for rocket combustion chambers and nozzles include copper alloys, cobalt-based alloys such as Stellite, and columbium alloys.

Additionally, the course covers advanced structural materials such as Al-Li alloys, magnesium alloys, titanium alloys, superalloys, stainless steels, and maraging steel.

In composites, focus areas include polymer matrix composites, carbon–carbon composites, and ablative composites.

Reference Books

1	*Adrian P Mouritz, Introduction to Aerospace Materials, Woodhead publishing, 2012*
2	*Cantor, B., Assender.H., and Grant.P(Ed), Aerospace Materials, CRC press, 2007*
3	*Reed.R.C., The Superalloys –Fundamental sand Applications, Cambridge Univ. Press, 2009*
4	*Campell.F.C., Manufacturing Technology for Aerospace Structural Materials, Elsevier, 2010*
5	*Krishnadas Nair, C.G. Handbook of Aircraft Materials, Interline Publishing, 1993*
6	*Balram Guptha, Aerospace Materials, Vol. I, II, III, S. Chand publications, 1993*
7	*Horst Buhl, Advanced Aerospace Materials, Springer, 2006*
8	*Harvey M Flower, High Performance materials in Aerospace, Springer, 2006.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Know about the components used in Aircraft, Rocket and Helicopter		2	1, 4

CO2	Understand different type of testing methods for aerospace components		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

Course Code	:	MTHO14					
Course Title	:	Ladle Metallurgy and Continuous Casting of steels					
Number of Credits		4					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites (Course Code)	:	MTPC18					
Course Type	:	HONOURS					

Course Learning Objectives

To develop an understanding of the basic principles of ladle metallurgy and continuous casting, impart modelling skills, and apply them to industrial problems to enable students to solve the challenges encountered in the steel industry.

Course Content

Terminology – scrap-based operation Vs refining; trends in quality of liquid steel; different approaches to refining; overview of various treatments including vacuum, inert gas, injection, electro-slag. Terminology related to injection metallurgy; Ladle furnace; advantages and approaches; injectables – type of materials; discussion of some specific treatments; impact on overall quality; foaming of slags. Ingot casting Vs continuous casting (CC); difficulties in CC of steels; increasing CC output in the steel industry; mould and machine details including different components and configurations; SEN, Ladle and Tundish.

Role of mould powders (fluxes) in CC; physical and chemical interactions during CC; overview of defects in CC; production stoppages such as breakouts; indicative heat sizes and machine output; concept and implementation of sequence casting.

Overview of process modelling; applications in ladle metallurgy and CC; mathematical modelling of solidification; physical modelling of fluid flow in CC; case studies from current literature.

Reference Books

1	*Tupkary R.H., 'Introduction to Modern Steel Making', Khanna Publishers, 2004*
2	*B. Deo, R. Boom, 'Fundamentals of steel making metallurgy', Prentice Hall International, New York, 1993*
3	*Continuous casting–Vol.1, 'Chemical and Physical Interactions during transfer operations', Iron and Steel Society, Warrendale, PA, USA, 1983.*
4	*Ahindra Ghosh, 'Textbook of Materials and Metallurgical Thermodynamics', PHI Learning, 2002.*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the terminologies used in the field of ladle metallurgy and continuous casting of steels.		2	1
CO2	Classify different kinds of treatments for the steel during manufacturing.		5	1, 2
CO3	Compare the capabilities of ingot casting and continuous casting.		2	4
CO4	Apply the basic modelling skills in the area of ladle metallurgy and continuous casting.		3	4, 5

Course Code	:	MTHO15					
Course Title	:	Recent Trends in Nanomaterials					
Number of Credits		4					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	1	0	4	4	
Prerequisites (Course code)	:	NIL					
Course Type	:	HONOURS					

Course Learning Objectives

To provide an understanding of the various concepts involved in the fabrication of nanomaterials and the focus on technological applications in various fields of science and engineering.

Course Content

Synthesis of Nanomaterials
Recent advances in Physical Vapor Deposition (PVD), pulsed laser deposition, Magnetron sputtering, Multi Beam Epitaxy, Arc-Discharge, Chemical Vapor Deposition (CVD), Atomic Layer Deposition (ALD) - Microlithography, Vapor (or solution)–liquid–solid (VLS or SLS) growth - pulse electrochemical deposition – Super Plastic Deformation, High energy ball milling, Chemical-Mechanical milling, Electro explosion, Laser ablation.

Nanotechnology in Electronics and Energy
Nano electronic devices and circuits – Semiconductor Memories - Dynamic Random Access Memory – Non-volatile Semiconductor Memories - Quantum Dot based Memory Cell - Sensors; physical and chemical - Electronic noses - Actuators - Micro and Nano- Electromechanical systems – Lighting and Displays – Quantum optical devices - Lasers – Batteries – Supercapacitors - Fuel cells – Role of nanomaterials in fuel cell applications - Photovoltaic cells – Application of nanotechnology in solar cells - Application of power in transportation including space.

Nanotechnology in Biomedical Industry
Nanoparticles and Micro-organism - Biosensors - Bioreceptors and their properties - Biochips - Integrated nano sensor networks for detection and response - Natural nanocomposite systems; spider silk, bones, shells - Nanomaterials in bone substitutes and dentistry – Tissue Engineering – Neuroscience - Neuro-electronic Interfaces - Nanorobotics – Protein Engineering – Nano sensors in Diagnosis – Drug delivery – Cancer therapy and other therapeutic applications.

Nanotechnology in Agriculture and Food Sector
Nanotechnology in Agriculture - Precision farming, Smart delivery systems – Insecticides using nanotechnology – Potential of nano-fertilizers – Potential benefits in Nanotechnology in Food industry – Global Challenges - Product innovation and Process improvement - Consumer benefits - Food processing - Packaging - Packing materials; physical properties - Improvements of mechanical and barrier properties - Antimicrobial functionality - Active packaging materials - Information and communication technology - Sensors - RF identification - Food safety - Nanomaterial based Food diagnostics – Contaminant detection – Intelligent packaging - Nanoengineered Food ingredients - Potential risks to Nano food to consumers.

Nanotechnology in Defence and Aerospace
Pathways to Physical protection - Detection and diagnostics of chemical and biological agents, methods - Chemical and Biological countermeasures - Decontamination - Post exposure and pre exposure protection and decontamination - Nanotechnology enabled biochemical weapons - Influence operations - Evasion of medical countermeasures - Nanotechnology based satellite communication system - Guidance, Navigation and control - Spacecraft thermal control - mini, micro, nanosatellite concepts - Fiber optic and Chemical microsensors for spacecraft and launch support - Micro/Nano pressure and temperature sensors for space missions

Reference Books	
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, “Nano particles: From Theory to Applications”, Wiley-VCH Verlag GmbH &Co., 2004.
4	Bharat Bhushan, “Springer Handbook of Nanotechnology”, Barnes & Noble, 2004.
5	Neelina H. Malsch (Ed.), “Biomedical Nanotechnology”, CRCPress2005.
6	W.N. Chang, “Nano fibres fabrication, performance and applications”, Nova Science Publishers Inc, 2009.
7	Margaret E, Kosal, “Nano technology for Chemical and Biological defence”, Springer2009.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Choose a tailor-made synthesis route according to the requirements of the end product.		1, 2	3
CO2	Provide instances of contemporary industrial applications of Nanotechnology.		4, 12	1, 2
CO3	To provide an overview of future technological advancements and increasing role of nanotechnology in industries.		2, 4, 6	5, 12

Course Code	:	MTHO16					
Course Title	:	Advanced Solidification Processing					
Number of Credits		3					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	3	
Prerequisites (Course Code)	:	MTPC19					
Course Type	:	HONOURS					

Course Learning Objectives

A study of important thermodynamic functions related to solidification of metal in molds involving the characteristics of liquid-solid phase transformations, laws of thermodynamics and other functions. To analyze solidification processing of engineering materials in terms of the phase equilibrium, transport, and interface phenomena governing microstructure development in liquid-solid transformations. To apply these principles to industrial solidification processes, with emphasis on microstructural capabilities and limitations. Assess the surface testing methods and comprehend the degradation properties.

Course Content

Introduction and important thermodynamic functions: Laws of thermodynamics — enthalpy, heat capacity, applications of first law to open and closed systems including chemical reactions; entropy, free energy and their interrelationships. Thermodynamics of solidification; Nucleation and growth; Pure metal solidification, Alloy Solidification, Constitutional undercooling, Mullins-Sekerka instability; Single phase solidification: Cellular and Dendritic growth; Multi phase solidification: eutectic, peritectic and monotectic; Modelling of solidification.
Heterogeneous systems — equilibrium constants, Ellingham-Richardson diagrams, predominant area diagrams, principles of free energy minimization; energy balance of industrial systems; solutions — chemical potential, Raoult/Henry's law, Gibbs-Duhem equations, regular solutions, quasi chemical theory. Evolution of Phase diagrams — phase rule, free-energy-composition diagrams, solidus-liquidus lines, retrograde solidus; determination of activity and other thermodynamic parameters from phase diagrams; thermodynamic analysis of ternary and multi-component systems, interaction parameters. Principles of applications — principles of applications to molten slags and silicate melts; electrochemical methods and applications, aqueous systems; Interfaces — energy, shape, segregation at external and internal interfaces; solid electrolytes; Effect of high pressure on phase transformations; Point imperfections in crystalline solids.

Reference Books

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

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand thermodynamics of solidification processes and alloys.			1, 2
CO2	Do thermodynamic modelling of solid-liquid phase change and solutions.		2, 3	4, 5
CO3	Describe kinetics of solidification such as nucleation, growth, constitutional supercooling, and multiphase solidification.		4	1, 2
CO4	Perform thermodynamic analysis of ternary and multi component system		1, 5	2, 4

Course Code	:	MTHO17
Course Title	:	Recent Developments in Welding Processes
Number of Credits		3
Prerequisites (Course Code)	:	MTPC21
Course Type	:	HONOURS

LTPC Breakup :

L	T	P	Contact hours	C
3	0	0	3	3

Course Learning Objectives

- Understand the various advancements in welding processes.
- Gain knowledge of the concepts, operating procedures, applications, advantages and limitations of various recent welding processes.

Course Content

GMAW, types of metal transfer, CO2 welding, pulsed and synergic MIG welding and surface tension transfer, CMT — Concepts, processes and applications.
Keyhole TIG, Narrow gap TIG, cold and hot wire TIG, dual shielding TIG, multi cathode TIG, buried arc TIG, A-TIG, AA-TIG, micro-plasma arc welding and AC/DC submerged arc welding process, twin wire SAW, tandem SAW, metal power addition SAW, cold and hot wire SAW.

MIAB, Microwave welding — Concepts, processes and applications, types of metal transfer and applications, advances in diffusion welding, advances in electron beam welding, laser welding, resistance welding, flash butt welding and underwater welding — concepts, types and applications.
Metal flow phenomena in friction stir welding, tool design, retreating tool, friction stir spot welding, friction stir processing, linear friction welding, orbital friction welding processes and applications.
Advances in adhesive bonding, brazing and soldering.
Cladding, CVD, PVD, laser and electron beam surface modification, ion implantation, and cutting.

Reference Books

1	*Parmer R.S., 'Welding Engineering and Technology', Khanna Publishers, 1997*
2	*Cary, Howard, "Modern Welding Technology', prentice Hall, 1998*
3	*Schwartz M., 'Materials and Applications- Metal Joining Manual', McGraw-Hill, 1979*
4	*Nadkarni S.V., 'Modern Arc Welding Technology', Oxford IBH Publishers, 1996*
5	*Christopher Davis, 'Laser Welding- A Practical Guide', Jaico Publishing House, 1994*
6	*Mishra. R.S and Mahoney. M.W, Friction Stir Welding and Processing, ASM, 2007*

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Explain the various advancements in GMAW and their applications		2	1
CO2	Explain the various advancements in TIG welding and their applications			1, 2
CO3	Explain the various advancements in MIAB, microwave welding, EBW, laser, and resistance welding and their applications		5	1, 2
CO4	Describe the various advancements in underwater welding and their applications		5	1, 4
CO5	Explain the various advancements in FSW and their applications			1
CO6	Explain the various advancements in surfacing methods and their applications		3, 5	1

Course Code	:	MTHO18
Course Title	:	Recent Developments in Forming Processes
Number of Credits		4
Prerequisites (Course code)	:	MTPC22
Course Type	:	HONOURS

LTPC Breakup :

L	T	P	Contact hours	C
3	1	0	4	4

Course Learning Objectives

To understand the concepts of advanced forming processes and their applications.

Course Content

Ring rolling: types and classification. Ring rolling of steels and nonferrous alloys- defects, remedial actions. Ring rolling mills.

Incremental bulk forming: Orbital riveting- types, orbital forging processes-types, Advantages and limitations. Presses and modifications needed for the incremental bulk forming.

Superplastic forming: Super plasticity –definition, types, structural Super plasticity–Superplastic materials– metals/alloys, composites and ceramics. Superplastic forming methods. Advantages and Limitations.

Pressing and sintering: Production of simple and complicated shapes–sequence of operation–sintering – mechanisms-near net shape production- Advantages and limitations

Isostatic pressing: Definition–stress tensor in Isostatic conditions–types–near net shape production- Advantages and limitations

Reference Books

1	Numerical Analysis-Theory and Application–Edited by john Awreicewicz, In Tech publisher, 2011.
2	J.M. Allwood, A.E. Tekkaya, T.F. Stanistreet, The development to fring rolling technology, Steel Res Int, 76(2005), pp. 111–120
3	J.M. Allwood, A.E. Tekkaya, T.F. Stanistreet, The developmentofringrollingtechnology-part2: investigation of process behavior and production equipment, Steel Res Int, 76(2005), pp. 491–507.
4	Edwards, L. and Endean, M., Manufacturing with materials, 1990, Butterworth Heinemann
5	Groche P., Fritsche D., Tekkaya E.A., Allwood J.M., Hirt G., Neugebauer R., Incremental bulk metal forming, Annals of the CIRP, 56, 2007, 635-656.
6	Cubberly, W. H.; Ramon, Bakerjian; Society of Manufacturing Engineers (1989), Desk edition: Tool And manufacturing engineer’s handbook, SME, p.42-17, ISBN 978-0-87263-351-3
7	K.A. Padmanabhan and G.J. Davies “Super plasticity", Springer Verlag, Berlin-Heidelberg-New York, August1980,
8	Angelo PC and Subramanian R, “Powder Metallurgy: Science Technology and Applications”, PHI, New Delhi, 2011.

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the Concepts of the advanced forming processes		2	1
CO2	Understand the applications of the advanced forming processes		5	1, 3
CO3	Choose suitable metal forming process for the given material		5	3, 4

Course Code	:	MTHO19
Course Title	:	Atomic-scale Modeling of Materials
Number of Credits		3
LTPC Breakup	:	L: 3, T: 0, P: 0, Contact hours: 3, C: 3
Prerequisites (Course code)	:	Nil
Course Type	:	HONOURS

Course Learning Objectives

To understand and perform atomic scale simulations on different materials

Course Content

Molecular dynamics

Introduction - 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 modelling 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

Reference Books

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

Course Outcomes

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

Course Code	:	MTHO**22**				
Course Title	:	Advanced microscopy techniques				
Number of Credits	:	3				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	3
Pre-requisites (Course code)	:	MTPC19 (Mat. Characterization)				
Course Type	:	Honours				

Course Learning Objectives

To comprehend the principles of various microscopy techniques for characterization of materials with submicron scale resolution.

Course Content

Atom probe tomography – principle, construction and operation, sample preparation, IVAS software, post processing and 3D construction, application and limitations
X-ray microscopy - principle, construction and operation, sample preparation, application and limitations
Electron back scattered diffraction – working principle, imaging, post-processing and orientation analysis, application
Transmission kikuchi diffraction - working principle, imaging, post-processing analysis, application, TKD vs EBSD, TKD vs TEM, TKD vs APT
Aberration-corrected Transmission electron microscopy – basic principle, construction and operation, high resolution imaging, applications

Reference Books

1. Micheal K Miller Richard G. Forbes, Atom probe tomography: The local electrode atom probe, Springer New York, 2014.
2. Chris Jacobsen, X-ray Microscopy, Cambridge University Press, 2019
3. Adam J. Schwartz, Brent L. Adams, Mukul Kumar, Electron Back Scattered diffraction in Material Science, 2nd Edition, Springer 2010
4. Glenn C. Sneddon, Patrick W. Trimby, Julie M. Cairney, Transmission Kikuchi diffraction in a scanning electron microscope: A review, Material Science and Engineering R: Reports, 2016
5. C. Barry Carter and David B Williams, Transmission Electron Microscopy: Diffraction, Imaging and spectrometry, Springer 2016

Course Outcomes

At the end of the course, students will be able to		PO Correlation		
		Low	Medium	High
CO1	Understand the working principle of various advanced microscopy techniques used for characterization of materials			
CO2	Understand various sample preparation methods for advanced microscopy			
CO3	Understand the post-processing of data from various advanced microscopy techniques			
CO4	Understand the application of various microscopy techniques			

MICRO-CREDIT COURSES

Students are also encouraged to take 4-week micro-credit courses from NPTEL, SWAYAM platforms

<table>
<tr><td>Course Code</td><td>:</td><td colspan="5">MTMC11</td></tr>
<tr><td>Course Title</td><td>:</td><td colspan="5">Introduction to Fluid Mechanics</td></tr>
<tr><td>Number of Credits</td><td>:</td><td colspan="5">1</td></tr>
<tr><td rowspan="2">LTPC Breakup</td><td rowspan="2">:</td><td>L</td><td>T</td><td>P</td><td>Contact hours</td><td>C</td></tr>
<tr><td>3</td><td>0</td><td>0</td><td>3</td><td>1</td></tr>
<tr><td>Pre-requisites (Course code)</td><td>:</td><td colspan="5">Nil</td></tr>
<tr><td>Course Type</td><td>:</td><td colspan="5">MC</td></tr>
<tr><td colspan="7">Course Learning Objectives</td></tr>
<tr><td colspan="7">To understand the various properties of fluid, instruments to measure fluid parameters and Practical applications of Bernoulli’s equation</td></tr>
<tr><td colspan="7">Course Content</td></tr>
<tr><td colspan="7">Properties of fluid, Fluid pressure, Pascal’s law, General equation of Fluid statics, Bernoulli’s equation
Pressure head of a fluid, Measurement of pressure, Simple manometers, Differential manometers, Mechanical gauges, Force on submerged surfaces: Horizontal,
Buoyancy: Stability of submerged and floating bodies, Practical applications.</td></tr>
<tr><td colspan="7">Reference Books</td></tr>
<tr><td>1.</td><td colspan="6">Robert W. Fox, Philip J. Pritchard, Alan T. McDonald, Introduction to Fluid Mechanics, Wiley India, 8th Edition, 2012</td></tr>
<tr><td>2.</td><td colspan="6">R. K. Bansal, Fluid Mechanics and Hydraulic Machines, Laxmi Publications, 9th Edition, 2017</td></tr>
<tr><td colspan="7">Course Outcomes
Measure pressure, calculate forces on submerged surfaces, predict stability of submerged & floating bodies and understand various types of flow & fluid motion.
Calculate pressure variations in accelerating fluid using Bernoulli’s equation.</td></tr>
</table>

Course Code	:	MTMC12					
Course Title	:	Introduction to Mechanical Engineering					
Number of Credits	:	1					
LTPC Breakup	:	L	T	P	Contact hours	C	
		3	0	0	3	1	
Pre-requisites (Course code)	:	Nil					
Course Type	:	MC					

Course Learning Objectives

Introduce various mechanical systems, Manufacturing methods and Energy generation systems

Course Content

Introduction to Mechanical Engineering, Thermal Engineering, Design, Manufacturing Engineering, IC Engines – 2 Stroke and 4 stroke systems in IC Engines. Automobiles - Transmission systems, E-Vehicles
Power plants, Types, Gas Turbines, Steam Turbines, system- Green Energy production and Devices – Fluid Movers, Pumps, Heat exchangers, Cooling towers and Compressors

Reference Books

1. K. Venugopal, ‘Basic mechanical Engineering’ ISBN: 9788187721291, Anuradha Agencies Pub-Chennai, 2014

Course Outcome

1. To identify the basic concept and fundamentals of mechanical engineering.
2. To understand the working principle of IC engines and Energy systems

Course Code	:	MTMC13				
Course Title	:	Introduction to Intellectual Property Rights				
Number of Credits	:	1				
LTPC Breakup	:	L	T	P	Contact hours	C
		3	0	0	3	1
Pre-requisites (Course code)	:	Nil				
Course Type	:	MC				

Course Learning Objectives

To understand and to create the awareness about IPR

Course Content

Introduction, types of intellectual properties, Patent rights, Trademarks, Copy rights, Geographical indications and Industrial Design

Patents - Elements of Patentability, Novelty, Non-Obviousness (Inventive Steps), Industrial Application - Non - Patentable Subject Matter - Registration Procedure

Reference Books

1. Nithyananda, K. V. (2019) Intellectual Property Rights: Protection and Management. India , IN: Cengage Learning India Private Limited.

Course Outcomes

The students once they complete the course, shall get an awareness on IPR